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Enhancing service delivery for chronic low back pain: evidence for patient-centred physiotherapy and the objective measurement of outcome.

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ENHANCING SERVICE DELIVERY FOR CHRONIC LOW BACK PAIN: EVIDENCE FOR PATIENT-CENTRED PHYSIOTHERAPY AND THE OBJECTIVE MEASUREMENT OF OUTCOME

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Abstract

This thesis incorporates two studies whose combined aims were to inform and improve the physiotherapy management of chronic low back pain (CLBP) patients in primary care.

A qualitative study explored patients' perceptions of physiotherapy for CLBP, in order to influence service redesign. Twenty-five people who had received physiotherapy for CLBP were purposively sampled. They participated in semi-structured interviews that explored their physiotherapy experience. Framework analysis was conducted on the data. The findings demonstrated that CLBP patients' expectations of physiotherapy were not consistently met and that attending physiotherapy did not consistently facilitate self-management of CLBP. Activity and participation were important to CLBP patients. However, in this sample, activity limitations and participation restrictions were not consistently addressed in physiotherapy. A definition of patient-centred physiotherapy for CLBP was generated from the patients' perspective; the physiotherapy received by this sample was not consistently patient-centred by this definition.

A quantitative study explored the potential for using gait and sit to stand (STS) analysis as objective measures, in order to enhance outcome measurement in CLBP patients. Convenience samples of 17 CLBP patients and 20 people without LBP were recruited. An optical motion analysis system was used to compare the spatial and temporal gait parameters, temporal STS parameters, and pelvic and spinal kinematic parameters of each sample. The relationship between CLBP patients' self-reported pain and disability levels and the objective measures of gait and STS was explored. The CLBP sample demonstrated statistically significant reductions in several parameters compared to the control sample: stride length and pelvic side flexion during normal gait, pelvic side flexion and spine flexion during fast gait, and peak spinal flexion during STS. An association was demonstrated between increased pain intensity and increased pelvic side flexion during fast gait.

New knowledge on the physiotherapy management of CLBP emerged from this research. Methods of enhancing patient-centredness and facilitating self-management emerged from the qualitative study. The differences detected in the quantitative study suggested that measuring gait and STS might provide useful additional outcome measures for CLBP patients, in order to overcome some of the limitations of self-report measures. They might also assist with classifying and planning individually tailored treatment approaches for CLBP patients. Although generalisation is limited by the sample sizes, the implications for practice and education and suggestions for further work arising from this research are important in attempts to enhance physiotherapy for CLBP.

Keywords: Chronic Low Back Pain, Physiotherapy, Patient-centred, Self-management, Gait, Sit to stand, Outcome measurement.

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Forthcoming publications

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List of abbreviations

CLBP: Chronic low back pain
NHS: National Health Service
STS: Sit to Stand
LBP: Low back pain
IASP: International association for the study of pain
UK: United Kingdom
SEHD: Scottish Executive Health Department
WHO: World Health Organisation
ICF: International Classification of Functioning, Disability and Health
GP: General Practitioner
USA: United States of America
OT: Occupational Therapy
CSP: Chartered Society of Physiotherapy
ODI: Oswestry Disability Index
RDQ: Roland Morris Low Back Pain Disability Questionnaire
EMG: Electromyography
ICC: Intraclass correlation coefficient
L1: First lumbar vertebra
ASIS: Anterior superior iliac spine
SEM: Standard error of the mean
SD: Standard Deviation
VAS: Visual analogue scale
VRS: Verbal rating scale
NRS: Numerical rating scale
BPI: Brief Pain Inventory
PSIS: Posterior superior iliac spine
IQR: Interquartile range
SPSS: Statistical Package for the Social Sciences
CV: Coefficient of Variation
CMC: Coefficient of multiple correlation
BMI: Body mass index
ROM: Range of motion

Chapter 1: Introduction

This thesis incorporates two studies whose combined aims were to inform and improve the physiotherapy management of chronic low back pain (CLBP) patients in primary care in the National Health Service (NHS) in Grampian, and possibly further afield. The studies explore the physiotherapy management of CLBP and objective measurement of CLBP patients during day to day activities. The overall hypothesis is that enhanced assessment of CLBP patients will lead to enhanced diagnosis, classification and evaluation of physiotherapy interventions, allowing for more appropriate physiotherapy management. More appropriate management will ultimately lead to enhanced outcome for the CLBP patient, and this outcome can be demonstrated using both subjective and objective outcome measures. This entire process needs to take place within a biopsychosocial and patient-centred perspective. The studies provide recommendations for physiotherapy practice and future research that will enhance individually tailored and patient-centred physiotherapy interventions, and that will enable the outcome of physiotherapy interventions to be objectively demonstrated. They will inform methods of enhancing the delivery of physiotherapy and of facilitating self-management in CLBP patients. They will also inform the understanding of gait and sit to stand (STS) impairments in CLBP patients, and the use of gait and STS as outcome measures with this patient group.

1.1: Aims of research

There were two aims of this research. Firstly, this research aimed to explore patients' perceptions of physiotherapy for CLBP in order to influence service redesign; patients' perceptions being defined as "ways of understanding or interpreting" their physiotherapy experience (Hoanes and Hawker, 2005). Secondly this research aimed to explore the potential for using analysis of gait and STS as objective measures of outcome in CLBP patients. Three broad areas influenced the need for this research. These concerned CLBP itself, NHS policy regarding long-term conditions, and local professional issues.

1.2: Chronic Low Back Pain background

Epidemiology

Low back pain (LBP) is a common condition, with 70 to 80% of all people experiencing back pain at some time in their life (Andersson, 1999). Reported annual prevalence rates vary from 15 to 45% with an average point prevalence of 30% (Andersson, 1999). Most LBP however is relatively mild and short-lived; 60 to 70% of sufferers will recover within six weeks (Andersson, 1999). However, approximately one third of those who recover will have another episode within six months, and up to 40% of those with back pain will still have symptoms one year later (Cassidy et al, 2005). *Chronic* LBP is LBP lasting beyond 12 weeks (Grabois, 2005; IASP, 1986), or LBP occurring episodically within a six-month period (Krismer and van Tulder, 2007). Although CLBP accounts for a relatively small proportion of all LBP, its further recovery is poor and demand on the health care system is large and costly (Grabois, 2005; Andersson, 1999). Smith et al (2004) demonstrated that 71% of individuals reporting CLBP in a population study in Grampian still had symptoms four years later, confirming the poor recovery process. Maniadakis and Gray (2000) estimated that back pain cost the NHS £1067 million in 1998, with £151 million of that being spent on physiotherapy. It is LBP of chronic duration that poses a particular challenge to the health care practitioner; positive outcome is infrequent (Kent and Keating, 2005) whereas dissatisfaction with health care is relatively frequent (Walker et al, 1999), and as yet there is no optimum treatment to deliver. Therefore, research to establish efficacy of different treatments is indicated and ongoing, and appropriate and useful outcome measures are required in order to do this (Bouter et al, 1998).

Physiotherapy management

There is no agreed gold standard physiotherapy intervention for CLBP, and indeed guidelines on CLBP, in contrast to back pain of acute duration, are sparse. Recently published United Kingdom (UK) physiotherapy guidelines for the management of "persistent" LBP, defined as LBP lasting six weeks or longer (Mercer et al, 2006), recommend exercise (with or without manual therapy), and advice and education to promote self-management. Several types of exercise are recommended, and many of the recommendations in these guidelines are based not on high quality research evidence, but on expert opinion and recommended good practice, suggesting that there is much further work required in this area. Dutch physiotherapy guidelines (Bekkering et al, 2003) state the following aims of physiotherapy for those with more persistent symptoms:

- To increase knowledge and understanding
- To change any inadequate behaviour
- To increase activity and participation
- To influence any other physical or psychosocial factors which may be associated with CLBP and within the scope of physiotherapy

In agreement with the UK guidelines, Bekkering et al (2003) suggest that this will be achieved with a combined exercise and education intervention aimed at increasing activity and participation. How to achieve these aims however is less clear; particularly which exercises and what education is appropriate for individual patients.

There are many different approaches to exercise for LBP, for example McKenzie extension or flexion exercises (Miller et al, 2005; Petersen et al, 2002), group rehabilitation based on aerobic exercise (Storheim and Bo, 2000), functional restoration programmes (Jousset et al, 2004), and spinal stabilising exercises (Hodges, 2003). Whether one approach is superior to the others has not yet been established, which may in part be due to the generic nature of CLBP with its many possible causes (Leboeuf-Yde et al, 1997). Therefore, research to try to subclassify LBP patients in order to direct treatment more effectively is considered a priority (Ford et al, 2007). Fritz et al (2006) focussed on classifying patients with acute symptoms, whereas Petersen et al (2004) proposed a classification system for acute and chronic LBP patients. This system is based on clusters of signs and symptoms and uses classifications such as "disc syndrome" (p92), "adherent nerve root" (p92) and "postural syndrome" (p 93). However, whether this system enhances treatment of CLBP patients has yet to be determined. O'Sullivan (2005) proposed a classification system based on three broad subgroups of CLBP; patients with an underlying pathological process, patients with primarily psychological and/or social factors, and patients with movement or control impairments. Those with movement or control impairments are proposed to comprise the largest of the three subgroups. The reliability of this system for classifying patients with motor control impairment was confirmed in a recent study (Dankaerts et al, 2006a) suggesting that it might be possible to target exercises appropriately, for this subgroup of patients at least.

It is suggested that education should be aimed at helping patients take control of their LBP, using a problem-solving approach in which patients are encouraged to achieve their own goals (Klaber Moffett, 2002). For education to be effective the method of delivery is clearly important, and an effective patient-therapist relationship and good communication skills are suggested to be key factors (Klaber Moffett, 2002). These factors are included in a conceptual model of "patient-centredness" developed from primary care literature (Mead and Bower, 2000). What exactly "patient-centredness" is in the context of physiotherapy for CLBP however, and how to deliver patient-centred education, is not clear.

In summary, physiotherapy for CLBP has well-defined objectives but less well-defined methods of achieving these objectives. Therefore, as suggested above, research to establish the efficacy of different treatments is indicated, and identifying appropriate and useful outcome measures is the crucial first stage in this research. However, exploring methods of delivering physiotherapy, for example how to be "patient-centred", is also indicated in order to maximise the likelihood of positive outcome.

Outcome measurement

Assessing the efficacy of treatments for CLBP requires valid and reliable outcome measures. There are many outcome measures available for use with CLBP patients, several of which have been endorsed by experts on LBP (Bombardier, 2000). Many of these outcome measures are subjective in nature and dependent on patient self-report. However, self-report measures have been shown to have limitations, since there can be discrepancies between how patients believe they perform and how they actually do perform (Reneman, 2002). It has therefore been suggested that objective tests of performance are required to supplement subjective measures (Wittink et al, 2003). Indeed, European guidelines on the management of chronic non-specific pain highlight research on the relationship between physical capacity and functional performance (objective) and self-reported disability (subjective) as requiring particular attention (Airaksinen et al, 2004).

1.3: National Health Service policy

The Scottish Executive Health Department (SEHD) stated that increased help and support would be made available to patients with long-term conditions in order for them to be able to play an increasing role in self-management (SEHD, 2005a). Physiotherapists clearly have a role to play in enabling and supporting patients in self-management activities (SEHD, 2006). As discussed above, CLBP has a poor recovery rate and the objective of physiotherapy is to increase activity and participation with the patient taking an active part in their management (Bekkering et al, 2003). Therefore, physiotherapy services need to address the self-management support needs of CLBP patients.

1.4: Local professional issues

The physiotherapy service for NHS Grampian serves a large geographical area, with departments in Aberdeen City, the main towns in the region, and also in some more rural locations; these departments range from fairly large and well-equipped hospital-based departments to small rooms within health centres. There is no dedicated Grampian-wide service specifically for LBP patients; however a clinical pathway for the physiotherapy management of LBP is in use in the region (NHS Grampian, 2005). Therefore, regardless of where CLBP patients receive their physiotherapy, their management should be based on similar principles. The clinical pathway drew on the Royal College of General Practice guidelines (Waddell et al, 1999) and the Dutch physiotherapy guidelines (Bekkering et al, 2003). However to date patients themselves have not been involved in service development for CLBP physiotherapy in Grampian. Despite the development of the pathway and associated education and training for physiotherapists, there remains a relatively high rate of re-referral of CLBP patients; 40% in an audit conducted in one physiotherapy department in

Grampian in 2004 (unpublished data). There also appears to be a high dropout rate from physiotherapy for CLBP, particularly for group rehabilitation (personal communication with lead physiotherapist for Aberdeen, November 2006). These two factors might suggest poor outcome from and dissatisfaction with physiotherapy, which is consistent with previous literature on satisfaction with chronic pain management (Walker et al, 1999). Therefore, it seems appropriate now to involve patients by determining their views on physiotherapy for CLBP, to identify areas in which patients would like to see change, and to allow patients' views to influence future service redesign. Clearly, any physiotherapy intervention for CLBP requires evaluation, whether in a large-scale research study, or on a more local level. Recommended LBP outcome measures are used in the Grampian region, but all are subjective in nature. As discussed above, objective measures might enhance outcome measurement in CLBP patients, and their potential use should be explored.

1.5: Conceptual framework

Two broad concepts underpin this research and are introduced here. The first is the biopsychosocial model of LBP (Waddell, 1987) which influences both the physiotherapy management of CLBP and measurement of CLBP patients. The second is the International Classification of Functioning, Disability and Health (World Health Organisation (WHO), 2001) which provides a language and framework for describing health and health-related states, including CLBP.

Biopsychosocial model of low back pain

It is now twenty years since it was proposed that the biopsychosocial model could help the understanding of LBP (Waddell, 1987), and it is widely used to underpin the approach towards LBP assessment and management (for example Bekkering et al, 2003). Previously, the disease or biomedical model was predominant; any pain was seen as a direct consequence of pathology and therefore the pain would be relieved on removal of that pathology (Waddell and Main, 1998). However, the biomedical model does not easily explain the long-lasting symptoms of CLBP. In contrast, the biopsychosocial model views CLBP as resulting from the interaction between biological (pain), psychological (attitudes and beliefs, psychologic distress, illness behaviour) and social factors (social environment). The biopsychosocial model considers CLBP as an illness rather than a spinal disease; therefore management addresses the physical, psychological and social aspects of the illness (Waddell and Main, 1998). This model therefore influences the physiotherapy management of CLBP and the measurements used to determine the efficacy of physiotherapy, since both must consider biological, psychological and social factors.

International Classification of Functioning, Disability and Health

The International Classification of Functioning, Disability and Health (ICF; WHO, 2001) is based on the biopsychosocial model (Waddell, 2006). The ICF is intended to provide a common language for describing health and health-related states, and is used as such in this thesis. Table 1.1 provides an overview of the ICF. Figure 1.1 demonstrates the relationship between the ICF and the biopsychosocial model on which it is based; the definitions that are relevant to this research are those highlighted in part one of the ICF that relate to functioning and disability. These terms and the other key ICF terms are defined in table 1.2.

Table 1.1: Overview of International Classification of Functioning, Disability and Health.

	Part 1: Functioning and disability		**Part 2: Contextual factors**	
Components	Body functions and structures	Activities and Participation	Environmental factors	Personal factors
Domains	Body functions Body structures	Life areas (tasks, actions)	External influences on functioning and disability	Internal influences on functioning and disability
Constructs	Change in body functions (physiological) Change in body structures (anatomical)	Capacity Executing tasks in a standard environment Performance Executing tasks in the current environment	Facilitating or hindering the impact of features of the physical, social and attitudinal world	Impact of attributes of the person
Positive aspect	Functional and structural integrity	Activities Participation	Facilitators	Not applicable
	Functioning			
Negative Aspect	**Impairment**	**Activity limitation** **Participation restriction**	Barriers/ hindrances	Not applicable
	Disability			

Terms in blue are those used throughout this research
From: ICF Introduction, World Health Organisation (2001), page 11

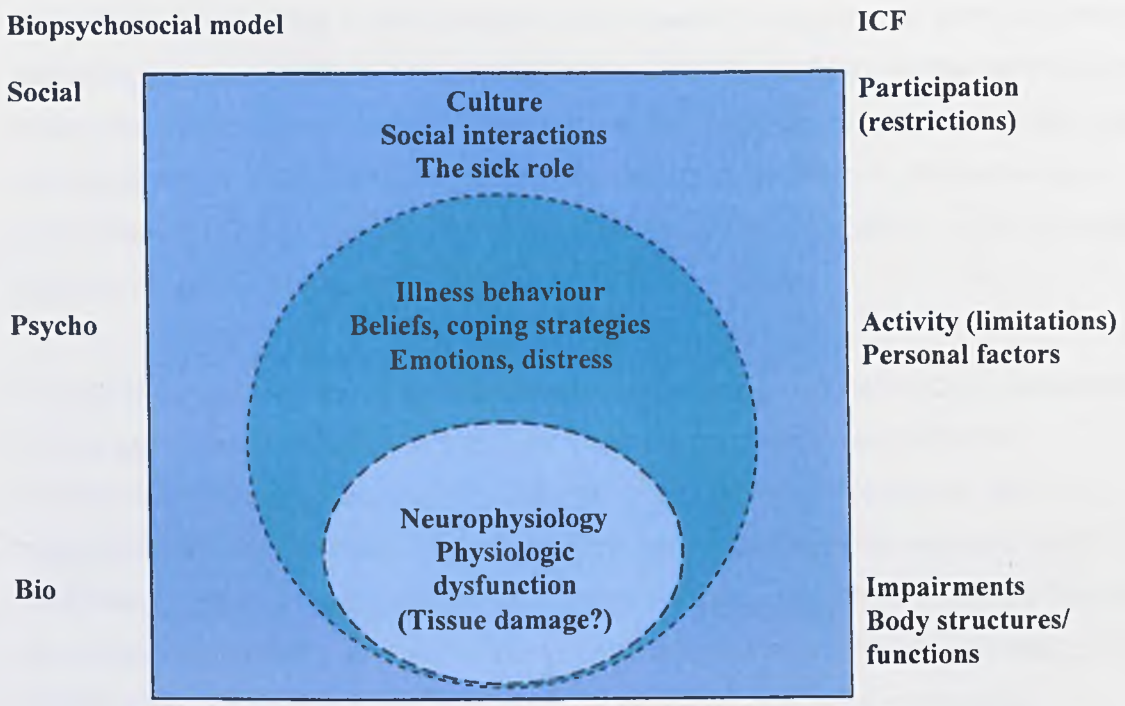


Figure 1.1: Biopsychosocial model and relationship with International Classification of Functioning, Disability and Health (ICF)
Reproduced from Waddell (2004). The Back Pain Revolution, 2nd edition, Churchill Livingstone, with permission from Elsevier.

Table 1.2: Key ICF terms and their definitions

Term	Definition
Body functions	The physiological functions of body systems
Body structures	Anatomical parts of the body (e.g. organs, limbs)
Impairments	Problems in body function/structure such as significant deviation or loss
Activity	Execution of a task or action by an individual
Participation	Involvement in a life situation
Activity limitations	Difficulties an individual may have in executing activities
Participation restrictions	Problems an individual may experience in involvement in life situations
Environmental factors	The physical, social and attitudinal environment in which people live and conduct their lives

From: ICF Introduction, World Health Organisation (2001), page 10

Therefore, functioning is the positive umbrella term relating to body functions and structures, activities, and participation, whilst disability is the term used when there is impairment in body functions or structures, activity limitations or participation restrictions. The ICF is referred to in the Dutch physiotherapy guidelines (Bekkering et al, 2003), and its use in rehabilitation, both clinically and for research purposes, is encouraged (Jette, 2006).

Due to the need for exploring methods of delivering physiotherapy described above (p4), the first study presented in this thesis explored patients' perceptions of physiotherapy for CLBP in order to influence future service redesign. Patients' perceptions of the key issues of expectations and their fulfilment, self-management, patient-centred care, and physiotherapy focusing on increasing activity and participation were included in this component of the thesis. Due to the need for developing a range of outcome measures, combined with the need to explore the relationship between objective and self-report measures, the second study explored the objective measurement of two activities, gait and STS, in CLBP patients. Gait and STS were chosen since they are fundamental activities common to many daily activities. This component of the thesis explored the relationship between both gait and STS and patients' self-report, and the potential for gait and STS to be incorporated into outcome measurement for CLBP. In combination the two components provided recommendations for physiotherapy management of and measurement of CLBP that should enhance physiotherapy for this complex condition.

1.6: Methodology

This thesis is presented as two studies as detailed above. Together, their aims were to inform and improve the physiotherapy management of CLBP patients in primary care. It was felt that the two studies were necessary to fully answer the overarching research question of how to improve physiotherapy management of CLBP patients. Exploring patients' perceptions of physiotherapy for CLBP in order to influence future service redesign would partly answer the overarching research question. However, making improvements to physiotherapy services without the ability to measure the effectiveness of the physiotherapy being provided was considered inappropriate. Therefore, in order to fully explore the area of improving physiotherapy for CLBP it was felt that both the delivery of physiotherapy and methods of measuring the physiotherapy delivered were important areas to address, and areas that relate to and inform one another.

In order to deliver effective physiotherapy treatment for CLBP patients, the actual intervention delivered is clearly important, and outcome measures will aid in determining the efficacy of such interventions. However, the manner in which the physiotherapy intervention is delivered will arguably affect the way in which it is perceived by the patient and may therefore affect its efficacy. Therefore, in order to provide the most effective physiotherapy for CLBP, it is essential to deliver it in the most appropriate way. The qualitative study therefore directly informs the quantitative study presented in this thesis.

Qualitative methods, or a flexible design (Robson, 2002), were used to explore patients' perceptions of physiotherapy for CLBP, in order to influence the design of services, in particular the way in which they are delivered to patients. Quantitative methods, or a fixed design (Robson, 2002), were used to explore objective measurement in CLBP patients in an attempt to enhance outcome measurement in this patient group. A fixed, quantitative research design is appropriate when the purpose is to measure certain variables and explore their relationship to one another (Polgar and Thomas, 1999). This type of design involves pre-determined research methods and extensive pilot work to ensure the feasibility of methods. A flexible, qualitative research design is appropriate when the purpose is to gain insights into patients' experiences (Polgar and Thomas, 1999). This type of design tends to evolve and develop as the research progresses. The particular fixed and flexible designs employed in the two studies are reviewed and justified in the relevant chapters.

1.7: Structure of thesis

This chapter has introduced the aims of this research, and the contextual factors, concepts and methodology that underpin it. Section 1.8 states the research questions of both studies presented in this thesis. Thereafter the studies are presented in turn in chapters two and three, along with a detailed review of the existing research literature in each of these areas, and finally their relationship and combined implications for enhancing physiotherapy are considered in chapter four.

1.8: Research questions

Aims

There were two aims of this research. Firstly, to explore patients' perceptions of physiotherapy for CLBP in order to influence service redesign, and secondly to explore the potential for using gait and STS analysis as objective measures of outcome in CLBP patients. The research questions relating to these aims were:

1. Patients' perceptions of physiotherapy

I. What do chronic low back pain patients expect from physiotherapy?
II. Are these expectations currently met in Grampian?
III. What do chronic low back pain patients perceive patient-centred physiotherapy to be?
IV. Is physiotherapy provision for chronic low back pain patients in Grampian currently patient-centred?
V. Could anything else be done to make physiotherapy provision for chronic low back pain patients in Grampian more patient-centred?
VI. Does physiotherapy in Grampian facilitate chronic low back pain patients to self-manage their condition?
VII. Could anything else be done in Grampian to facilitate chronic low back pain patients to self-manage their condition?
VIII. How important is activity and participation to chronic low back pain patients?

2. Gait and sit to stand analysis

I. Are there differences between chronic low back pain patients and control subjects in spatial, temporal and spinal kinematic parameters of gait and sit to stand?
II. Is there a relationship between spatial, temporal, and spinal kinematic gait parameters and patients' self-report of pain and disability?

III. Is there a relationship between temporal and spinal kinematic sit to stand parameters and patients' self-report of pain and disability?

IV. Is gait and/or sit to stand analysis a potentially useful outcome measure for chronic low back pain patients?

V. What other outcome measures are important for chronic low back pain patients?

Chapter 2

Patients' perceptions of physiotherapy for chronic low back pain

2.1: Introduction

This chapter presents the qualitative study on patients' perceptions of physiotherapy for CLBP. Firstly, the literature relating to four key aspects of physiotherapy for CLBP relevant to this study is critically reviewed. The need for more research in these areas is highlighted in order to justify the study and its aims and objectives. Secondly, a pilot study is presented. The pilot study tested the methods of recruitment, data collection and analysis prior to conducting the full study. Thirdly, the methodology underpinning and methods used in the study are presented and justified, and finally the study's findings are presented and interpreted.

2.2: Literature review

Introduction

The purpose of this study was to elicit the views of CLBP patients on several aspects of the physiotherapy they had received in Grampian, in order to influence service redesign. The four main aspects of CLBP physiotherapy under consideration were as follows: 1) Patients' expectations of physiotherapy and the extent to which these expectations were met, 2) patients' perceptions of patient-centredness, 3) patients' views regarding long-term management of CLBP, and 4) the importance of activity and participation to CLBP patients. These areas were chosen since they would inform the development of patient-centred interventions aimed at enhancing activity and participation and supporting self-management, thereby fulfilling the overall aim of this study, to allow CLBP patients to influence service redesign.

This literature review therefore focuses on the four areas itemised above. Patients' views on these areas are often incorporated in studies of satisfaction with services as a whole, and it would be difficult to determine patients' perceptions of these four areas without their consideration of overall satisfaction with physiotherapy. Therefore, the relevant literature regarding satisfaction is firstly reviewed, followed by the four substantive areas relating to this study.

Literature relating directly to the physiotherapy management of CLBP is often lacking and where relevant literature concerning the medical management of CLBP is reviewed. In addition, literature regarding CLBP management itself is also at times lacking, and where this is the case relevant literature on chronic pain management in general is reviewed.

This review incorporates literature dating from ten years prior to the start of this study to the completion of this thesis (May 1994 to April 2007). In addition, some earlier material is included where it is considered to be seminal work in any of the relevant areas.

2.2.1: Satisfaction

2.2.1.1: What is satisfaction?

Patient satisfaction has been defined as "the extent to which treatment gratifies the wants, wishes, and desires of clients" (Lebow, 1982). It is seen as a multidimensional and continuous variable which is dependent on both the clinical setting and characteristics of the individual patient (Baker, 1997). Satisfaction is seen as an important outcome measure, partly due to the drive for user involvement in the health service (Scottish Executive Health Department, 2003; 2001). Its importance in physiotherapy is reflected in the development of numerous tools that have been developed to measure patients' satisfaction with physiotherapy services (Hills and Kitchen, 2007; Beattie et al, 2005; 2002; Goldstein et al, 2000). Patient satisfaction with physiotherapy for CLBP has received little attention to date; this review found only one such study. Indeed, satisfaction with physiotherapy in general appears to be only just emerging as an area of research.

2.2.1.2: Satisfaction with chronic pain management

Patients in poorer health are less likely to be satisfied with their health care (Hall et al, 1998), which may explain why chronic pain patients have been reported as being dissatisfied with their management. However, it may be that measuring different aspects of satisfaction can yield different results. For example, Hirsch et al (2005) demonstrated that chronic pain patients attending a pain clinic distinguished between the quality of care they received and their treatment outcome. These patients were significantly more satisfied with their care than they were with the improvement in their symptoms, as measured with a 5-item self-report questionnaire using scales (0-100) for each item (mean score 77.43 out of 100 for satisfaction with care, 55.53 for symptom improvement, $p < 0.001$).

This highlights the importance of exploring different aspects of satisfaction in chronic pain patients, but clearly relates to a wider population being managed in a different way than those of interest in the current study. In addition, the use of scales is limited to establishing overall levels of satisfaction and not useful for exploring the reasons for any differences in satisfaction between care and symptom improvement. Hirsch et al (2005) suggest that aspects of the patient-provider relationship may be more important to the patient than the level of pain-relief itself. It may therefore be important to establish which aspects of the patient-provider relationship are important to chronic pain patients when evaluating satisfaction with care.

Harding et al (2005) also investigated satisfaction with management of chronic musculoskeletal pain. They sampled patients who had previously attended a pain clinic and who had recent (within one year) experience of hospital doctors, General Practitioners (GPs), and for a few, physiotherapists. Eleven of their fifteen participants had LBP; therefore their results might be more relevant to the population of interest in the present study. They conducted in-depth qualitative interviews with each participant and one of their main findings was disappointment with their medical care. They felt that they were not taken seriously and that doctors appeared not to care about their pain. Whether these perceptions were also held by those with physiotherapy experience is not clear in the study, but would be worthy of investigation.

2.2.1.3: Satisfaction with Chronic Low Back Pain management

Walker et al (1999) demonstrated the understanding that can be gained by using qualitative methods to explore the experiences of pain clinic attendance in CLBP patients. They analysed narrative accounts of the LBP experience of 20 patients, all of whom expressed dissatisfaction with their medical care. Aspects of care that dissatisfaction was expressed about commonly related to long waiting times, poor communication by medical professionals, poor diagnosis and treatment efficacy and a feeling that medical professionals lose interest in their patients when they are unable to treat their pain adequately. This was a small study of limited use for generalisation, but it helps to explain and understand some of the reasons for the reported low levels of satisfaction in other studies.

Evans et al (2003) took a similar approach to exploring which factors were considered by patients when deciding upon their treatment satisfaction. They conducted qualitative interviews with 31 patients undergoing spinal manipulation, epidural injections or self-care for the treatment of sciatica. The proportions of the sample receiving each treatment are not reported; therefore any bias in the results is unknown. However, patients reported pain-relief as being the primary factor in determining satisfaction with care, with personnel factors close behind (for example friendliness, competency and courtesy). Satisfaction with change in symptoms was, perhaps unsurprisingly, measured by all subjects in terms of pain-relief; with ability to carry out daily activities close behind. These results agree with those of Hirsch et al (2005) in that they demonstrated that patients can assess care and symptom improvement independently. However, unlike Hirsch et al (2005), the patients interviewed by Evans et al (2003) demonstrated similar levels of satisfaction with both care and improvement (three-quarters of their sample were very or completely satisfied with their care, and similar numbers reported 75 to 100% improvement in symptoms).

The sample interviewed by Evans et al (2003) were described as having sciatica resulting in moderate pain and disability, and as such their symptoms may have been more amenable to change than the chronic pain clinic patients studied by Hirsch et al (2005). This may account for the discrepancy in results between the two studies. This reinforces the theory of Baker (1997) that individual clinical settings and patient characteristics affect satisfaction and these need to be considered when designing and interpreting studies of patient satisfaction.

Two further studies also demonstrated that low levels of satisfaction with treatment outcome can co-exist with high levels of satisfaction with patient-provider relationship (Nyiendo et al, 2001; 2000). These studies involved CLBP patients, although chronicity was defined as symptom duration of 6 weeks or longer, rather than the more usual 12 weeks (IASP, 1986).

Satisfaction was a secondary measure here, the focus of the studies being on pain and disability levels in two groups of patients; those treated by chiropractors and those being managed medically. However, the results further support the multidimensional nature of satisfaction.

Laerum et al (2006) in their qualitative study of CLBP patients' consultations with consultants uncovered several aspects that patients regarded as important for a "good back-consultation" (p 261). These included being taken seriously, receiving an understandable explanation of their LBP, having their preferences considered, receiving reassurance, and receiving information on what could be done including self-management strategies. Since the study involved observation of the back-consultation and interviews with the patients, the results may have been affected by the presence of the researcher in the consultation itself. However it suggests several areas that might affect satisfaction with CLBP management and that may be important to explore further in future studies with CLBP patients.

2.2.1.4: Satisfaction with physiotherapy management

George and Hirsch (2005) used three ordinal rating scales to investigate satisfaction in 66 acute LBP patients being managed by physiotherapists. They again demonstrated high levels of satisfaction with care (89% would have the same physiotherapy treatment again, and 91% rated their physiotherapist as good, very good or excellent) but lower levels of satisfaction with symptom improvement (only 40% were satisfied with their symptoms). This again supports the multidimensional nature of satisfaction discussed above, suggesting similarities between ratings of satisfaction in medical and physiotherapeutic settings. However, patients with acute and chronic LBP may differ in both their physiotherapeutic management and outcome and therefore their satisfaction ratings may differ also.

Layzell (2001) also demonstrated high levels of satisfaction with physiotherapy for LBP of unspecified chronicity. This was a large questionnaire-based study. However, a limitation is that the questionnaire was not validated prior to its use in the study. Employing a questionnaire, whilst enabling a large sample to be included in the study, does have limitations. The questionnaire evaluated satisfaction with five pre-determined areas; explanations, advice, treatment, symptoms and access.

However, it is not known whether the patients sampled may have taken other factors into account when evaluating overall satisfaction with physiotherapy.

Potter et al (2003a) addressed this when they explored patients' perspectives of a "good" physiotherapist (p 200) and of the physiotherapy experience. They employed a qualitative approach (nominal group technique) in a sample of 26 private practice patients of unspecified diagnosis. Three categories were important to these patients, in descending order: Communication (e.g. interpersonal skills, manner and patient-education techniques), "other" attributes (e.g. professional behaviour and organisational abilities), and characteristics of the service (e.g. diagnostic and treatment expertise, the environment, convenience and accessibility). A "good" physiotherapy experience was one where effective communication ranked highly, followed by a high quality service. Conversely, a "bad" experience was one where the service ranked poorly, followed by poor communication skills. Although this study concerned Australian private practice patients, who may differ from those being treated in the NHS in Scotland, and does not exclusively relate to CLBP patients but out-patients in general, it does suggest some areas that may be important to explore when assessing satisfaction with physiotherapy.

The only study to have explored satisfaction in LBP patients attending physiotherapy in the NHS was conducted by May (2001) in England. He interviewed 34 subjects, who mostly had chronic symptoms. Although at 15 to 25 minutes' duration the interviews were fairly short for qualitative interviews (Legard et al, 2003), several dimensions of satisfaction with physiotherapy emerged from the data. These were the personal and professional manner of the physiotherapist, explaining and teaching, treatment being consultative, access and time with the physiotherapist, and the outcome which ensued. In this study again, many patients reported high overall satisfaction with care but little improvement in symptoms, in keeping with the work discussed above. There are also similarities between the dimensions reported by May (2001) and those of Potter et al (2003a), and the aspects of care that subjects were dissatisfied with in the study by Walker et al (1999) discussed above. These combined results therefore suggest areas that are of interest in any study aiming to evaluate patient satisfaction.

In summary, patient satisfaction is a complex, multidimensional variable, which is individual to both the treatment setting and the patient reporting it. Patients can simultaneously be satisfied with their overall care but dissatisfied with the outcome of that care, which presents a dichotomy and indicates that both the process of and outcome of care should be assessed independently. The patient-healthcare provider relationship appears to be central to satisfaction with care. Aspects of that relationship have been identified which appear to be important to patients, as have aspects of service delivery. However, little research to date has been conducted on satisfaction with physiotherapy for CLBP, suggesting that further research would be beneficial. Finally, qualitative methods may allow for a deeper understanding of patient satisfaction than more traditional research methods, since they allow aspects of satisfaction to be patient determined and not pre-determined by the researcher.

2.2.2: Expectations

2.2.2.1: Relationship with satisfaction

Although expectations are believed to be one of the primary determinants of satisfaction (Thompson and Sunol, 1995), several studies have demonstrated a complex relationship between the two variables. Thompson and Sunol (1995) in their review of literature proposed four types of expectations that people may hold: Ideal (preferred), predicted (realistic), normative (deserved) and unformed (lack of or inability to express expectations). They also suggested that expectations are influenced by several personal and social factors, and that the complexity of the relationship between expectations and satisfaction may in part be mediated by the fact that satisfaction is an affective construct whereas expectations lie in the cognitive domain.

Staniszewska and Ahmed (1999) demonstrated the benefit of employing qualitative methods to explore expectations and satisfaction in cardiac patients. They used in-depth interviewing with 33 patients, exploring the broad areas of expectations and evaluation of care. The patients were encouraged to discuss the themes that were important to them and not those predetermined by the researcher. Their sample simultaneously held ideal and realistic (predicted) expectations of their treatment, suggesting that patients can distinguish between these two types of expectation. Staniszewska and Ahmed (1999) suggested that an awareness of political and economic issues such as cutbacks and long waiting times might have shaped the realistic beliefs. They also demonstrated that their sample tended to evaluate their care with reference to their initial expectations, again confirming that it is impossible to explore either expectations or satisfaction without also exploring the other.

Yelland and Schluter (2006) demonstrated that patients could distinguish between desired and worthwhile outcomes in their trial of injection and exercise therapy for CLBP. They asked patients what their minimum worthwhile and desired improvements in pain and disability levels were before treatment. Patients reported low minimum worthwhile reductions (25 to 30%) but high desired reductions (80%). In this study minimum worthwhile or desired reductions in pain and disability were not related to treatment satisfaction scores at 12 months. However, this might be related to the limited nature of the questions asked in the study; the actual outcome expected by the patients might have lain somewhere in between the minimum worthwhile and desired reduction, representing the realistic expectations of Staniszewska and Ahmed (1999).

McCarthy et al (2005) explored expectations and satisfaction in LBP patients. They employed qualitative methods, in the form of focus groups and a Delphi technique, to rank both expectations and satisfaction in a group of patients attending a secondary care spinal clinic. They found that for expectations a clear diagnosis and effective treatment were ranked highly, whereas for satisfaction ease of access and post-discharge follow-up were the most highly ranked. This suggests that expectations were not necessarily used to rate satisfaction in this group of subjects. This study also demonstrated that overall satisfaction was rated more highly than satisfaction with some of the individual components such as diagnosis and treatment. This is in agreement with the studies discussed above where overall satisfaction can be high but satisfaction with specific outcomes low (George and Hirsch, 2005; Hirsch et al, 2005; Nyiendo et al, 2001; 2000).

In summary, expectations and satisfaction are related, but the relationship is not a straightforward linear one. Asking patients to rate their overall general satisfaction is therefore not likely to determine the extent to which their individual treatment expectations are met. In order to understand patients' expectations of a service and the extent to which they are fulfilled, it is necessary to explore expectations in relation to the specific service in question in order to identify factors of importance to individual patients. This will identify the areas that require to be addressed when redesigning services. The following section therefore considers the literature on expectations relating to the treatment of LBP and to physiotherapy.

2.2.2.2: Expectations and Low Back Pain

In a systematic review on expectations of treatment for LBP (Verbeek et al, 2004) only one study out of twenty reviewed related specifically to physiotherapy treatment, with the focus of the study being acute LBP (Grimmer et al, 1999). Indeed the current literature search only discovered a further four physiotherapy-related studies. One reporting on Australian private practice patients (Potter et al, 2003b), two UK papers (reporting on one sample) on non-spinal outpatients (Metcalfe and Klaber Moffett, 2005a, 2005b), with only one study, from the United States of America (USA), reporting on expectations of physiotherapy for both acute and chronic LBP patients (Morlock et al, 2002). Due to this lack of previous research on CLBP patients expectations of physiotherapy, the literature on expectations of treatment in general for LBP is firstly reviewed, followed by the literature on expectations of physiotherapy in general, and finally the literature on expectations of physiotherapy for LBP.

2.2.2.3: Expectations of treatment for Low Back Pain

Expectations can be divided into expectations of treatment and the outcome of that treatment. In the review by Verbeek et al (2004) the most common expectations of treatment were that a diagnosis and instructions on back-care would be given. This has also been demonstrated in patients being managed in primary care (McPhillips-Tangum et al, 1998), secondary care (McCarthy et al, 2005) and by chiropractors (Sigrell, 2001). In addition, expectations of the healthcare practitioners themselves (commonly GP's, osteopaths or chiropractors) were that they would be confident, good communicators, listen to patients, treat patients with respect and involve patients in decision-making.

The most common expected treatment outcome found by Verbeek et al (2004) was pain-relief, followed by sickness certification. Pain-relief appears to be a common expectation irrespective of management style (Sigrell, 2001; McPhillips-Tangum et al, 1998).

It has been suggested that expected outcome might have a significant effect on treatment efficacy. Kalauokalami et al (2001) demonstrated in a large study that confidence in a particular treatment was positively related to treatment outcome. They measured treatment confidence in massage and acupuncture before patients were randomised to receiving one of the two treatments and demonstrated a greater improvement in functional disability scores for those who had a greater confidence in the treatment they received. Eighty-six percent of those with high treatment expectations compared with 68% of those with low treatment expectations had significantly improved disability scores at 6 month follow-up (p<0.01). General optimism about improvement in symptoms was not predictive of functional outcome, suggesting that the expectation of the specific treatment was the important predictor.

Goldstein et al (2002) demonstrated similar findings when they compared LBP patients being treated medically (with or without added physiotherapy) or by chiropractors (with or without electrophysical modalities). They only demonstrated an association between treatment confidence and improvements in disability scores in patients treated medically with added physiotherapy; however this was the group that originally demonstrated the highest confidence that their treatment would help them. Therefore, patients' expectations of specific treatments as well as the outcome of treatment in general may be important to explore in future studies.

Verbeek et al (2004) found that dissatisfaction with the common expectations of diagnosis, information giving and pain relief was widespread in the studies reviewed. Patients often expected diagnostic tests in the studies reviewed; however these are not routinely recommended in LBP treatment guidelines. Verbeek et al (2004) suggested that this apparent gap between expectations and guidelines, also demonstrated elsewhere (Klaber Moffett et al, 2000), may best be bridged by improving communication skills of healthcare providers or by public information campaigns. One such campaign has already been conducted with some success in Australia (Buchbinder et al, 2001). Verbeek et al (2004) also found that LBP patients were most satisfied with chiropractic care. This appeared to be related to aspects of the patient-practitioner relationship such as information-giving and explanation of diagnosis, again confirming the importance of these aspects of care.

These findings provide some insight into the expectations of LBP patients but clearly they relate to the non-physiotherapeutic management of LBP. Whilst there may be some similarities in expectations, perhaps most likely between primary care and physiotherapy, there may be distinct differences between physiotherapy candidates and those being managed in other ways.

Therefore, the results of the literature presented above are not generaliseable to expectations of physiotherapy for LBP. In addition, many of the studies on LBP have not been limited to patients with symptoms defined as chronic. There may be distinct differences in the expectations of those in acute and chronic painful states; therefore it would be beneficial to explore the expectations of physiotherapy held by patients with symptoms of chronic duration.

2.2.2.4: Expectations of physiotherapy

Potter et al (2003b) explored the expectations of patients attending private physiotherapists in Australia. They used a qualitative, nominal group technique with 26 participants and found three main categories of expectations, in order of importance: physical (e.g. pain-relief, self-management strategies, hands-on treatment and electrotherapy), communication (e.g. explanations, diagnosis and prognosis) and behavioural (e.g. listening, being friendly and polite, being punctual). Unusually, they also explored physiotherapists' perceptions of patients' expectations, using the same technique. Physiotherapists perceived that patients would rank behavioural expectations as most important, followed by physical and finally communication. Although this was a small study and it is not known whether any LBP patients were included in the sample, it does give an indication of possible expectations of physiotherapy, which are in reasonable agreement with those of the medical studies presented above. That the physiotherapists held incorrect perceptions regarding the patients' expectations suggests that physiotherapists may need to determine from patients what their expectations are in order to establish an effective therapeutic relationship.

Metcalfe and Klaber Moffett (2005a), in a postal survey of 285 patients with upper or lower limb conditions, investigated the factors that were associated with a high expectation of treatment benefit from physiotherapy. These factors were traumatic rather than degenerative condition, upper rather than lower limb condition, shorter duration of symptoms, shorter waiting time for physiotherapy, lack of previous physiotherapy experience, previous beneficial physiotherapy for a different problem, satisfaction with previous health care, no anticipation of surgery for limb condition, and female gender. Although the sample was biased towards older females and therefore not generaliseable to all physiotherapy patients, the results demonstrated that patients had expectations of the benefit of physiotherapy and these expectations were related to several variables.

In a follow-up study on the same sample of patients (Metcalfe and Klaber Moffett, 2005b) they demonstrated that expectations were related to change in disability, perceived improvement, and change in health status, agreeing with the work by Goldstein et al (2002) and Kalauokalami et al (2001). The factors that Metcalfe and Klaber Moffett (2005) did not explore were the actual expectations other than the degree to which patients expected to be better or worse. In what way did the patients expect to be better or worse? Did they consider pain or activities or some other factors when making their prediction? It would be interesting to explore by what means physiotherapy patients measure expected (and actual) outcome, in order to aid understanding of this complex area.

2.2.2.5: Expectations of physiotherapy for Low Back Pain

Grimmer et al (1999) did explore the actual expectations of 121 Australian patients with acute LBP, in their questionnaire-based study. They found that patients largely expected pain-relief after their first treatment. Those with no previous physiotherapy experience were more likely to expect a complete cure, whilst those with previous experience expected advice and knowledge on the likely course of their LBP rather than to be cured by the physiotherapist. This is in agreement with the findings of Metcalfe and Klaber Moffett (2005) who found higher expectations in those with no previous experience. Grimmer at al (1999) also found that patients based their decision on returning for further physiotherapy on pain-relief, the physiotherapist's interpersonal skills, and the physiotherapist's ability to impart information.

The sample in the study by Grimmer et al (1999) was largely drawn from private practices, and therefore may not easily be generalised to LBP patients being treated in the NHS in Scotland. Also, due to the acuity of symptoms it may be reasonable to expect some pain-relief from physiotherapy, whereas patients with chronic symptoms may be aware that pain-relief is less likely, particularly after a single physiotherapy session. This study does suggest however that the personal and communication skills of physiotherapists may be particularly important, as suggested by the studies reviewed in section 2.2.1 (Hirsch et al, 2005; Potter et al, 2003a: Evans et al, 2001; May, 2001). In keeping with previous studies (Verbeek et al, 2004), it also suggests that pain-relief is important to LBP patients, at least in those with acute symptoms.

Morlock et al (2002) explored outcome expectations of 111 LBP patients for five dimensions of physiotherapy (symptoms, daily activities, sleep, work, and recreation). Their sample comprised mainly patients with subacute and chronic symptoms. They demonstrated that patients with high expectations had an improvement in pain and function of 34.11 points (measured on the North American Spine Society scale, from 0-100), whilst those with low expectations had an improvement of only 16.35 points ($p<0.01$). This agrees with the studies discussed above which also suggested that higher expectations are related to better treatment outcomes (Metcalfe and Klaber Moffett, 2005b; Goldstein et al, 2002; Kalauokalami et al, 2001). Due to this study being conducted in the USA the findings may not be easily generalised to a Scottish NHS sample, again suggesting that this area needs to be explored in a Scottish context. It also focused on expectations of outcome and not actual expectations of treatment, which may also be useful to explore. It does however suggest that expectation of treatment outcome may play an important role in actual treatment outcome, and therefore is an important area for physiotherapists to increase their understanding of.

In summary, expectations of and satisfaction with treatment for LBP share a complex relationship, suggesting that both should be explored. Although patients can hold expectations of both the treatment itself and the outcome of that treatment (Verbeek et al, 2004) much of the research in relation to LBP has focused on treatment outcome, suggesting that further work is required to understand patients' expectations of treatment itself. The available research suggests that LBP patients expect a diagnosis and instructions on back care from a professional with good interpersonal and communication skills, which will result in pain-relief. The available research also suggests that these expectations are frequently unfulfilled and patients dissatisfied with their care to some degree. However, few studies have focussed on LBP of chronic duration, and even fewer on the physiotherapy management of CLBP. This suggests that there is a gap in the current understanding of patients' expectations of physiotherapy for CLBP. Due to the relationship between expected and actual outcome presented above, further exploration of this important area could enhance physiotherapists understanding and management of CLBP.

2.2.3: Chronic Low Back Pain Patients' perceptions of patient-centred physiotherapy

2.2.3.1: What is patient-centred physiotherapy?

Although patient-centred healthcare is frequently referred to, and indeed aspired to (SEHD, 2005a), there appears to be a diversity of definitions of this term. For example, "care centred around patients needs" (SEHD, 2003, p8), "a relationship in which the patient is involved in decision-making, and the "person" rather than the "medical problem" is the focus of treatment" (Krupat et al, 2000, p50) and "an approach that consciously adopts the patient's perspective" (Gerteis et al, 1993, p5) have all been employed. Gillespie et al (2004) found that the patient being at the centre of the care process, information sharing and patient involvement in decision-making were common understandings of patient-centred care; however they argued that what these terms actually meant was not always clear.

There is no consensus on what patient-centred care means within a physiotherapy context. This was highlighted in a professional supplement which suggested that in the absence of a definition it is impossible to determine whether physiotherapists are providing patient-centred care (Blackledge, 2005).

In the absence of a clear definition relating to physiotherapy, the literature from the fields of nursing, occupational therapy and medicine are reviewed here, since definitions and concepts of patient-centred care have been developed in these fields. Some aspects of what is believed to be patient-centred care have been researched in physiotherapy, and these are therefore also reviewed. The need to further explore the concept of patient-centred physiotherapy for CLBP is discussed, and the methods by which this might best be carried out presented.

2.2.3.2: Concepts of patient-centred care

Nursing

Gerteis et al (1993) defined seven dimensions of patient-centred care, presented in table 2.2.1. These were derived from focus groups with recently discharged medical and surgical patients and their families in one city in the USA, telephone interviews with a further 50 patients and 50 friends/family from five other hospitals in the USA and focus groups with hospital staff. Whilst some of these dimensions may appear to be relevant to physiotherapy, because they were derived from hospital in-patents they might not readily generalise to CLBP patients attending out-patient physiotherapy.

Table 2.2.1: Seven dimensions of patient-centred nursing

Dimension	Description
1. Respect for patients' values, preferences, and expressed needs	Paying attention to quality of life, involvement in decision-making, dignity, and patients needs and autonomy
2. Co-ordination and integration of care	Relates to three areas of care: Clinical, ancillary & support, "front-line" patient care
3. Information, communication and education	Need for information in three areas: Clinical status, progress & prognosis, processes of care, self-care & health promotion
4. Physical comfort	Pain management, help with daily activities, adequate surroundings & hospital environment
5. Emotional support and alleviation of fear and anxiety	Anxiety related to clinical status, treatment & prognosis, impact of illness and financial impact of illness
6. Involvement of family and friends	In decision-making, as caregivers and recognising the needs of family & friends
7. Transition and continuity	Paying attention to information, co-ordination & planning and support

Source: Gerteis et al (1993)

West et al (2005) developed a questionnaire based on the seven dimensions presented by Gerteis et al (1993) to determine whether nurses experienced any barriers to providing care in these dimensions. They found that nurses perceived lack of time, tools (such as staff and equipment) and training to be barriers to patient-centred care as defined by Gerteis et al (1993), and that they specifically wanted training in communication, information giving, addressing patients anxieties and involving patients in their care.

Although the focus of both these studies was on acute in-patient nursing, they give some indication of the types of dimensions that patients might perceive as important, and some possible reasons for patient-centred care not always being provided. How these relate specifically to physiotherapy however is unknown, and further research would be required in order to determine which dimensions the professions have in common.

Occupational Therapy

Law et al (1995) reviewed the literature and defined six dimensions of client (patient) centred care relating to Occupational Therapy practice. These are presented in table 2.2.2. There are few similarities between this concept and that of Gerteis et al (1993). Autonomy/choice and respect for diversity (Law et al, 1995) perhaps encompass respect for patients' values, preferences and expressed needs (Gerteis et al, 1993). The lack of similarity may provide support for patient-centred care to be defined in relation to particular professional and/or client groups (Blackledge, 2005), and therefore highlights the need for patient-centred physiotherapy for CLBP to be explored. There is a key theme of decision making in the Occupational Therapy concept (Law et al, 1995) suggesting that the role this element may or may not play in relation to physiotherapy for CLBP would be important to explore.

Table 2.2.2: Six dimensions of client-centred care in Occupational Therapy

Dimension	Description
1. Autonomy/choice	Information provided to enable clients to make decisions, clients opinions sought by Occupational Therapists
2. Partnership & responsibility	Interdependent partnership between client and Occupational Therapist, client-determines goals and outcomes, Occupational Therapist facilitates decision-making
3. Enablement	Occupational Therapists enable clients to achieve goals, client decision-making facilitated
4. Contextual congruence	Assessment and interventions are individualised, clients roles, interests, environment and culture are respected
5. Accessibility & flexibility	Services meet the needs of the client
6. Respect for diversity	Clients values and opinions are respected

Source: Law et al (1995)

Medicine

The literature in this area may relate more easily to physiotherapy than that already presented, due to out-patient physiotherapy taking place in a primary care environment and much of the literature on patient-centredness in medicine being derived from primary care. Patient-centred care is not a new development in medicine, particularly within primary care. McKinstry, in 1992, suggested four possible doctor-patient relationships (autocratic, paternalistic, doctor as agent and patient yielding autonomy). He suggested that whilst most doctors act as their patient's agents, assessing how much explanation and /or involvement a patient wants should be an important part of the consultation.

Henbest and Stewart (1990) evaluated patient-centred care in 73 patients attending six family physicians in the USA. They defined patient-centred as "care in which the doctor responded to the patient in such a way as to allow the patient to express all of his or her reasons for coming to the doctor, including symptoms, expectations, thoughts and feelings" (p29). They used a validated method of measuring patient-centredness by scoring the doctors responses during audiotapes of patient consultations. The patients also completed a satisfaction scale and interview, with a telephone interview two weeks later. They demonstrated that a high patient-centred score rated in this way correlated with patients feeling their reasons for attending were discussed (Spearman's rank correlation coefficient 0.416, p=0.001), that their doctor understood the importance of the reason to the patient (Spearman's rank correlation coefficient 0.296, p=0.006), and that the doctor knew what the reason for coming was (Spearman's rank correlation coefficient 0.326, p=0.003). They also demonstrated that a high patient-centred score resulted in decreased concern about symptoms following consultation; 87.5% of patients consulting doctors with high patient-centred scores compared with 65.2% of patients consulting doctors with low patient-centred scores had decreased symptom concern (x^2 7.3, p=0.03). However, there was no association between patient-centredness and satisfaction. The authors attributed this to the low numbers of highly patient-centred consultations (only eight out of 46). However, it may reflect the complexity of satisfaction as an outcome (see section 2.2.1, p15). The 90% of patients who were "quite satisfied" with the consultation at the two week follow-up may have been satisfied with their care overall, but possibly not with some specific aspects of it which may (or may not) relate to patient-centredness. What this study does demonstrate is that one definition of patient-centred care can be rated and does impact upon patients' perceptions of their medical consultation.

Krupat et al (2000) surveyed 57 primary care doctors and 453 of their patients, exploring the effect of practice orientations (ranging from patient-centred to doctor-centred) on patient satisfaction. They measured practice orientation with the Patient-Practitioner Orientation Scale (PPOS), and patient satisfaction with a questionnaire, although a limitation of this study is that the reliability and validity of the PPOS is not presented. They defined patient-centred care as "characterised by the practitioner's desire for a relationship in which the patient is involved in decision-making and the "person" rather than the "medical problem" is the focus of treatment" (p50). They demonstrated that information sharing and decision-making were related with satisfaction, whereas patients' expectations, feelings and life circumstances were not. Satisfaction was high in situations where doctors and patients shared the same orientation (patient or doctor-centred; highest possible score 37.4% of the time), slightly higher when the doctor was more patient-centred than the patient (40.3%), but lower when the patient was more patient-centred than the doctor (24.6%). These findings suggest that patient-centred care is not *an approach* but needs to be flexible to the needs and wishes of the patient even if they want what is considered to be a doctor-centred approach to care.

Little et al (2001) employed a five-domain model of patient-centred care (Brown et al, 1995 in Little et al, 2001) involving exploring experience and expectations of disease and illness, understanding the whole person, partnership, health promotion, and enhancing the doctor-patient relationship. This was a large quantitative study based on questionnaire responses of patients waiting to be seen by their GP. The results demonstrated that communication, partnership and health promotion appeared to be the most important dimensions to the patients, and that most patients wanted a patient-centred approach. However, due to the nature of the questionnaire any dimensions outwith the five enquired about would not be disclosed. Therefore, the results indicate to what extent the patients agreed with the model of patient-centredness proposed in the study, but not to what extent alternative or additional dimensions may require to be incorporated into that model.

The three studies reviewed above employed different definitions of patient-centred care. Mead and Bower (2000) suggested that this lack of agreement on the concept of patient-centredness could delay developments in the field of patient-centred care and from an extensive review of literature conceptualised the term in relation to medicine, with most of the literature being drawn from primary care. They defined five key dimensions of patient-centred medicine which all relate to the doctor-patient relationship in some way. These are presented in table 2.2.3. There are some similarities between these dimensions and those of Law et al (1995), with the exception of the biopsychosocial perspective and "doctor-as-person", making this the first concept to consider the personal qualities of the healthcare provider.

Table 2.2.3: Five dimensions of patient-centred medicine

Dimension	Description
1. Biopsychosocial perspective	Considering and understanding all aspects of the patient, not just the organic disease
2. The "patient-as-person"	Understanding the individual patient's experience of illness within their own unique context
3. Sharing power and responsibility	Encouraging patients involvement in their care
4. The therapeutic alliance	Developing the doctor-patient relationship, for example empathy and congruence
5. The "doctor-as-person"	Awareness of the influence of the personal qualities of the doctor

Source: Mead and Bower (2000)

There is less agreement between Mead and Bower (2000) and the earlier work of Gerteis et al (1993) perhaps because Gerteis et al (1993) concentrated on more practical dimensions, whereas Mead and Bower (2000) define somewhat more abstract dimensions. Decision-making is also less explicit than in the Occupational Therapy concept (Law et al, 1995). The differences between the three professional groups again suggest that there is a need to define patient-centred care within the context of physiotherapy (Blackledge, 2005).

2.2.3.3: Physiotherapy and patient-centred care

The physiotherapist's perspective

Resnik and Jensen (2003) explored the phenomenon of expert physiotherapy in relation to the treatment of LBP amongst a small sample of physiotherapists. They concluded that expert practice was distinguished by a patient-centred approach to care. They presented four dimensions that contributed to that patient-centred approach, described in table 2.2.4. This patient-centred approach to LBP management rather than years of physiotherapy experience appeared to account for the differences in outcome between physiotherapists classed as expert or average by their patients' treatment outcomes.

Table 2.2.4: A patient-centred approach to physiotherapy

Dimension	**Description**
1. Knowledge	Multidimensional knowledge base, including listening, observation, professional education, clinical experience, continuing education & experience as a patient
2. Virtues/values	Ethic of caring, passion for clinical care, lifelong learning, humility, power of education, patient-therapist relationship
3. Clinical reasoning	Empowerment, collaborative problem solving, context of clinical practice (coach & teacher)
4. Clinical practice style	Emphasis on education, individualised care, regulation of support personnel

Source: Resnik and Jensen (2003)

This was a small qualitative study with six "expert" and six "average" physiotherapists interviewed regarding their approach to LBP management and overall practice philosophy. The extent to which these views relate directly to their actual interaction with patients was not evaluated in any way. However, it does give some insight into possible aspects of the physiotherapist, which could relate to the "doctor-as-person" dimension in the concept of patient-centredness presented by Mead and Bower (2000). Clearly this research focused on the physiotherapist's perspective and did not involve patients' views on either their physiotherapists' expertise or patient-centred treatment style. Patients' views could potentially have provided alternative findings and are arguably important to explore, particularly as patients' views are increasingly sought to evaluate and design services (SEHD, 2003; SEHD, 2001).

The patient's perspective

There appears to be a lack of literature on patients' views of patient-centred physiotherapy, possibly due to the diversity of definitions of patient-centred care already discussed. However, patients' views on various aspects of their physiotherapy which relate to one or more of the dimensions of patient-centred care in the concepts presented above have been explored. These studies are therefore now reviewed.

Payton and Nelson (1996) explored patients' perceptions of their involvement in goal-setting, treatment planning and evaluation of outcomes. This relates to the dimensions of "sharing power and responsibility" (Mead and Bower, 2000) and "partnership and responsibility" (Law et al, 1995). They involved 20 patients, seven of whom had musculoskeletal conditions, in short semi-structured interviews. Most patients felt they were not particularly involved in goal setting, some felt they played a role in treatment planning and most felt they were involved in evaluating the outcome of treatment.

Whilst this study described the extent to which patients were involved in these processes, assumptions were made about the extent to which patients should be involved. Therefore, it did not elicit patients' views on whether they felt involvement in these processes was relevant or important. Exploring patients' views on the extent to which they should be involved in goal setting, treatment planning and evaluating outcomes may help to define this dimension of patient-centred physiotherapy from the patient's point of view. This could in turn inform physiotherapists of the importance that patients, rather than physiotherapists, place on involvement in their care.

Payton et al (1998) expanded on their earlier study (Payton and Nelson, 1996) by exploring not only the extent to which patients were involved in decision-making, but also the extent to which they expected and wanted to be involved. Using a similar methodology to the previous study but with a much larger sample of 109 physiotherapy patients, they found that the physiotherapist made treatment decisions in 95% of cases. Forty percent of the sample had no preconceptions of the physiotherapist's role in decision-making, with almost half the sample expecting the physiotherapist to know what to do or to explain things to the patient. This suggests that the assumptions of the previous study (Payton and Nelson, 1996) that patients should be involved in treatment decisions may have been misplaced. They also demonstrated that most subjects either had no expectations of their own role in physiotherapy, or expected to be passive recipients (do as told/get help). Only 20% of patients felt that they made health care decisions, but 75% felt that there should not be a change in the decision-making power, suggesting that the majority of patients did not wish to be involved in decision-making. However, when asked specifically about physiotherapy-related decision-making, 68% would have liked more involvement in goal-setting and 47% in deciding upon treatments. This highlights the importance of ensuring patients understand the issues that are being enquired about, and that whilst they may want little involvement in many decisions, they might wish involvement in some more specific decisions. It may therefore be important for physiotherapists to determine the extent to which individual patients want to be involved in individual decisions. However, patients with varied diagnoses participated in this study; the proportion (if any) of LBP patients being unreported. Therefore, the extent to which these results would be replicated in CLBP patients is unknown.

Harrison and Williams (2000) found similar perceptions of decision-making amongst musculoskeletal physiotherapy patients. Whilst the five physiotherapists interviewed felt that patients were involved in decision-making, the five patients interviewed largely disagreed. They also demonstrated a mismatch in perceptions of power; physiotherapists perceiving a small imbalance in their favour, patients perceiving themselves as relatively powerless. Harrison and Williams (2000) suggested that the environment may be a factor, as they had previously described (Williams and Harrison, 1999), since the patients found the lack of privacy and time in an out-patient department to be disempowering. These results implied that patients wished a more equal power balance and to be more involved in decision-making. Clearly this was a small study focussing on power and decision-making, but the results suggest that this area should be further explored when considering patient-centred physiotherapy for CLBP.

The work on patients' perceptions presented above largely relates to decision-making; however, some other dimensions of patient-centredness from the concepts previously discussed have also been investigated. Ostlund et al (2001) interviewed 20 patients with neck, shoulder or low back disorders regarding their rehabilitation, for which many had experience of physiotherapy. Their subjects were young and of narrow age range (35 to 47) to be representative of the CLBP population, but their results give some insight to the dimensions of "therapeutic alliance" (Mead and Bower, 2000) and "information, communication and education" (Gerteis et al, 1993). Their main finding was that subjects placed great importance on supportive relationships in rehabilitation and the management of their life situation as a whole. Supportive relationships were those in which patients were treated as an individual, trusted, listened to, and asked for opinions. Conversely, a non-supportive relationship was one in which patients were treated as "one in the crowd" (p290), mistrusted, ignored, ordered by the professional or given a standardised treatment.

Ostlund et al (2001) proposed a "socioeconomic model of rehabilitation" (p290) from their subjects' perceptions. In this model there are two types of supportive and non-supportive relationship, depending on the extent to which rehabilitation is individualised or standardised. This results in four possible types of rehabilitation, presented in table 2.2.5, with a professional mentor arguably representing the "gold standard" of rehabilitation agent from the patient's perspective.

Table 2.2.5: Socioemotional model of rehabilitation

Rehabilitation agent	Qualities
Professional mentor	Supportive, Individualised treatment
Empathic administrator	Supportive, Standardised treatment
Distant technician	Non-supportive, Individualised treatment
Routine bureaucrat	Non-supportive, Standardised treatment

Adapted from Ostlund et al (2001) p290

Clearly communication is central to developing a supportive relationship, and Ostlund et al (2001) did find dissatisfaction with the communication skills of professionals among their sample of patients. Therefore, patients' perceptions of their relationship with the physiotherapist and of the physiotherapist's communication skills may be important to consider in any study of patients' perceptions of patient-centred care.

Trede (2000) similarly reported on the importance of the patient-therapist relationship and communication skills, this time in patients with LBP. Although a small pilot study with its focus on education of LBP patients by physiotherapists, the results are in agreement with those of Ostlund et al (2001). The eight patients interviewed said that communication skills were the most important factor for effective education, and patients overwhelmingly wanted their physiotherapist to listen to them and take them seriously. The patients wanted to be the focus of treatment and they valued a good relationship with their physiotherapist. Trede (2000) conceptualised listening to patients, displaying a positive attitude, providing support and opportunities to learn independently, planning exercises *with* patients and providing meaningful education as a patient-centred approach. By this definition, seven of the eight physiotherapists they interviewed did not demonstrate a patient-centred approach to education.

Although focusing on the education component of LBP, which is only one aspect of physiotherapy management for this condition, the study by Trede (2000) and that by Ostlund et al (2000) suggest potential areas of patient-centred physiotherapy that might be important to LBP patients, and are therefore important to explore in more depth.

Potter et al (2003a), reviewed above in relation to satisfaction (p17) based their study on the concept of patient-centred care presented by Mead and Bower (2000). They also found that the patients in their sample ranked communication skills as the most important quality of a good physiotherapist; specifically interpersonal skills, manner and teaching ability. The similar findings of these three studies (Ostlund et al, 2001; Trede, 2000; Potter et al, 2003a) highlights the important role that communication appears to play in patient-centred care.

In summary, various definitions of patient-centred care are in use in the literature. Whilst some authors have conceptualised patient-centred care in the fields of nursing, Occupational Therapy and medicine, there is no concept or definition of patient-centred care in physiotherapy that incorporates the patient's perspective, let alone physiotherapy for CLBP. However, the differences between the concepts presented by the three other professions suggest that there is a need to conceptualise the meaning of patient-centred care within the context of physiotherapy.

The research to date on physiotherapy patients' perceptions has centred on decision-making, communication and the patient-therapist relationship. These areas are compatible with three of the five dimensions from Mead and Bower's (2000) concept (sharing power and responsibility, the therapeutic alliance, the "doctor-as-person"), three of the six from Law et al's (1995) concept (autonomy/choice, partnership and responsibility, enablement) and only one of the seven from that of Gerteis et al (1993) (information, communication and education). This may mean that some of the previously suggested concepts are redundant within a physiotherapy context. Alternatively, it might mean that patients' perceptions of patient-centred physiotherapy require to be more broadly studied, in order to provide a more encompassing concept which perhaps includes aspects relating to the biopsychosocial perspective and the patient as a person (Mead and Bower, 2000).

The research on patients' perceptions above has all employed qualitative methods, mostly in the form of semi-structured or in-depth interviews. This is perhaps because qualitative research aims to "gain a thorough understanding of particular phenomena within certain contexts" (Grbich, 1999, p28), and therefore by employing such methods the phenomenon of patient-centred physiotherapy can be understood from the patient's perspective. Semi-structured interviews arguably allow more scope for patients to discuss aspects of their physiotherapy or patient-therapist relationship than pre-determined questions in a written survey questionnaire. Therefore, there is evidence to support the use of qualitative methods to further explore patients' perceptions of physiotherapy for CLBP.

2.2.4: Patients' perceptions of self-management of Chronic Low Back Pain

2.2.4.1: Introduction

Varied definitions of self-management, self-care and their related concepts appear in the literature. Self-care appears to be a multidimensional concept involving everything that people do to maintain health and prevent illness. This incorporates health-promoting behaviour, interacting with healthcare providers, adhering to treatment protocols, self-monitoring, and managing the effects of illness on functioning, self-esteem and relationships with others (Gruman and VonKorff, 1999). Self-care may therefore take place with or without the support of a healthcare provider.

Self-management is concerned with managing the day-to-day impact of a condition, which is often a lifelong task (Lorig and Holman, 2003). Self-management involves five key elements: problem-solving, decision-making, resource utilisation, forming a patient/healthcare provider relationship and taking action (Lorig and Holman, 2003). Defined in this way self-management is dependent on collaboration between the patient and healthcare provider (Bodenheimer et al, 2002a).

However, Blyth et al (2005), in a large population survey of people living with chronic pain, demonstrated that several self-management approaches were used by people, many of whom had no recent (within six months) use of health services. They found that passive strategies such as rest, massage and medication use were more prevalent than active strategies such as postural and relaxation techniques. The only active strategy in reasonably common use was exercise. Therefore, it is possible that some people with chronic pain do self-manage without visiting healthcare providers; it is those who do visit healthcare providers, specifically physiotherapists, that are the focus of this research.

Two other terms are frequently discussed in the literature; self-management support and self-management education. Self-management support is a collaborative approach that helps patients (and their families) to acquire the skills and confidence to manage their chronic condition, provides self-management tools (such as glucometers for diabetic patients), and routinely assesses problems and accomplishments (Bodenheimer et al, 2002b). Self-management education aims to "provide patients with the skills to live an active and meaningful life with their chronic condition" (Lorig, 2003, p699). Self-management education programmes are often based on self-efficacy theory and provide patients with problem-solving skills (Lorig, 2003). Self-management education is therefore seen as complimentary to traditional patient-education, which offers information and technical skills. (Bodenheimer et al, 2002a). Much of the work on self-management education has originated from Stanford University's chronic disease self-management programme (Lorig et al, 1999), on which the Expert Patient Programme in the NHS in England is based (Hawley, 2005). Arthritis, asthma and diabetes have been the topic of much research to date, although self-management education programmes aimed at people with LBP have also been evaluated (Moore et al, 2000; VonKorff et al, 1998).

Both self-management education and self-management support shift the emphasis towards patients as their own caregivers. However, healthcare professionals need to inform, activate and assist patients in their self-management (Bodenheimer et al, 2002a). The difference between the two is that self-management education is an intervention, which may be completed within seven weeks (Lorig et al, 2001), whereas self-management support may be a more ongoing process (Bodenheimer et al, 2002a).

2.2.4.2: Evidence to support self-management interventions

A review of self-management interventions for people with chronic conditions (Barlow et al, 2002) concluded that most interventions demonstrated positive outcomes in the short-term. Such outcomes were increased knowledge, self-efficacy and the use of self-management behaviours, with some studies reporting improved mood. Most of the studies reviewed concerned people with asthma, diabetes or arthritis, although two each on chronic pain and back pain were included. Warsi et al (2003) reviewed self-management programmes for arthritis only, finding similar results; small but significant improvements in pain and disability were demonstrated. Nolte et al (2007) in a large questionnaire-based study in Australia investigated the impact of chronic disease self-management courses on over one thousand participants. They used a health education impact questionnaire, and therefore evaluated the educational outcomes rather than the effect on pain or disability. Approximately one third of participants reported substantial improvements, particularly relating to "skill and technique acquisition" and "self-monitoring and insight". This would suggest that the self-management courses were achieving their primary aim of enabling participants to monitor their condition and provide them with tools to self-manage. However, the questionnaires were completed at the last session of the self-management courses; therefore no information on the sustainability of these outcomes is provided.

Despite these promising results there are several areas that require attention. The theoretical model underpinning self-management interventions is not always defined (Newman et al, 2004; Cooper et al, 2001). Models that have been used include social learning theory, cognitive-behavioural models and educational models, however whether one is superior to the others is as yet unknown (Newman et al, 2004). The use of group or individual delivery has not been researched in-depth and the relative efficacy of health-professional or lay-led interventions is not established (Newman et al, 2004).

2.2.4.3: Need for changes to existing services

Current guidelines on LBP management stress the importance of the patient's role in self-management (Bekkering et al, 2003). This is in keeping with current political drivers for enhancing self-management of chronic conditions. The Scottish Executive emphasised the need for self-management in its recent plan for the NHS in Scotland (SEHD, 2005a), with figure 2.2.1 showing the role of self-care within the overall model for supporting individuals with long-term conditions. Therefore, it is envisaged that self-management will play an important role in long-term conditions such as CLBP. In the absence of a cure for CLBP and in order to adhere to the most recent physiotherapy guidelines (Bekkering et al, 2003), it would appear that physiotherapists need to be involved in assisting patients to self-manage their CLBP.

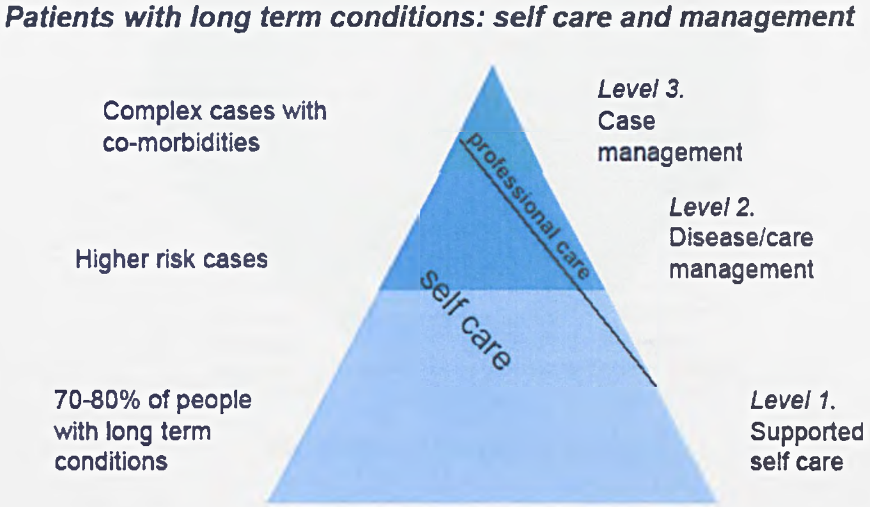


Figure 2.2.1: Self-care and management of long-term conditions Reproduced from Scottish Executive Health Department (2005). Delivering for health pp19

Wagner (1998) suggested that primary care services need to change in order to improve care for patients with chronic illness. He developed the chronic care model (figure 2.2.2), which has self-management support as an integral component. Figure 2.2.2 shows that care of patients with chronic conditions takes place within three overlapping areas: the community, the healthcare system and the individual organisation (for example clinic). It then illustrates six key elements within these overlapping areas that are essential for chronic care: community resources and policies, health care organisation, *self-management support*, delivery system design, decision support, and clinical information systems. Since this is a model developed for the American healthcare system there may be differences within a UK context. Nonetheless, it serves to illustrate the importance of self-management in contributing to the overall goal of enhancing clinical outcomes and outcomes related to functioning in chronic conditions.

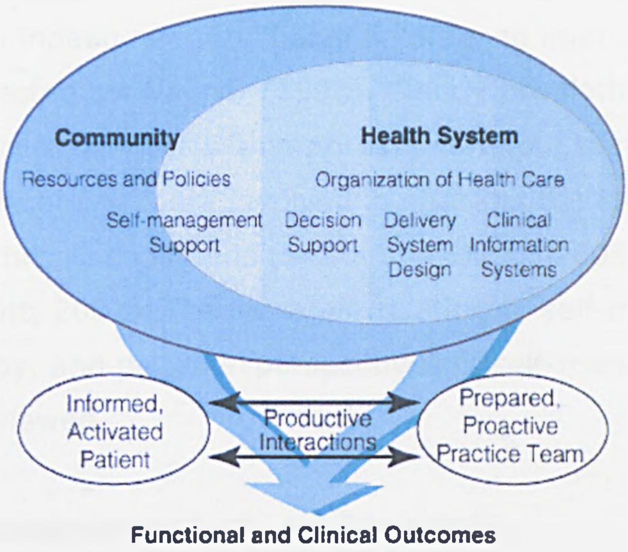


Figure 2.2.2: Chronic care model for improvement of chronic illness care Reproduced from Wagner (1998). What will it take to improve care for chronic illness, *Effective Clinical Practice,* 1, pp2-4, with permission from the American College of Physicians

Rogers et al (2005) reached similar conclusions on the need for changes to services in their mixed methods study on self-management of inflammatory bowel disease in the UK. The self-management intervention being researched resulted in fewer hospital admissions and an enhanced perception of self-management skills by participants. However, the qualitative arm of their study suggested that there were some barriers to self-management in the consultant-led outpatient service. These included the practice style of the consultant, since some viewed self-management as compliance with medical instructions rather than in its wider context. However, organisational issues such as time, disruptions to consultations and the patient not always seeing the same health professional at each clinic attendance were seen as negatively affecting the promotion of consultations which could enhance self-management. Therefore, it appears that services may benefit from redesign in order to create an environment in which it is more feasible to facilitate self-management activities.

Some patients with CLBP will attend pain management programmes, which are usually based on cognitive-behavioural theory and include elements of self-management education (for example Dysvik et al, 2004; Walsh and Radcliffe, 2002). However, it is unlikely that all CLBP patients will have access to such services (Smith and Elliott, 2005). Therefore, other primary care services may indeed need to change in order to improve care for CLBP patients, as suggested by Wagner (1998). Clearly physiotherapy is one of a number of healthcare services within primary care, but perhaps one which is well suited to becoming more involved in enabling the long-term management of chronic conditions (Smith and Elliott, 2005), in particular LBP (Klaber Moffett, 2002). The literature relating to self-management and LBP, physiotherapy, and patients' perspectives of self-management is therefore now reviewed.

2.2.4.4: Self-management and Low Back Pain

Various methods of encouraging self-management in LBP patients have been evaluated. These range from the practice style of physicians during consultations (VonKorff et al, 1994), to the efficacy of a self-help book (Udermann et al, 2004), to group-based self-management programmes delivered by lay-people (VonKorff et al, 1998), professionals (Moore et al, 2000) and over the internet (Buhrman et al, 2004). All have demonstrated, usually modest, improvements in outcomes in comparison to "usual care" or waiting list controls.

However only one study (Buhrman et al, 2004) of an internet-based cognitive-behavioural treatment programme has exclusively studied LBP of chronic duration, and none of the above-mentioned studies involved patients receiving physiotherapy. This suggests that the results of these studies can not be generalised to the CLBP population receiving physiotherapy for their condition; encouragement of self-management may conceivably mean something different in this context. Additionally, the uptake rates by self-selected participants of the interventions mentioned above have varied from 80% (Moore et al, 2000) to 68% (Von Korff et al, 1998), suggesting that the interventions may not have generic appeal. It may therefore be pertinent to explore CLBP patients' perceptions of their need for self-management interventions and their preferences in terms of delivery, as suggested by Cooper et al (2001). Indeed, it was recently suggested (Jordan and Osborne, 2007) in Australia that there is a need for "a suite of self-management education interventions that are flexible and cater for the patients needs..." (p 86), further supporting the exploration of patients' perceived needs and preferences.

2.2.4.5: Self-management and physiotherapy for Chronic Low Back Pain

Although facilitating patients to self-manage is a recommended part of physiotherapy for CLBP (Bekkering et al, 2003; Klaber Moffett, 2002), there appears to be a lack of literature evaluating this area of practice.

Miller et al (2004) compared video-based teaching of exercises to face-to-face teaching by the physiotherapist in a large sample of patients with shoulder or LBP. They demonstrated no differences between the groups in terms of clinical outcomes, measured using valid and reliable tools at four to six weeks following commencement of treatment. This would suggest that self-exercising using videotapes is as effective as exercising with the physiotherapist. Moreover, they did report that the patients who received the videotape were more skilled in performing the exercises and that patients were satisfied with the videotapes. However, contact time for both groups was equal, with LBP patients attending 3.8 - 4.4 sessions, equating to 1.61-1.81 hours of physiotherapy contact time. Perhaps this means that exercising was a relatively small part of the treatment for these patients, and that they required physiotherapy contact for other treatment modalities. It is not documented what other treatments the patients received during their physiotherapy contact time, or indeed the chronicity of the LBP patients. Therefore, this study was not a direct comparison of self-management with usual care, but it does suggest that one part of usual physiotherapy for LBP (exercises) might be delivered equally effectively as a self-management intervention. The long-term effectiveness of video-based exercises in facilitating self-management was not evaluated in this study, but would perhaps be a relevant area to explore.

Klaber Moffett et al (2005) compared a brief physiotherapy intervention based on cognitive behavioural principles to encourage self-management (lasting for 1-3 sessions) with usual physiotherapy (duration not specified) in patients with neck pain. Although the focus of this study was not LBP, the results may be relevant to the self-management of CLBP due to the study's aim of enhancing activity and participation which is often the aim of CLBP interventions (Bekkering et al, 2003). They demonstrated greater improvements in outcome measures for the usual care group compared to the brief intervention group, suggesting that the brief intervention was not as effective as usual physiotherapy. The between-group differences were small, but statistically significant nonetheless. They did however demonstrate that treatment preference influenced patients' outcomes, with those who both wanted and received the brief intervention achieving the greatest improvements. This was not statistically significant, but given the evidence for expectations affecting treatment outcomes discussed previously (section 2.2.2.3, p23), it might suggest that carefully selected patients could benefit from such a treatment approach.

2.2.4.6: Patients' perceptions of self-management

Jerant et al (2005) conducted focus groups with 54 people presenting with more than one chronic condition (commonly diabetes, arthritis, depression and congestive heart failure) in order to understand the barriers to self-management in this population. They found that there were several barriers to adopting active self-management techniques, based on Lorig and Holman's (2003) definition of self-management described above. The barriers were depression, weight problems, difficulty in exercising, fatigue, poor communication with doctors, lack of support from family/friends, pain, and financial problems. They also found the following barriers to accessing self-management services and resources: lack of awareness, physical symptoms, transport problems and financial restraints. Most of the participants *wanted* access to self-management resources, suggesting that patients as well as health professionals realise the importance of self-management in chronic conditions.

Jerant et al (2005) interpreted these results as providing support for developing a home-based self-management education programme. However, their results could be used to inform the design of any self-management intervention. CLBP patients were not the focus of this study, and further work to establish whether similar barriers exist within the CLBP population would require to be carried out prior to generalising the results, but they do suggest areas for exploration.

Some studies of LBP patients have also suggested that there is a desire for elements of self-management support or education. For example, McCarthy et al (2005) (see p21 for further details of study) demonstrated that spinal patients attending a pain management programme wanted follow-up after discharge, which has been described as an integral part of self-management by Gruman and Von Korff, (1999). McCarthy et al (2005) however also demonstrated a low correlation between expectation of and satisfaction with follow-up (Spearman's rank correlation coefficient 0.44, $p<0.001$), suggesting that this expectation was not commonly fulfilled.

Layzell (2001; discussed in section 2.2.1.4, p18), demonstrated that their focus group participants wanted information, including telephone numbers for support groups, in order to reduce the risk of further episodes of LBP. This would suggest that they were willing to participate in active self-management, since resource utilisation is considered an integral component of active self-management (Lorig and Holman, 2003).

Potter et al (2003b; see section 2.2.2.4, p24) also demonstrated an expectation amongst a high proportion of private physiotherapy patients of being shown self-management strategies as part of their treatment. Although the conditions for which patients were being treated were not reported in this study, these results and those from the previous studies suggest that patients want and expect self-management to at least be a part of their physiotherapy. To what extent this is being delivered however, and the efficacy of any such interventions remains to be established. Taylor et al (2002) did pilot the use of telephone advice to LBP patients during their wait for an out-patient physiotherapy appointment. Patients in the group receiving the telephone advice were more satisfied with their physiotherapy than those who did not receive advice whilst waiting for their appointment (satisfaction rating 74.16 out of a possible 80 compared to 63.39 for the control group, $p<0.001$). Subjects reported that the telephone advice had helped them to get better, although most still attended for their physiotherapy appointment. Aside from the subjective rating of satisfaction however, outcome in terms of pain or disability was not measured, therefore no conclusions on the efficacy of the telephone advice can be made. Satisfaction and actual outcomes are not always related, as discussed previously (section 2.2.1). However this study does illustrate the acceptability of telephone advice to a group of LBP patients. The chronicity of symptoms is not described by Taylor et al (2002); therefore it is not known how many patients with chronic symptoms were being encouraged to self-manage or whether this intervention was designed to help those with acute symptoms which may be expected to rapidly resolve (Waddell and Main, 1998). Therefore, the potential of telephone advice in CLBP patients can not be concluded, but may be worthy of investigation.

In summary, self-management clearly has a role to play in CLBP, and physiotherapists may be well placed to facilitate self-management by providing both education and support to patients. The method by which this should be done however is not firmly established, and the potential for self-management education programmes and /or self-management support being provided by physiotherapists in primary care has not been evaluated. Patients appear to want aspects of both self-management education and support, and it has been suggested that patients should be included in the design of interventions (Cooper et al, 2001). However, studies focusing on patients' perceptions of self-management of CLBP are lacking, suggesting that this is a priority in terms of research.

2.2.5: Importance of activity and participation

2.2.5.1: Introduction

According to the ICF function refers to "physiological functions of body systems" (WHO, 2001, p10). Impairments in these body systems can lead to *activity limitations*, defined as "difficulties an individual may experience in executing activities" (WHO, 2001 p10) and *participation restrictions*, defined as "problems an individual may experience in involvement in life situations" (WHO, 2001, p10). *Functioning* is the positive umbrella term relating to body functions and structures, activities and participation. Conversely, *disability* is the term used when one or more of the following are present: Impairments in body functions and structures, activity limitations, or participation restrictions. Activity limitations and participation restrictions are referred to in some of the more recent literature relating to physiotherapy for CLBP (Grotle et al 2004; Bekkering et al, 2003). However, much of the literature refers to the term "function" when describing activity limitations and participation restrictions. Although perhaps not strictly correct in the context of the ICF, this reflects that the common language of the ICF was not in use in much of the earlier research.

2.2.5.2: Importance of activity and participation to physiotherapists

Activity and participation is of great importance to physiotherapists in relation to the management of CLBP patients. This is evident in practice guidelines, the development of treatment programmes and outcome measurement. According to Dutch guidelines on LBP management, the examination of LBP patients "should be focused on abilities and participation, instead of finding a physical cause for the back pain" (Bekkering et al, 2003 p87). In addition, these guidelines also state that "the main objective of treatment for LBP is a return to the highest (or desired) level of activities and participation." (Bekkering et al, 2003 p88). Numerous treatment programmes have been developed in recent years with the specific aim of addressing activity limitations and participation restrictions, one example is that developed by Klaber Moffett and Frost (2000). In addition, measures of disability which focus on activity limitations and participation restrictions due to impairments (pain) are widely recommended as outcome measures with CLBP patients. Examples are the Roland Morris LBP disability questionnaire (Roland and Morris, 1983), the Oswestry Disability Index (Fairbank et al, 1980) and the Quebec Back Pain Disability Scale (Kopec et al, 1995). It is therefore evident that activity and participation are important to physiotherapists treating CLBP patients in several ways and that they influence assessment, treatment and measurement of outcome in this client group. However, the emphasis in this study is on the patient; therefore the importance of activity and participation to the CLBP patient is now considered.

2.2.5.3: Importance of activity and participation to Chronic Low Back Pain patients

CLBP patients do present with activity limitations and participation restrictions (Porter-Moffitt et al, 2006) and therefore these limitations are often the focus of treatment. However, patients also present with pain and often expect pain reduction to be the focus of treatment, as discussed earlier (section 2.2.2). How important then are these activity limitations and participation restrictions to CLBP patients?

Some qualitative studies that have explored the personal experience of LBP have suggested the importance of activity and participation and the impact of limitations and restrictions in LBP patients. For example, Borkan et al

(1995) conducted focus groups, individual interviews and participant observation with LBP patients in Israel, in order to understand LBP from the patient's perspective. Two of their six themes that arose during data analysis were related to function, which in their study was the term used to describe activity and participation. Firstly they suggested a five-tier classification system for LBP, ranging from background to hyper-severe pain, based on characteristics that patients discussed. These were pain synonyms (e.g. back tension in background pain, terrible pain in hyper-severe category), treatment, duration, and function. Function ranged from normal activity/ "live with it" in the background pain category to cease all work/activities and "can't move" in the hyper-severe pain category. The second function-related theme was consequences, which incorporated limitation. Limitation related to parenting, housework, gardening, employment and community involvement, and was often associated with anxiety at not being able to participate fully. This study was carried out in Israel, with the participant observation taking place in kibbutzim, which would limit its generalisation. However, the fact that patients defined their LBP partly in terms of activity limitations and participation restrictions and discussed the consequences of these limitations suggests that both are of importance to them.

Osborn and Smith (1998) conducted an interpretative phenomenological analysis on the meaning of pain with nine female pain clinic patients. These patients also discussed activity limitations and participation restrictions, in particular they compared themselves to others of the same age, and to their previous selves (prior to having LBP) and projected future selves. The women described not being able to do the things they felt they should be doing, and not being able to function at the level they previously did. Some felt that LBP denied them the pleasure of participating in leisure activities and many felt despair and were pessimistic about their future capabilities. These were patients from a secondary care pain clinic, who may conceivably have a different presentation from those being seen by physiotherapists in primary care. However, this small study again suggests that activity and participation is important to patients, since they discussed limitations and restrictions without specific questioning.

Cook and Hassenkamp (2000) conducted another small qualitative study with seven subjects, but this time with primary care patients who had attended a back rehabilitation group. The focus of the study was on the experience of rehabilitation and ability to self-manage following physiotherapy, but the experience of having CLBP itself was also enquired about and a theme relating to quality of life briefly presented. The interviewees in this study described their quality of life as having been affected in terms of activities that they had been forced to stop, such as socialising. This would be considered a participation restriction in the ICF model (WHO, 2001). However, a limitation of this study is that the effects of LBP on any other activities were not presented in this study.

Layzell (2001, see section 2.2.1.4, p18 for full discussion) did describe the activity limitations of eight focus group participants. They also had limitations related to socialising, but in addition discussed limitations related to parenting, housework and gardening, also found by Borkan et al (1995) discussed above. They found that some participants had given up sports and physical activities, also documented by Osborn and Smith (1998). In addition, participants discussed other practical limitations such as shopping, "do-it-yourself" jobs around the house and even getting out of bed and getting dressed. Participants were not asked specifically about activity limitations, but were asked about the consequences of back pain. Therefore, that they freely discussed activity limitations again suggests that they were in some way important to this small group of people with LBP.

In summary, patients with CLBP present to physiotherapists with both activity limitations and participation restrictions. These limitations and restrictions are usually the focus of assessment and treatment by physiotherapists and treatment efficacy is often measured in terms of the effect on these limitations and restrictions. However, research that explains from the patient's perspective the importance of activity and participation and the effect of activity limitations and participation restrictions is surprisingly limited. Therefore, in order to understand whether the activity limitations and participation restrictions that CLBP patients present with are perceived as important by the patients, and to explore what these limitations and restrictions are and their consequences, it will be necessary to conduct further research in this area. By furthering the understanding of activity limitations and participation restrictions from the CLBP patient's perspective, physiotherapists will be able to target individual interventions appropriately and ensure that appropriate measures of outcome are employed.

2.2.6: Summary of literature review

The purpose of this study was to elicit the views of CLBP patients' on expectations of physiotherapy, patient-centredness, self- management, and the importance of activity and participation. The preceding literature review has presented current knowledge in each of these four areas and highlighted gaps in the knowledge base where further research would be beneficial.

The literature reviewed has demonstrated that patient satisfaction is a complex and multidimensional variable, individual to both the patient and the setting in which it is measured. However, it has highlighted that little research has been conducted to date on satisfaction with physiotherapy for CLBP.

The literature review has also demonstrated that satisfaction with and expectations of treatment share a complex relationship where one does not represent the other. It has demonstrated that most of the research to date has focused on expectations of the outcome of treatment, rather than expectations of the actual treatment process itself. It has also highlighted that few studies have been conducted on LBP of chronic duration and even fewer on the physiotherapy management of CLBP.

The literature review has also demonstrated that there is presently no definition of "patient-centred physiotherapy" and that the relevancy of concepts of patient-centredness from other professional groups is not known.

The literature review has also demonstrated that research on patients' perceptions of self-management of CLBP is lacking.

Finally, the literature review has demonstrated that although activity limitations and participation restrictions are at the cornerstone of CLBP assessment, treatment and measurement by physiotherapists, literature regarding CLBP patients' views on these dimensions is sparse.

By further exploring each of these areas from the patient's perspective, where current research is lacking, understanding of patients' needs in terms of physiotherapy management will be enhanced and services redesigned appropriately, taking account of the perceived needs of the patients whom they seek to serve.

Throughout the literature review it has been demonstrated that qualitative methods will be best suited to fulfilling the overall aim of the study: using patients' opinions to inform the development of patient-centred interventions aimed at optimising activity and participation and supporting self-management. The following section (2.3) outlines the research questions designed to contribute to the knowledge of patients' perceptions of the key areas outlined above.

In order to answer the research questions presented in chapter 1 (p12) a qualitative interview study employing the Framework method of data analysis was conducted. The choice of this methodology is described and justified here.

2.3: Methodology

2.3.1: Introduction

Chapter one introduced the overall design of this thesis, explaining that the most appropriate methods were chosen for answering the research questions involved in the two studies. In this study, the research questions concerned CLBP patients' perceptions of physiotherapy. It might be possible to answer such questions using a quantitative design similar to that employed by George and Hirsch (2005), who studied satisfaction with physiotherapy for low back pain using self-completed postal questionnaires subjected to statistical analysis. However as discussed in section 2.2, this type of methodology explores views of physiotherapy predetermined by the researcher, in the case of George and Hirsch (2005) satisfaction with symptoms was explored, and not any other views that might be of importance to the patient. In a study of patients' perceptions the views of patients on areas not predetermined or expected by the researcher to be important might provide valuable understanding of the topic area. Qualitative methods are often aimed at exploring the experiences and perceptions of research participants (Cresswell, 2003; Polgar and Thomas, 1999); therefore it was decided that qualitative methods were most appropriate for this study.

2.3.2: Qualitative Research

Qualitative research has many and varied definitions in different texts. However, Denzin and Lincoln (1994) defined qualitative research as:

> *"...multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them."* (Denzin and Lincoln, 1994, p2)

A number of perspectives and theoretical underpinnings are incorporated within qualitative research (Gibson and Martin, 2003), however they have three broad methodological principles in common; naturalism, focus on meaning and understanding, and flexible research strategies (Green and Thorogood, 2004). Naturalism involves studying phenomena in a real life context as opposed to manipulating the research environment. The focus on meaning and understanding is from the participant's perspective, and although qualitative studies do require planning, they also must remain flexible to change as the study progresses. For these reasons qualitative research is particularly useful for studying and understanding the perspectives of participants, who are in this study CLBP patients.

2.3.3: Qualitative research in Physiotherapy

In the 1990's qualitative research was not generally recognised within physiotherapy as a credible methodology, and several authors argued for it to become more widely accepted (Ritchie, 1999, Shepard et al, 1993). However, it is now seen as a methodology that can both contribute valuable evidence to patient care and form an integral component of evidence-based practice (Gibson and Martin, 2003). This is evident in the studies published in the field of low back pain alone (for example Potter et al, 2003a; May, 2001; Trede, 2000).

2.3.4: Qualitative methodology in this study

As discussed above, qualitative methodology incorporates a number of perspectives and theoretical underpinnings (Gibson and Martin, 2003). The approach taken within this study was influenced by that developed for applied social policy research (Ritchie and Lewis, 2003). This has its roots in subtle realism in which there is a belief that the social world can only be understood from study participants' interpretations of it, but that there is a diverse "reality" that can be "captured" (Snape and Spencer, 2003). A key feature of this approach is that although qualitative methods are employed, a number of factors traditionally associated with quantitative design influence the research process (Snape and Spencer, 2003). These include striving for neutrality in the data collection, interpretation and presentation of qualitative data, and a consideration of reliability and validity. However, interpretevism and pragmatism are also key factors of this approach. Interpretevism in this context is reflected in obtaining understanding from the perspectives of the study participants. Pragmatism refers to the pragmatic approach adopted in selecting the research methods; pragmatic being defined as "dealing with things in a practical rather than theoretical way" (Hoanes and Hawker, 2005). Hence in this approach the best methods are chosen to address the specific research question of interest (Snape and Spencer, 2003). Applied social policy research uses the knowledge gained in research studies to understand an issue or influence change in policy (Ritchie, 2003). In this study, the overall aim was to understand patients' perceptions of their physiotherapy experience in order to influence service redesign; therefore the similarity in the objectives of this research with that of applied social policy research was influential in selecting this approach. The specific methods chosen for sample selection, data collection and analysis are presented and justified in sections 2.4 and 2.5 which report on the pilot and full stages of this research respectively.

2.4: Pilot study

A small study was undertaken to pilot the methods of recruitment, data collection and analysis proposed for the full study. The results of this pilot study are presented here and their implications for the design of the full study considered.

2.4.1: Study design

The aim of this study was to explore several aspects of patients' perceptions of their physiotherapy management. Due to this exploratory nature, and the desire to describe and explain patients' perceptions, an interview-based study design was used. Questionnaires were initially considered, but it was concluded that they were of limited use in this study due to the difficulty of eliciting "rich" information from questionnaires (Bryman, 2004, p134). Focus groups were also considered unsuitable since the individual perceptions and attitudes of each patient were of interest, and may be lost in a group setting (Bryman, 2004, p360). Interviews can take many forms depending on the nature of the enquiry (Green & Thorogood, 2004, p80). It was felt for this study that a semi-structured interview was most suitable; there were some specific topics that required addressing in order to answer specific research questions, but within these topics there needed to be some flexibility of what was actually discussed. Due to this, face-to-face interviews were considered most suitable, since it could be difficult to conduct this type of interview on the telephone. The NHS Grampian Research Ethics Committee granted ethical approval for all stages of the study on 17.08.04 (Appendix 1).

2.4.2: Population

The population of interest was people who had received physiotherapy treatment for CLBP in Grampian within the previous six months.

Definition of Chronic Low Back Pain

The definition of chronicity used by the International Association for the Study of Pain (IASP) was adopted here; therefore an episode of LBP lasting longer than twelve weeks was defined as chronic (IASP, 1986). This is in keeping with many current LBP researchers (for example Lewis et al, 2005; Niemisto et al, 2003). A further definition of LBP is found in the literature: that of recurrent LBP, defined as several episodes of LBP within one year, the total duration of which amounts to less than six months (Von Korff, 1994). Since there may be some overlap between these two definitions, and for simplicity, people who fulfilled either definition were referred to as having CLBP for the purposes of this study. There was a lack of reliable methods of sub classifying CLBP patients at the time of commencing this study (see Fritz et al, 2006; O'Sullivan, 2005 for ongoing work in this area).

Therefore, it was decided to adopt the commonly used definition of non-specific CLBP, in keeping with many other LBP researchers (Kappa et al, 2006; Jousset et al, 2004; Niemisto et al, 2003). This defines LBP as LBP, with or without leg pain, which can not be given a specified physical cause (such as herniated intervertebral disc, trauma, infection or tumour). This comprises a typical group of CLBP patients managed by outpatient physiotherapists and of interest in this study.

Time span

The study aim was to explore the perceptions of CLBP patients regarding their most recent physiotherapy experience and their needs, preferences and suggestions for patient-centred physiotherapy that supports self-management. Therefore, the patients sampled needed to have some recall of their recent physiotherapy experience, but also needed to have had some time since discharge to be able to comment on the self-management aspects. It was decided that sometime within the previous six months was a reasonable compromise between the two, where patients would hopefully recall the encounter in sufficient detail but would also be able to comment on their experience since discharge.

2.4.3: Sample

Inclusion criteria

Participants who were aged 18 to 65 and who had received physiotherapy for non-specific CLBP within the previous six months were included. CLBP affects all age groups (Webb et al, 2003); therefore a broad age range was necessary. However, CLBP and its management in the young (under 18) and older (over 65) populations may have specific age-related considerations, and are often managed outwith the routine outpatient physiotherapy setting. For these reasons these groups were considered outwith the scope of this study. Participants who had received physiotherapy within the previous six months were included as discussed above (2.4.2).

Exclusion criteria

Participants were excluded if they were currently receiving treatment for CLBP and if they were currently involved in CLBP research. It was felt necessary to exclude patients if they had been re-referred to physiotherapy for treatment of their LBP due to the self-management aspect of the study and the need to select participants who had some experience of being self-managing. Participants who were involved in other CLBP research might have particular prior knowledge that could have affected their views; they were therefore excluded.

2.4.4: Location

All participants were recruited from one physiotherapy department in Aberdeen City, for convenience.

2.4.5: Sampling strategy

Four pilot interviews were conducted during November 2004 with the participants described in table 2.4.1. All participants were recruited by post from one physiotherapy department in Aberdeen City. Participants were identified from physiotherapy discharge files. Nineteen patients who had attended at least two physiotherapy sessions and for whom the GP and/or physiotherapist had diagnosed non-specific CLBP were identified. The physiotherapy notes were read to ensure the diagnosis and management had not changed during the course of physiotherapy. Identified participants were then contacted by letter (Appendix 2), inviting them to read the study information sheet (Appendix 3) and consider taking part in the study. Those who were interested returned a reply slip in a pre-paid envelope stating their interest and intimating suitable days and /or times for the researcher to contact them by telephone. It was felt that a letter was a suitable form of first contact since clearly physiotherapists were no longer in contact with the patients. Therefore, a letter could explain how and why the researcher was able to obtain the participants' names and addresses, and allow them ample time to consider the invitation, which initial telephone contact could not have allowed for. On receipt of a positive response, the researcher contacted the participant by telephone to discuss the study further. During this telephone call the researcher also answered any questions, ensured that they fulfilled the inclusion and exclusion criteria and where appropriate arranged a suitable day and time for the interview to take place. Four replies were received from the participants described in table 2.4.1.

Table 2.4.1: Pilot interview study participants' characteristics

Participant	Age	Gender	History of CLBP
P01	58	F	Chronic recurrent, 8 years duration. Recent flare-up.
P02	51	M	Chronic recurrent, 4 years duration
P03	61	F	Chronic recurrent, 20 years duration
P04	34	F	Chronic recurrent, 3 years duration. Currently pain-free.

2.4.6:Consent

Each volunteer had the opportunity to read the study information sheet (Appendix 3) prior to deciding whether or not to take part in the study. When they agreed to participate, the interview was arranged for at least two days time, but usually about one week, giving time for the participant to change their mind and withdraw if they wished. All participants provided written consent (Appendix 4) prior to the interview being conducted.

2.4.7: Instrumentation

Semi-structured interviews were conducted with each participant, and were recorded and transcribed verbatim. An interview schedule was constructed and subjected to peer-review within the School of Health Sciences, The Robert Gordon University. Some minor amendments were made following feedback from the peer-review. The final version (Appendix 5) ensured that the main topics of enquiry were explored in each interview but it was not strictly adhered to in terms of sequence or precise wording of questions. Interviews were conducted in the homes of two participants, in one health centre clinic room and one hospital conference room, according to the participant's preference.

2.4.8: Data analysis

Data was managed using NVivo, a computer-assisted qualitative data analysis software package. The method of data analysis was Framework (Ritchie and Spencer, 1994). Framework analysis is described in full in section 2.5, but in brief it involves five main stages: Familiarisation with the data, identifying a thematic framework, indexing the data, charting the main themes and finally interpreting the data. Due to the pilot nature of this study and the very small sample size a full thematic analysis including the explanatory stage was not conducted; instead a largely descriptive analysis was conducted. This was sufficient to indicate whether the research questions could be answered using the chosen methods.

2.4.9: Findings

Six key themes were identified (table 2.4.2.), each containing several sub themes. These themes contributed to two wider areas or concepts, as follows:

1. What patients expect physiotherapy to achieve (expectations)
2. Key aspects of the patient-therapist relationship (advice, communication, self-management, satisfaction)

Functioning contributed to both concepts.

Table 2.4.2: Themes identified in pilot interview study and their definition

Theme	Definition of theme
Advice	Advice received or considered missing
Communication	Issues relating to patient-therapist communication
Self-management	Issues relating to self-management
Expectations	Motivation for attending physiotherapy, patients' expectations and goals of treatment.
Functioning	Activity limitations & Participation restrictions
Satisfaction	Satisfaction with physiotherapy treatment, with individual therapists and other factors

What patients expect physiotherapy to achieve

Only one participant requested to be referred to physiotherapy, the others were persuaded by their GP to attend. Two participants had attended their GP to specifically request interventions (x-ray or injections), to be informed that they had to go to physiotherapy first. This may have affected their expectations and their physiotherapy experience, and re-emphasises the important role that GP's can play in influencing patients' expectations. None of the participants cited relief of pain as an expected outcome. They largely wanted to understand their back problem and what they could do for it.

> "*... I wanted to find out exactly if it was a problem with my back or muscles... that's really what I wanted to know, to know if it was something that was internal*"
> (Participant P02)

> "*... I just actually would like to understand what happened to my back...If were the bones, or if were the muscles, or if there were nerves, you know, what was involved, why I had this sore back*"
> (Participant P04)

> "*I didn't think it would actually get rid of it [pain]...But I was feeling, well maybe I would get some ideas of, really what I was doing wrong... I thought I'd maybe, well get some other kind of tips and that*" (Participant P03)

Other expected outcomes were related to activity and mobility, as this participant demonstrated.

> "*Well I wanted a bitty more mobile... so that I could do things... (...) when my back was really bad, I thought oh gosh I'm going to have to give up my bowling, and I really don't want to give up exercise.*" (Participant P01)

When asked what the most important indicator of treatment success was, this participant replied:

> "*Well, movement, I can, if I can move a bit... eh easier (...), a bitty more flexible sort of thing*" (Participant P01)

All participants expected their treatment to take the form of exercise, which was influenced by their prior physiotherapy experiences. One participant also expected machines and "hands on" treatment in addition to exercise.

Only one participant considered her expectations to have been met. She received a somewhat "passive" treatment (acupuncture) which could be argued to be increasing dependency on physiotherapy and the expectation of pain-relief, rather than facilitating self-management. However, how much the actual treatment influenced satisfaction, and how much was due to the patient-therapist interaction, can not be determined.

The remaining three participants' expectations were not met, confirmed by their overall dissatisfaction with physiotherapy and for two, their decision not to complete their treatment course.

It would therefore seem that these participants' expectations were largely in tune with what physiotherapy guidelines suggest for CLBP: exercise, advice and education (Bekkering et al, 2003). Therefore, unlike previous studies (May, 2001), mismatched expectations may not be the cause of dissatisfaction in this small sample, and may be caused by other factors. However, the small sample size itself might also be the reason for this finding and the full study therefore included participants with a range of expectations, including pain relief.

Key aspects of the patient-therapist relationship

There were four main areas that related to the patient-therapist relationship. Advice, communication, issues relating to self-management, and satisfaction.

Advice

Two of the participants recalled receiving some advice as part of their treatment; however they did not report this as being helpful. All four participants could identify advice they would like to have received. This was related to activity limitations, such as the following example.

> "*I've got stairs in the house. When your back's really sore (...) if they showed you how to, (...) get up and down the stairs*" (Participant P01)

One participant suggested that this advice could be practically demonstrated.

> "*Like there where we were, could have had something set out or, it was big enough the room. Maybe just to try you doing things that were affecting you... It wouldn't have to be hoovering; you wouldn't have to do that... You could put the bed in with it*"
> (Participant P03)

The need for advice to be relevant to the individual and their lifestyle and environment was also a recurring theme, illustrated by the following quote.

> "*Like, eh, one of the things that the lassie said was get up every hour and just do a bit of walking about, which our place is, you can't really walk about*"
> (Participant P02)

Due to these responses it was felt that further exploration in the full study of participants' perceptions of the advice they received in physiotherapy would be worthwhile.

Communication

Communication skills of the individual physiotherapist were extremely important. Positive examples were physiotherapists who provided a large amount of face-to-face contact, appeared interested in the patient, provided explanations of the treatment process and afforded them their time.

> Interviewer: "*Is that important?*" [that they speak to you]
> Participant: "*Well, I think, aye, and listen to you, you know. Not just, oh right, aye, aye OK, and you think, you're not really listening to me.*" (Participant P01)

Time spent with the patient was an important issue. Participants wanted the physiotherapist to spend time with them, to watch them conducting their exercises and to appear interested in them. Participants were dissatisfied with physiotherapists who kept leaving the cubicle during their treatment session. This was the reason given for stopping going to physiotherapy by one participant:

> "*To my mind, she wasn't there long enough to, to see, because every time I was sort of doing something, oh, she says, oh you're doing fine and then she went away and did something else...* (Participant P02)

Explanations and understanding were key to gaining patients' confidence. Participants reported being encouraged by the knowledge that what they were doing would benefit them and being reassured that the physiotherapist knew what s/he was doing when able to provide explanations. If the physiotherapist did not have a professional manner, the patient did not have confidence in them.

A didactic approach was generally taken towards physiotherapy treatment, with the physiotherapist deciding on the course of treatment, which one patient reported as being reassuring:

> "*Well I think, the way I think is there's no point in going to physio if you're not going to listen to what they're going to say to you*". (Participant P01)

However, one participant felt that this resulted in her treatment being decided before she got to physiotherapy to be assessed. She also felt that this prevented her knee condition from being taken into account and felt she couldn't participate fully in her treatment (group rehabilitation) because of that knee condition.

Self-management

Despite indicating the desire for advice and understanding which could implicate an underlying desire for facilitated self-management, most of these four participants did not appear confident to self-manage their condition. Three expected to return to a healthcare professional. One intimated she would specifically request physiotherapy referral (for acupuncture, having been discharged two months previously). One expected to return to his GP; largely due to physiotherapy having been unsatisfactory and still believing that he may have an "internal" problem that needs investigating. One would return to private physiotherapy at the first sign of a painful back, as she found her experience of private physiotherapy preferable to that of the NHS. Only one participant was resigned to the fact that she would have to put up with her back pain and try to cope on her own. However, she didn't feel that physiotherapy had influenced her point of view and said that any self-management techniques she used were those that she had used prior to attending physiotherapy anyway.

One of the aims of this study was to explore how physiotherapists can facilitate patients to become self-managing. However, this was difficult to explore with this sample; since they had little or no experience of being self-managing it was a topic that they were unable to contribute towards. For this reason, the full study recruited self-managing and non self-managing participants in order to explore this area further.

Satisfaction

There were three domains of satisfaction that were important to these participants: Satisfaction with the physiotherapist as a person, satisfaction with physiotherapy treatment, and satisfaction with factors associated with the environment and process of care. Each is now discussed in turn.

The physiotherapist

Two participants reported satisfaction with the physiotherapist as a person. Their manner and communication skills were important factors here, and appearing interested in the patient was the key factor to the participant being satisfied with their individual physiotherapist. Being satisfied with the physiotherapist was linked with treatment satisfaction. One of these participants had received treatment from two different physiotherapists, and the contrasting levels of satisfaction are interesting and illustrate how important the physiotherapist's manner is.

> Interviewer: "*So what was it about her that (...) made you feel more confident with her* [than with the other physiotherapist]*?*"
> Participant: "*Well, I think it was just her taking an interest. ...when you were doing your exercises, eh, stretching or whatever, she's: oh yes I can see what's happening there*

> *blah, blah, blah. And she was always speaking to you all the time ... it made you feel as though she was taking an interest."* (Participant P02)

Physiotherapy treatment

Overall, only one participant was satisfied with physiotherapy treatment. However, this satisfaction prompted her to seek out physiotherapy once more, shortly after being discharged. The remaining three participants were dissatisfied, largely due to the attitude of the physiotherapist.

Environment/process of care

Only one participant had very strong views on the length of time she had to wait for physiotherapy. She sought private physiotherapy, and was satisfied with this due to the lack of waiting time, but also due to factors concerning the physiotherapist's manner. The same participant felt that lack of privacy and the old-fashioned nature of the environment contributed to her lack of confidence in the NHS physiotherapist. This may have been a lone view, but the process of care was explored in the full study to determine the extent of related views within the sample.

Considering the literature presented in 2.2.3, the above themes might be considered as contributing to a concept of patient-centred physiotherapy. The themes relate to three of the dimensions in the concept of patient-centred medicine proposed by Mead and Bower (2000). Treatment relating to the patient as an individual and the patient being made to feel important by their physiotherapist relate to "patient-as-person" (Mead and Bower, 2000). The need for adequate face-to-face contact with the physiotherapist relates to "therapeutic alliance" (Mead and Bower, 2000), and professional manner of the physiotherapists relates to "doctor-as-person" (Mead and Bower, 2000). The patient-therapist relationship was therefore further explored in the full study, in order to define patient-centred physiotherapy from the CLBP patient's perspective.

Patients having power in the decision-making process was not reported as being important in this sample, in contrast to the concepts of patient-centredness discussed in the literature review (Law et al, 1995; Mead and Bower, 2000). When explored in the interviews, the didactic approach to deciding upon treatments was expected and wanted by the participants, and increased their confidence in the physiotherapist. Decision-making was therefore also further explored in the full study, to uncover the extent to which participants wanted to be involved in decision-making and what types of decisions they wanted to be involved in.

Functioning

Functioning was a theme derived originally from the literature on CLBP, which suggested that patient-centred physiotherapy for CLBP would need to focus on enhancing activity and participation (Bekkering et al, 2003). Participants supported this by reporting goals that were related to activity limitations and volunteering information on activity limitations that were problematic to them. These activities were varied, but had walking and hoovering in common. However, participants largely felt that although they had mentioned these limitations to their physiotherapist they hadn't been advised on how to deal with them, often being told they would just get better as they continued their exercises. This theme was therefore also further explored in the full study to determine the importance of activity limitations and participation restrictions to participants, and the extent to which participants felt that physiotherapy should, and did, address these limitations and restrictions.

2.4.10: Suitability of recruitment method

Four replies were received from a total of nineteen letters sent, resulting in a 21% response rate. This was in keeping with a previous interview based study on satisfaction with physiotherapy for LBP (May, 2001), and gave an indication of the number of letters likely to be required for the full study.

Self-selection of participants may be a limitation of the method of recruitment chosen for the study, since participants may be different in some way from non-respondents (Bryman, 2002). Participants who have particularly strong feelings on their physiotherapy experience (positive or negative) might be most likely to volunteer their participation; therefore the study may lack a subgroup of participants with more moderate views. However, letters of invitation target a large number of possible participants, and participants must take part in the study freely and willingly having given their informed consent (Iphofen, 2005). To allow for the likelihood of non-respondents, a sampling matrix was devised for the full study, in order to ensure participants fulfilled certain criteria. This is explained fully in section 2.5.

2.4.11: Suitability of data collection

It was felt that the interview schedule was somewhat prescriptive, not allowing exploration of some issues in-depth. It was also felt that two questions (7 and 18) asking about the physiotherapist visiting participants home/work and about the physiotherapist assessing day-to-day activities were difficult for participants to answer, due to their hypothetical nature. It was decided to omit these questions, due to the volume of data relevant to the study objectives that would still be gathered without asking them. It was also felt that the specific questions on functioning (16 and 17) were not required, since these questions were answered in all cases during the course of the interview, their inclusion being repetitive for the participants. Consequently, the interview schedule was converted to a topic guide (Appendix 6) which included prompts for the questions included in the original schedule (with the exception of the questions discussed above). It was felt that the topic guide would allow for more spontaneous conversation and exploration of issues important to the participant whilst still addressing the study objectives relating to expectations, patient-centredness, self-management, and activity and participation.

2.4.12: Suitability of data analysis

The framework method of analysis employed (Ritchie and Spencer, 1994) produced findings relevant to the aims and research questions of the study and was therefore deemed appropriate for use in the full study.

2.4.13: Conclusion

This pilot study demonstrated that the methods of recruitment, data collection and analysis were suitable for answering the research questions. The data derived from this small study confirmed that the research questions were relevant due to the nature of the participants' responses and the knowledge gained from this pilot study alone. This pilot study identified several themes to explore further in the full study. The findings of this pilot study suggested that the full study would yield some interesting results in this important area of CLBP management, and inform the enhancement of patient-centred physiotherapy aimed at facilitating self-management.

Section 2.5 describes and justifies the methods employed in the full study, which were informed by the pilot study presented here.

2.5: Methods

2.5.1: Study design

This was a qualitative, interview-based study, as described for the pilot study in section 2.4.1. The Grampian Local Research Ethics Committee granted ethical approval for the study on 17.08.04.

2.5.2: Population

The population of interest was individuals who had received physiotherapy treatment for CLBP in a physiotherapy department in Grampian region within the previous six months. All definitions, inclusion and exclusion criteria were as described in the pilot study (sections 2.4.2 & 2.4.3).

Justification of study location

The aim of the study was to explore aspects of physiotherapy in a particular location; the Grampian region of Scotland. This area was chosen because it was the intention to inform service redesign in this region. This region includes the three main areas of Aberdeen City, Aberdeenshire and Moray with physiotherapy services being centrally influenced and a region-wide LBP management pathway being followed (NHS Grampian, 2005). For practical reasons (time, travel and finance) it was decided to base the research in the Aberdeen and Aberdeenshire areas only. Participants were recruited from both urban and rural areas in Aberdeen and Aberdeenshire (see 2.5.3 below) which are not atypical of the locations of physiotherapy departments in the Moray area, therefore the results would still be considered relevant for the Grampian-wide physiotherapy service. The issue of generalisation is one of some controversy in qualitative research (Galvin, 2005). However, the qualitative approach taken in this study was influenced by applied social policy research, in which generalisation is considered appropriate. One particular form of generalisation, "representational generalisation", is defined by Lewis and Ritchie, (2003) as "the extent to which findings can be inferred to the parent population that was sampled" (p 268). This refers to the range of phenomena under study being inferred to the population, and was the approach taken in this study. Generalisation in this context is related to the reliability and validity of qualitative research, both of which are discussed below (2.5.7).

2.5.3: Sample

Inclusion and exclusion criteria were as described for the pilot study (section 2.4.3).

Sampling strategy

In keeping with the qualitative methods used, a purposive sampling strategy was employed in order to sample for diversity (Bryman, 2004, p333). As suggested in the pilot study, a sampling matrix was designed (table 2.5.1) with primary selection criteria being location of physiotherapy, whether participants completed their course of treatment or not and gender. Secondary criteria, which were monitored but controlled to a lesser degree, were age and management style. Allocations of two participants per cell on the matrix would have resulted in 16 participants being recruited to the study; the actual numbers recruited can be seen in table 2.5.1, with reasons for the empty cells being discussed below.

Table 2.5.1: Sampling matrix showing distribution of final 25 study participants

	Urban		**Semi - Rural**	
	Male	**Female**	**Male**	**Female**
Completed treatment	3	4	0	11
Failed to attend	2	4	0	1
Age: 18 – 34 :3 **35 – 50:** 8 **51 – 65:** 14		**Management style:** Group:4 Individual:14 Mixed:7		**Total: 25**

Justification of selection criteria

Location of physiotherapy

Physiotherapy departments within Grampian are located in both urban and rural areas and vary in size and staffing levels accordingly. This may affect the management that is offered to CLBP patients. For example some smaller departments may not have sufficient space to offer the group rehabilitation that is more routinely offered in larger departments in urban areas. It was therefore felt that it was necessary to sample patients who had attended physiotherapy in both urban and rural areas. The Scottish Executive's definition of "rural" is a community with a population of less than 3000 (Scottish Executive, 2004). There are some physiotherapy departments within Grampian in communities of this population. However, when negotiating access to physiotherapy departments for recruitment of patients, physiotherapy managers and physiotherapists themselves felt that recruiting from bases with only one out-patient physiotherapist providing the service in that location could be seen as threatening to that physiotherapist, since the researcher would know which physiotherapist a particular participant was referring to. Bases with one out-patient physiotherapist tended to be those in rural locations; therefore Holdsworth et al's (2006) definition of semi-rural was used to refer to departments in communities with a population of between 3 and 12000 that also provide a service to a more widespread population. In reality this included communities with populations of between 3,894 and 11,060 (Aberdeenshire Council; 2005), with departments staffed by between two and five physiotherapists. Five departments were initially selected, three in urban and two in rural areas. These are shown in figure 2.5.1 as black and green triangles respectively. A further two departments were later included, shown in figure 2.5.1 as red triangles, to try to increase the number of male respondents from rural locations. The addition of these two later bases also meant that the sample was drawn from both Aberdeen City and most of the districts within Aberdeenshire.

Figure 2.5.1: Location of physiotherapy departments used in sampling for qualitative interview study
Map used with permission from The Gazetteer for Scotland at http://www.geo.ed.ac.uk/scotgaz/ (c) The Gazetteer for Scotland, 1995-2006

Completion of physiotherapy

It was hypothesised that people who had completed their course of physiotherapy and those who had failed to attend after two or more sessions might hold differing opinions on the physiotherapy they received. This was based on the assumption that some of those who failed to attend would have done so due to being dissatisfied in some way with their physiotherapy. There may also be other reasons for people failing to attend, and indeed some of these were found in the study sample. Whatever the reason for failing to attend, it was felt important to gain the views of those who did so and also those who completed a course of treatment and were discharged by their physiotherapist.

Gender

Since CLBP affects both genders it was necessary to recruit both male and female participants. Initially it was intended to recruit equal numbers of male and female participants. However it proved particularly difficult to recruit males to the study, especially in semi-rural areas. It was for this reason that a further two semi-rural departments were added to the recruitment strategy; however they also failed to produce male participants. Female CLBP patients comprised the majority of the available population to sample from. Sixty-four percent of patients treated for CLBP in the previous six months in the seven selected physiotherapy departments were female. Therefore it was decided that a female majority in the study sample was acceptable. Table 2.5.2 illustrates the proportion of each gender in the final sample compared to all those invited to take part; both the sample and those invited to take part were mostly female. The lack of male respondents from semi-rural areas was a limitation, however the recruitment of five male participants, both completers and those who failed to attend, and the need for pragmatism resulted in the decision being made not to continue recruitment in the pursuit of male participants from semi-rural areas. It was felt that no new material was being discovered long before the inclusion of the two additional bases. Therefore, the inclusion of an additional three participants, who also yielded no new information, helped to ensure that saturation had been reached.

Table 2.5.2: Gender and age of those invited to take part in qualitative interview study compared to final sample

	Participants invited to take part (n=138)	Final sample (n=25)
Male	42%	25%
Female	58%	75%
Age 18 – 34	25%	10%
Age 35 – 50	42%	35%
Age 51 - 64	33%	55%

Secondary selection criteria

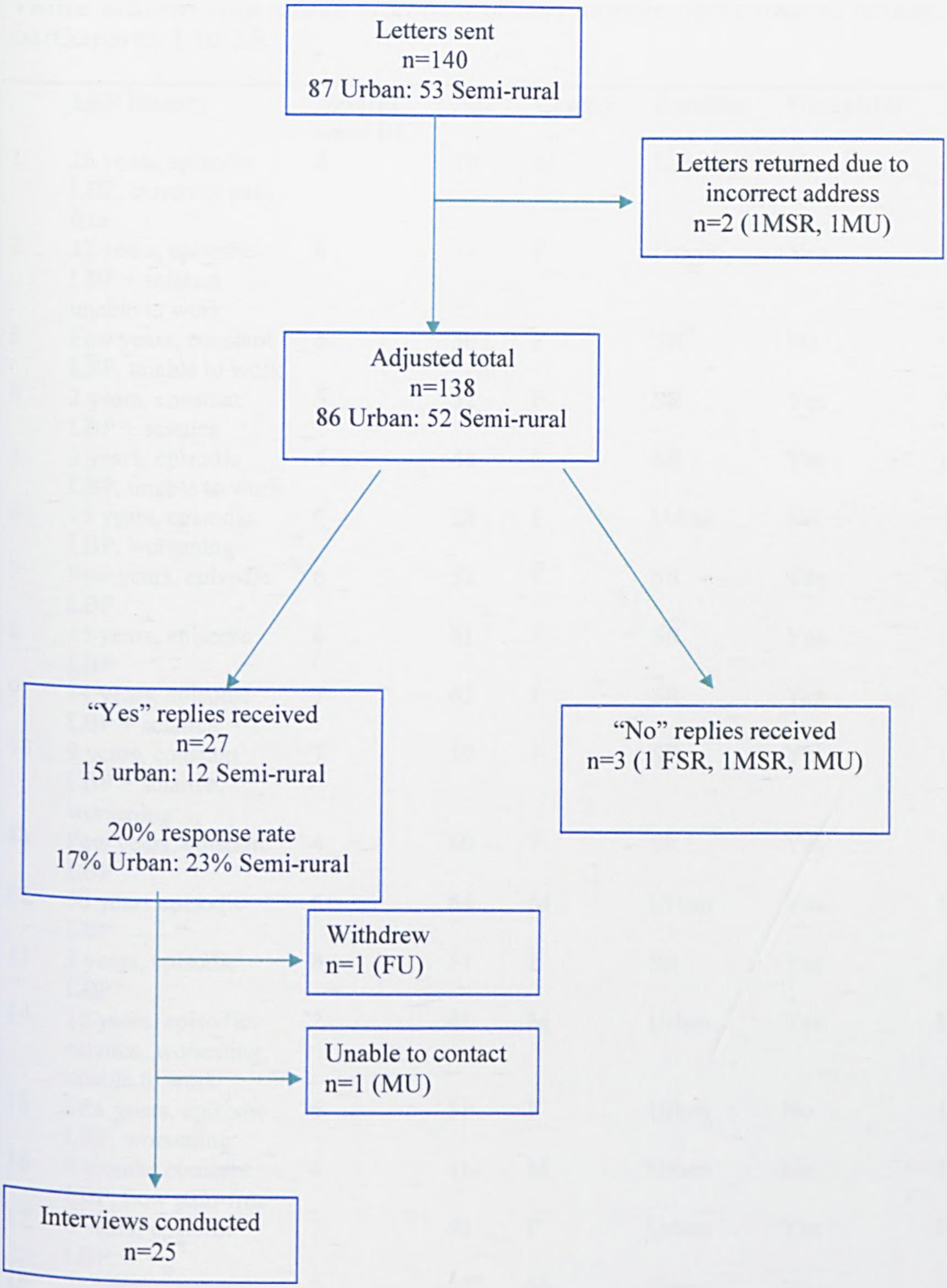
Age was monitored but not strictly controlled since it was anticipated that a range of ages would automatically be recruited, which did turn out to be the case as table 2.5.1 illustrates. Likewise, management style in terms of whether physiotherapy was delivered on a one-to-one basis, in a group, or as a mixture of the two was monitored, and all three were included in the sample.

Sampling method

Participants were identified from physiotherapy discharge files, as described for the pilot study (section 2.4.5), using identical letters of invitation and information sheets (Appendices 2 and 3). A summary of the recruitment process can be seen in figure 2.5.2. Letters were sent out in batches from each base in turn. Two letters were returned unopened, the addressee no longer present at the address provided from the physiotherapy notes. It can be seen that the overall response rate was 20%, ranging from 9% to 33% for individual bases, which is similar to that of other interview-based studies on physiotherapy (May, 2001). It was not possible to contact one respondent on the telephone number they had provided, and one withdrew from the study due to illness. It was decided to interview all 25 respondents who were willing to take part, the sampling matrix acting as a guide rather than a prescribed quota. A description of the final sample with respect to the selection criteria is presented in tables 2.5.3a and b.

2.5.4: Consent

All participants read the study information sheet (Appendix 3) prior to deciding whether or not to take part in the study. The interviews were arranged to allow for time to withdraw as explained for the pilot study (section 2.4.6). It can be seen from figure 2.5.2 that one participant withdrew from the study. All participants provided written consent as for the pilot study (Appendix 4) prior to the interview being conducted.



Key: MSR= Male, semi-rural; FSR= Female, semi-rural; MU= Male, urban; FU= Female, urban

Figure 2.5.2: Recruitment summary for qualitative interview study

Table 2.5.3a: Qualitative interview study; sample demographic details, participants 1 to 20

	LBP History	Months since DC	Age	Gender	Location	Completer	Style
1	26 years, episodic LBP, currently pain free	6	39	M	Urban	Yes	1 to 1
2	12 years, episodic LBP + sciatica, unable to work	6	57	F	Urban	Yes	Mixed
3	Few years, constant LBP, unable to work	6	50	F	SR	No	Group
4	2 years, constant LBP + sciatica	5	52	F	SR	Yes	Mixed
5	3 years, episodic LBP, unable to work	4	48	F	SR	Yes	Group
6	15 years, episodic LBP, worsening	6	28	F	Urban	No	1 to 1
7	Few years, episodic LBP	6	52	F	SR	Yes	1 to 1
8	15 years, episodic LBP	6	61	F	SR	Yes	1 to 1
9	34 years, episodic LBP + sciatica	7	62	F	SR	Yes	1 to 1
10	9 years, constant LBP + sciatica, worsening	7	59	F	SR	Yes	1 to 1
11	Few years, episodic LBP	4	60	F	SR	Yes	1 to 1
12	30 years episodic LBP	6	64	M	Urban	Yes	Mixed
13	2 years, episodic LBP	8	51	F	SR	Yes	Mixed
14	10 years, episodic sciatica, worsening, unable to work	7	41	M	Urban	Yes	Mixed
15	Few years, episodic LBP, worsening	6	51	F	Urban	No	1 to 1
16	6 months constant LBP, now pain-free	4	41	M	Urban	No	1 to 1
17	6 years, episodic LBP	7	60	F	Urban	Yes	Mixed
18	28 years, constant sciatica, worsening	5	52	M	Urban	No	1 to 1
19	7 years, episodic LBP, currently pain free	7	29	F	Urban	Yes	1 to 1
20	10 years, episodic LBP, worsening	5	53	F	Urban	Yes	Group

Key: Months since DC= Months since discharge (at time of interview); M=male, F=female; Location= Location of physiotherapy; SR=semi-rural; Completer= whether completed course of physiotherapy (Yes) or failed to attend after 2 or more appointments (No) (according to physiotherapy notes); Style= management style of physiotherapy.

Table 2.5.3b: Qualitative interview study; sample demographic details, participants 21 to 25

	LBP History	Months since DC	Age	Gender	Location	Completer	Style
21	1 year, constant LBP	7	39	F	Urban	No	Group
22	16 years, constant LBP	4	33	F	Urban	No	1 to 1
23	13 years, episodic LBP, currently pain free	3	48	F	SR	Yes	Mixed
24	6 years, episodic LBP	4	64	F	SR	Yes	1 to 1
25	10 years, episodic LBP, currently pain free	4	38	F	SR	Yes	1 to 1

Key: Months since DC= Months since discharge (at time of interview); M=male, F=female; Location= Location of physiotherapy; SR=semi-rural; Completer= whether completed course of physiotherapy (Yes) or failed to attend after 2 or more appointments (No) (according to physiotherapy notes); Style= management style of physiotherapy.

2.5.5: Instrumentation

Semi-structured interviews were conducted with each of the 25 participants during April to September 2005. Following the pilot work (see section 2.4.11) an interview topic guide was developed (Appendix 6). It was thought that this would allow for the conversation to flow more naturally and for the participant to talk about topics of importance to them. However, it was found with the first two participants that the topic guide was either too vague and the interview was veering away from the topics required to answer the research questions, or that the responses required more prompting. Therefore, the original interview schedule used in the pilot project was once again employed to structure the interviews in a more coherent way, with the omission of the specific questions discussed in section 2.4.11. This was in keeping with the qualitative methods being used, which needed to be flexible and respond to the development of the project (Green and Thorogood, 2004). The amended interview schedule, which comprised 16 questions, is available in Appendix 7.

Each interview began with a general question about LBP such as "do you want to start by telling me a little bit about your low back pain and how you ended up at physiotherapy?" This was in order to put the participants at their ease and allow them to talk about their LBP, and often answered research question seven relating to the importance of activity and participation (see 1.8, p12). Interview questions two and three were designed to answer research questions one and two relating to expectations of physiotherapy and their fulfilment. Interview questions four to nine were concerned with the physiotherapy experience, and were designed to answer research questions three and four relating to patient-centred physiotherapy. Interview question five in addition contributed to research question one on expectations, as it asked what participants most wanted physiotherapy to achieve. The remaining interview questions, ten to 14, related to self-management and were therefore designed to answer research questions five and six. The schedule was used to ensure the questions were all included, but not strictly adhered to in terms of exact wording or flow. Interviews ranged in duration from 24 minutes to one hour and two minutes, with an average of 36 minutes. All interviews were recorded on a digital voice recorder (Olympus DM-1) then downloaded to a personal computer for transcribing to take place with a digital transcriber (Olympus DSS 2002). There was one exception, which was not recorded but had notes taken instead, which is discussed in section 2.5.6 below.

The researcher transcribed all interviews verbatim, reproducing the precise words, pauses and interruptions as recommended by Green and Thorogood (2004). Few notes were taken during the interviews, in order to encourage communication with eye contact and non-verbal communication. However, some points were noted to prompt the researcher to ask subsequent questions at the end of the interview, or to remind the researcher of what was happening, such as something being pointed to or demonstrated by the participant, or to note the participant's own non-verbal communication at certain points in the interview. In addition, field notes were taken immediately after the interview, which documented the researcher's first impressions of the interview; points raised that seemed to be important to the participant and the general feel of how the interview had gone. Points to be raised in future interviews were also documented here in keeping with the fluid and flexible nature of the research method.

The researcher introduced herself as a "researcher" on the day of interviewing. However in the initial letter sent to each participant, the fact that the researcher was a physiotherapist had to be disclosed for ethical reasons, to explain how and why the researcher had gained access to their name and address, therefore the participants knew that the researcher was a physiotherapist. Some participants made reference to this and when asked, the researcher replied that she did indeed have background in physiotherapy but was currently working as a researcher.

2.5.6: Location

The interviews took place either in the participants own home, or in NHS premises located close to their home, but not in physiotherapy departments, with the participants being free to choose. Nine chose to be interviewed in their own home, fifteen in NHS premises and one in a pub/restaurant adjacent to her work. The fifteen interviews which took place in NHS premises varied in location from conference rooms in hospitals or health centres, offices of hospital managers who were absent at the time and clinic rooms in hospital out-patient departments. For the interviews in NHS premises, as informal an atmosphere as possible was adopted, with refreshments being made available and arranging furniture in a less formal manner. Where there was little scope for altering the layout, such as in the clinic rooms, the participant was always seated in the "Doctor's" chair, so that the interviewer could not be perceived to be in the more powerful position. Physiotherapy departments were not used as interview locations, in order to prevent the participant coming into contact with the physiotherapist who treated them, which may have affected their responses in the interview. One participant requested that the interview took place in a pub/restaurant located close to her place of work, in order for the interview to take place during her lunch break. Despite the premises being relatively empty of other customers, due to the background noise from piped music it was decided not to record in this instance. Instead, notes were taken during the interview, extensive field notes were written directly after the interview and the interview was transcribed that day.

2.5.7: Data analysis

Choice of method: Framework analysis

There are many methods of qualitative data analysis, the choice for some dependent on the theoretical underpinnings of the research (Spencer et al, 2003) and for others the purpose of the research (Green and Thorogood, 2004, p176). As discussed previously (2.3.4, p56) the approach adopted in this study was one of pragmatism; therefore the method of data analysis was chosen as that best suited to answer the research questions. Content analysis was considered, but its focus on frequency of occurrence of themes may have meant that understanding and explaining the reason for the themes' occurrence may not have taken place (Bryman, 2004, p197).

The aims of this project were to provide some answers regarding aspects of physiotherapy service delivery. Description and some explanation of the data were primarily required in order to do this. Considering these aims and the methodological influence of applied social policy research discussed previously (2.3.4) framework analysis was explored (Ritchie and Spencer, 1994). This type of analysis was developed for policy and evaluation research, its aim being to "provide answers about the social contexts for social policies and programmes and the effectiveness of their delivery and impact" (Spencer et al, 2003, p201). It is a thematic analysis, allowing for both descriptive and explanatory accounts of the data. Some of the interview questions in this study required largely descriptive analysis, whilst some required further explanatory analysis; the framework method allowed for both. It is now in widespread use amongst qualitative researchers, including physiotherapy related projects (May, 2001). The purpose of this research was therefore compatible with this type of approach to analysis. Furthermore, Framework analysis facilitates both rigour and transparency during the data management stages, aspects of qualitative research which are often criticised (Tobin and Begley, 2004). The desire for the process to be transparent and to leave a clear "audit trail" (Holloway and Wheeler, 2002, p262) combined with the purpose of the research led to the Framework method being chosen.

There are several stages involved in Framework analysis, which can be summarised into three broad headings in common with most qualitative analysis strategies: Data management, descriptive analysis and explanatory analysis (Ritchie et al, 2003,p220, 237 & 248). How each of these three stages were carried out is now described in detail.

Data management

It was decided to use NVivo, a computer assisted qualitative data analysis software package, for this stage. It would have been equally possible to

deal with "pen and paper" methods; however it was felt that storing, organising and retrieving the data would be simplified with this method, allowing for more systematic and thorough analysis (Green & Thorogood, 2004, p190).
Several stages were necessary in order to manage the data appropriately. Firstly, familiarisation with the data was essential (Ritchie et al, 2003, p221). Since the interviews were conducted and transcribed by the researcher, this began at an early stage in the project, with recurrent themes being noted. Once all the interviews had been conducted and transcribed, the researcher familiarised herself with the data set once more, and identified further themes and concepts.

The next stage of constructing an index with which to label and sort the data is also common to most analytic methods (Bryman, 2004, p408). In this case, the list of themes and concepts were grouped thematically and arranged in a hierarchical order. The final index can be seen in table 2.5.4.

Following the construction of the thematic index, the researcher and both supervisors to this study independently applied the index to a sample of data (two full interview transcripts). Near perfect agreement between all three individuals was reached with respect to which label to attach to each section of data. The index was therefore maintained in its original form and the researcher applied it to the remaining 23 transcripts.

The final two stages of data management involved sorting the data by theme and summarising or synthesising the data. In framework, these stages are carried out by creating a series of matrix based charts (Ritchie et al, 2003, p230). In this study a chart was created for each of the five major themes shown in table 2.5.4; objectives, experience, process, long term management and function. The charts were created using Microsoft Excel software. Each subtheme (bullet-points in table 2.5.4) was allocated a column in the relevant chart, and each participant allocated a row. NVivo was used to retrieve the relevant data for each subtheme, which was entered in summary form into the appropriate cell for each participant. At this stage the context and language used by the participants was retained (Ritchie et al, 2003, p232).

Table 2.5.4: Index used to label qualitative data set

1. **Objectives**
    - **Goals** of treatment (e.g. Pain relief, improved function etc)
    - **Outcome** (what was outcome for patient & how patient measures if treatment helped)

2. **Physiotherapy Experience (The actual physiotherapy intervention/s experienced)**
    - **Expectations** of Physiotherapy (i.e. what did patients expect to happen at physiotherapy and whether these expectations were met/unmet/partially met)
    - **Views about Physiotherapy** received (any comments, positive and negative, about what they thought of the physiotherapy they received)
    - **Advice/Explanations** (anything to do with the advice/explanation part of the treatment)
    - **Exercises** (anything related to the exercise component of physiotherapy)
    - **Interventions** (anything relating to interventions, e.g. manipulation, other "hands-on", electrotherapy, acupuncture)
    - **Group** (anything relating to group rehabilitation)
    - **Involvement** (anything to do with patients involvement in the physiotherapy intervention, i.e. what they thought of decision-making etc.)
    - **Individual** needs/patient as an individual (anything relating to the patient as an individual, e.g. individual symptoms, circumstances being addressed)
    - **Contact** with Physiotherapist (comments relating to actual contact with the physiotherapist, not just time spent in physiotherapy in general)
    - **Intensity** of Treatment (may relate to exercises, group or other treatments)
    - **What patients want** Physiotherapy to be like (anything suggested by interviewees as something they very firmly would like e.g. more time with physio, more appointments, being able to contact, different advice etc.)
    - **Physiotherapist** as a person (anything relating to physiotherapist(s) directly e.g. s/he was this, did this, should be like this etc.)
    - **Communication** (anything to do with patient-therapist communication during the physiotherapy intervention)

3. **Process of Physiotherapy**
    - **Duration** (anything relating to number or length of sessions)
    - **Continuity** (anything relating to seeing the same physiotherapist each session – may be positive or negative)
    - **Organisational issues** (anything relating to appointment times etc)
    - **Support from other patients** (relating to group environment)
    - **Need for tests/x-rays** (as perceived by the patient)
    - **Communication between Physiotherapist and others**: GP/Consultant (as perceived by the patient)
    - **Physiotherapist as "the expert"** (anything which suggests the patient has this point of view)

4. **Long-term Management**
    - **Self-management strategies** (any techniques used by interviewees to self-manage LBP once discharged & whether influenced by self or physiotherapist)
    - **Post discharge support** (anything suggested by interviewee or interviewer relating to post-discharge support)
    - **Telephone helpline** (anything relating to phone support post-discharge)
    - **Physiotherapist/GP/Other consultation** (current or future)

5. **Functional limitations of CLBP**

- **Function** (anything relating to functional activities such as walking, daily activities, housework etc. May be related to any interview topic)

Descriptive accounts

Three key steps were involved in creating descriptive accounts of the data; detection, categorisation and classification (Ritchie et al, 2003, p237).

In this study separate charts were created for each subtheme. The first column contained the summarised data from the original framework chart. A second column was then created to identify dimensions within the data (detection). Finally, a third column was used to categorise the data. Categorisation involved attaching labels to the data in a more conceptual way, identifying similar features described differently by different participants, and refining categories so that those similar in nature were combined to simplify the process. This resulted in many categories for each subtheme. These were then arranged as sets of categories within broader classifications; these are described fully in section 2.6.

Explanatory accounts

The categories and classes described above were explored to identify links between sections of the data and subgroups within the data and where possible to try to explore why such associations and subgroups existed. The framework charts and interview transcripts were frequently referred back to at this stage.

Reliability

Reliability, or dependability as some qualitative researchers prefer, is an important consideration in qualitative research (Tobin and Begley, 2004). It refers to the extent to which the same results would be found in a study using the same methods (Lewis and Ritchie, 2003). Due to the nature of the research it is unlikely that identical results would be found in another study using similar methods, largely due to the variability in individuals' experiences and attitudes. However, steps can be taken to ensure that wider inference can be drawn from the findings. These steps are broadly to ensure that the data collection and analysis is robust, and that the research process is transparent (Tobin and Begley, 2004).

Lewis and Ritchie (2003, p272) suggest several steps to increase reliability, which were adhered to in this study:

- *Unbiased sample selection:* In this study the sample was symbolically representative of CLBP patients who would attend physiotherapy due to the sampling strategy described above (2.5.3). In other words they represented and symbolised the "character" (Ritchie et al, 2003, p83) of the CLBP population (not the statistical distribution).
- *Consistency of fieldwork:* The methods have been described (2.5.5) and involved the use of a standardised interview schedule allowing sufficient opportunity for participants to provide relevant data.
- *Systematic and comprehensive analysis:* The analysis as described above (2.5.7) was by its nature both systematic and comprehensive. Each stage was conducted on every section of data such that none was omitted from analysis. Furthermore, there was a clear audit trail for this process to be verified.
- *Interpretation is supported by the evidence:* This should be clear to the reader in chapter 2.6, where all of the categories and classes are presented along with their interpretation.
- *Design allowed for all perspectives to be identified:* No data was omitted from analysis, therefore all perspectives were included.

Validity

Validity or credibility of research findings is also an important consideration in qualitative research (Tobin and Begley, 2004). Unlike quantitative research where validity refers to the "precision" of a research finding (Sim and Wright, 2000, p32), here it refers to "the accurate reflection of the phenomena under study as perceived by the study population" (Lewis and Ritchie, 2003, p274). Due to the methods used and described above for sample selection, data collection, data management and analysis in this study the findings can be considered to be a valid representation of the CLBP patients' experiences.

Validation

Validation is the process by which the validity of research findings can be determined (Lewis and Ritchie, 2003), and in this study two types of validation were used:

Internal validation

A constant comparative method, which involved testing hypotheses from one part of the data on another and constantly checking and comparing across different individuals, was an inherent part of developing both descriptive and explanatory accounts within the Framework analysis method used in this study. Likewise, deviant case analysis where outliers were not ignored or forced into classes but used to aid understanding was also an integral part of this analysis (Lewis and Ritchie, 2003, p275).

External validation

It is suggested that triangulation, or the use of different sources of information, helps to confirm qualitative research findings (Tobin and Begley, 2004). In this study, triangulation took the form of having multiple participants and multiple analysts (at the stage of verifying the coding system, see p81).

Member validation has been suggested as another method of external validation, and involves taking the results back to the participants for them to confirm the interpretation (Lewis and Ritchie, 2003). However, due to time constraints member validation was not carried out in this study.

2.6 Findings

2.6.1: Introduction

The findings and their interpretation are presented here as four sections relating to the four topics of enquiry previously discussed: expectations, patient-centred physiotherapy, self-management, and the importance of activity and participation. For each topic a description of the classes and categories of data that were constructed during the thematic analysis are first presented. Secondly, the descriptive analysis is presented and where appropriate the explanation of relationships or subgroups detected within the data is presented. Finally, the findings are further discussed in relation to the research reviewed in section 2.2.

Section 2.6.2: Expectations

This section relates to research questions one and two, which were:

1. What do CLBP patients expect from physiotherapy?
2. Are these expectations currently met in Grampian?

Interview questions two, three, five and fifteen were designed to answer these questions since they related to the following topics. Participants' expectations of physiotherapy, the extent to which participants felt these expectations were fulfilled, what participants had wanted to achieve by attending physiotherapy, and how participants evaluated the efficacy of the physiotherapy they had received.

The data contributing to this topic arose from three of the main themes in the index presented in table 2.5.4 (p82). "Objectives" and the two subthemes "goals" and "outcome", the subtheme "expectations" from "physiotherapy experience", and the subtheme "need for tests/x-rays" from "process of physiotherapy". The subsequent analysis consolidated these into two themes: expectations and outcome. Expectations comprised data relating to expectations of the physiotherapy itself and expectations of what the physiotherapy would achieve. Outcome comprised data relating to how participants evaluated the efficacy of the physiotherapy they had received. Both themes are now presented.

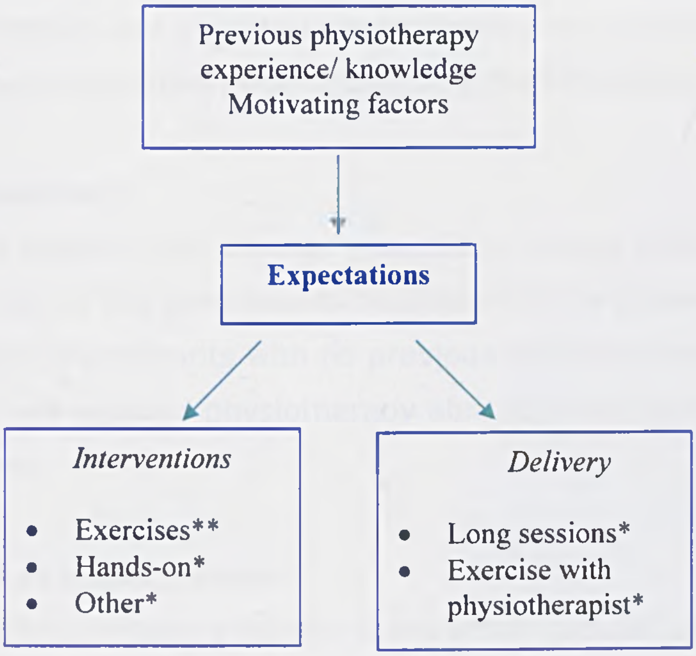
Expectations

2.6.2.1: Expectations of physiotherapy

The categories constructed during data analysis and the classes in which groups of categories were arranged are displayed in table 2.6.1. These classes represent the seven issues relating to expectations of physiotherapy that were either determined from the interview schedule or that emerged during analysis of the data. Figure 2.6.1 displays the relationship between some of the classes and categories that are discussed below. It can be seen that participants' expectations related to the physiotherapy interventions they had expected to receive and the method of delivery of these interventions.

Table 2.6.1: Expectations of physiotherapy: categories and classes of data

Categories	Classes
Exercises, intensive exercise, hands-on, electrotherapy, back class, coping strategies	Expected interventions
Long sessions, assessment/diagnosis, exercise with physiotherapist	Expected delivery
Expectations met, partially met, unmet, exceeded, no expectations	Fulfilment of expectations
Previous experience or lack of previous experience affected expectations	Previous physiotherapy experience
Not expecting physiotherapy to help, hoped would be different to previous experience, no disappointment at not getting expected interventions	Attitudes
X-rays/scans required for physiotherapist to treat effectively, need for orthopaedic opinion that x-ray not required	Belief that tests required
Reassurance, confusion	Effect of having tests



Key: ** Expectations commonly met * Expectations commonly unmet

Figure 2.6.1: Diagrammatic representation of expectations of physiotherapy

Previous physiotherapy experience

Participants commonly had some expectation of what their physiotherapy treatment would involve. However, this was influenced by previous experience of physiotherapy or its lack thereof. Lack of previous physiotherapy experience was related to two opposing categories of expectation; lack of expectations or expectations similar to those with prior experience. This suggested that factors other than first-hand experience could influence expectations. A previously negative physiotherapy experience resulted in a lack of specific expectations relating to interventions; only that "something different" had been expected on this occasion. Participants in this category had attended physiotherapy on the advice of their GP, but had not expected physiotherapy to help their LBP. Therefore, motivation for attending physiotherapy and previous physiotherapy experience appeared to affect expectations in this group.

Expected interventions

The actual interventions expected fell into two almost mutually exclusive groups, exercises and some type of hands-on treatment (such as manipulation or massage). It was less common to expect "other" interventions such as advice on coping with LBP, electrotherapy, or group treatment; those who expected electrotherapy or group treatment had received these previously, again reflecting the influence of prior experience.

Expected delivery

These were expectations of lengthy sessions (longer than turned out to be the case) and for the exercises to be done with the physiotherapist rather than at home. Participants with no previous physiotherapy experience, or those who had received physiotherapy abroad commonly held these expectations.

Fulfilment of expectations

Fulfilment of expectations fell into three broad groups; unmet, partially met and met in full.

Unmet expectations

Unmet expectations commonly related to hands-on treatment, electrotherapy, and spending large amounts of time doing exercises with the physiotherapist present. Participants with unmet expectations commonly had no previous physiotherapy experience or, in two cases, were recalling physiotherapy treatment received abroad and expecting their encounter here to replicate that. Experiences of treatment abroad involved several sessions per week of intensive exercises carried out under the supervision of the physiotherapist.

Partially met expectations

Those with partially met expectations commonly did have previous physiotherapy experience. The difference between those with met and partially met expectations was that those whose expectations were met commonly expected exercise as the mainstay of treatment, whilst those with partially met expectations expected exercise but additionally expected either long appointments, hands-on treatment or electrotherapy, which were commonly not received. A less common theme was that of expecting exercise in combination with coping strategies. The latter expectation was not fulfilled. Participants who fell into this category had received group treatment, and it was felt that group treatment was not individualised enough to address individual needs relating to coping strategies. Indeed, those who had received group treatment alone or in combination with one-to-one treatment rarely had their treatment expectations fulfilled. This raises an interesting question regarding the mode of delivery of treatment, which is considered further in section 2.6.3.

Expectations met in full

Those who reported their expectations as being met had all previously attended physiotherapy for treatment of CLBP. There was one exception; this participant had experience of animal physiotherapy and attributed her knowledge of that to her knowing what she wanted the physiotherapist to do for her and to show her. The framework charts demonstrated that there was an association between expectations being met and an overall satisfaction with physiotherapy and achievement of treatment goals. The only participants to have requested physiotherapy referral from their GP also fell into the category of met expectations, the remainder having been referred at their GP's suggestion. These participants explained that they knew what they needed (the physiotherapist to do), asked to be referred, explained to the physiotherapist what they felt they needed and had it carried out to their satisfaction, as this participant explains.

> *"I went down to the local GP and said: "right, I need to see the physiotherapist" (...). You know...I know what's the matter... Went down there. Same thing again...popped it back in place (...). That's all it needed (...). It just needs popped back, pop it back in place and I can take care of the rest myself"*
>
> (Participant 1, 39 year old male)

Therefore, both motivation to attend and prior experience were related to the fulfilment of expectations for these participants.

One participant considered his expectations to have been exceeded due to the level of explanation provided by his physiotherapist and the continuity of care, not having expected to see the same physiotherapist each time he attended. A small group of participants explained that they weren't disappointed that their expected interventions were not delivered since they were pleased with the interventions they did receive. Yet another small group explained that they had not expected physiotherapy to help in the first place.

Belief that tests were required

A belief that tests such as magnetic resonance imaging scans or x-rays were required was related to the fulfilment of expectations of physiotherapy for some participants. Although participants did not expect the physiotherapists to arrange for tests/x-rays, they did view them as part of their overall treatment package that might have enhanced the outcome. These participants held the view that tests would have provided the physiotherapist with the knowledge required to more adequately treat their LBP and therefore to achieve a better treatment outcome; these participants commonly considered their treatment goals to have been unmet. However, the effect of having tests was not always a positive one. Those who did receive x-rays either prior to or following physiotherapy described them as "negative" or showing "normal wear and tear". Although reassuring for some to know that nothing was seriously wrong, this caused confusion in others since the x-ray findings could not provide an explanation for their ongoing LBP.

In summary, most participants had some expectation of their physiotherapy treatment and its delivery. Prior knowledge and experience of physiotherapy and motivation for attending physiotherapy affected expectations in this sample. Expectations of exercises were most commonly fulfilled; hands-on, other interventions, and expectations relating to delivery of interventions were more commonly not fulfilled.

2.6.2.2: Expectations of what physiotherapy would achieve

The categories constructed during data analysis and the classes in which groups of categories were arranged are again summarised in table form (table 2.6.2), with figure 2.6.2 illustrating the range of treatment goals within the sample, which are described below.

Table 2.6.2: Expectations of what physiotherapy would achieve: categories and classes of data

Categories	**Classes**
Pain-free, pain relief, be able to bear it	Pain related (passive)
Learn to deal with LBP, learn correct posture and exercises, learn to relieve pain without taking painkillers, learn how to prevent recurrence and deterioration, long-term help, learn exercises to improve movement, learn how to strengthen muscles	Self-management (active)
Diagnosis, find out what's wrong and what can be done, find out if any new exercises, find out if curable	Explanatory
Get back independence, increase mobility, return to work, be able to do sports/hobbies without pain	Functioning (active)
Quick-fix, physiotherapist make it better	Physiotherapist dependent (passive)

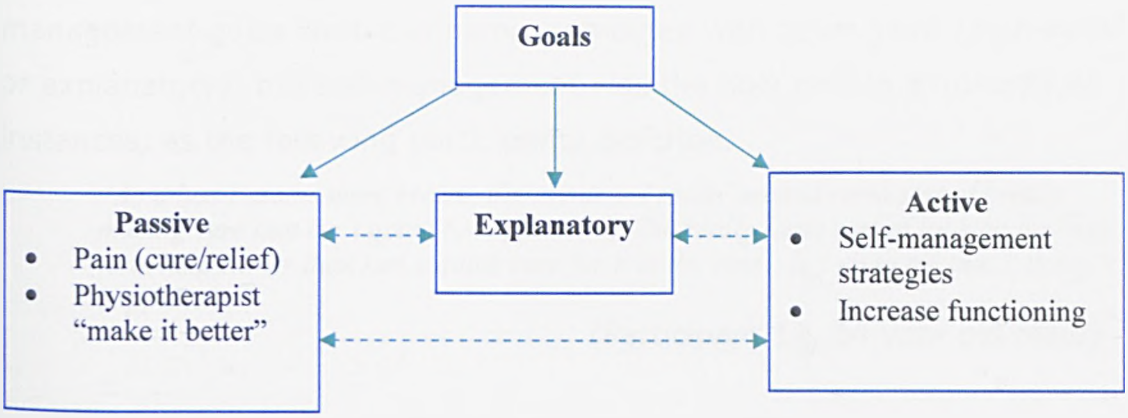


Figure 2.6.2: Range of physiotherapy treatment goals described by participants; dotted lines indicate commonly combined goals

Passive goals

Passive goals were related to a belief that the physiotherapist would make the participant better, commonly in terms of pain. Participants fell into two groups; the first wanted to be pain-free following physiotherapy, demonstrated by these excerpts.

> *"I just wanted rid of the pain (...). Rid of the pain. That's exactly what I thought"*
> (Participant 4, 52 year old female)

> *"I just thought that they would make my back better. I thought that they would just like sort of work on the back and do something. Like a miracle"*
> (Participant 22, 33 year old female)

> *"I suppose after my first visit I was, I thought well, you know maybe they can wave a magic wand and make me better; you know that, that's the truth you know!"*
> (Participant 8, 61 year old female)

The second wanted some, but did not expect complete, pain-relief as the following illustrate.

> "[I was hoping that the] *pain would ease off. That was the most important thing!"*
> (Participant 5, 48 year old female)

> *"Well you're hoping it's going to, well I don't know about curing but eh, helping, just help it."*
> (Participant 10, 59 year old female)

> *"I really wanted to get rid of the pain if it was possible. But I don't think that's going to happen, because I will get aches and pains as I get older."*
> (Participant 7, 52 year old female)

Active goals

Some participants expected to be involved in their own self-management or had goals relating to lifestyle and independence. Self-management, although a recurrent goal, was not as widespread as the passive goals. Self-management goals were commonly combined with other goals (pain-relief or explanatory); but self-management was the only goal in a minority of instances, as the following participants describe.

> *"As it had become more recent, the events... I really wanted some sort of help in making sure that isn't going to happen. (...). But really I was sort of looking for long term help rather than just a quick cure for it at the time...It's up to me that it doesn't happen..."*
>
> (Participant 12, 64 year old male)

> *"I knew it would involve exercises, but really I was hoping to get some advice* [on lifting at work and managing LBP in work environment] *as well which I did.*
>
> (Participant 17, 58 year old female)

Goals relating to work, hobbies or regaining independence were again less widespread than passive goals, and were commonly combined with pain-related goals. Some of these are illustrated here.

> *"But I just wanted as I say, pain free and independent, because I am an independent person. I don't sit down and wait for folk to do everything to me, I do it myself...."*
>
> (Participant 2, 57 year old female)

> [An important outcome is] *"to be able to get out of a chair and move about..."*
>
> (Participant 14, 41 year old male)

> *"(...) I want to be able to do horse riding. I compete at dressage and cross-country and all that and I want to be able to do that and still be able to walk afterwards!"*
>
> (Participant 25, 38 year old female)

Explanatory goals

The explanatory goals centred on receiving a diagnosis or explanation of their condition combined with finding out what could be done for it.

It was rare for a participant to have no treatment goal. When this did occur it was related to having no expectations whatsoever of physiotherapy and what it might achieve.

In summary, participants commonly expected physiotherapy to achieve at least some pain-relief. Explaining the cause of LBP was expected to accompany pain-relief in a group of participants. In another group pain-relief was combined with more active goals of increasing activity and participation and enabling self-management; however it was less common for these more active factors to be the only treatment goals.

2.6.2.3: Outcome

Outcome was the second main theme resulting from the data analysis. Table 2.6.3 displays the categories constructed during data analysis and the classes in which groups of categories were arranged in relation to this theme, and figure 2.6.3 displays the relationship between outcome and the goals of physiotherapy discussed above.

Table 2.6.3: Outcome: categories and classes

Categories	Classes
Goals achieved, not achieved, partially achieved, achieved by self not physiotherapist	Goal attainment
Outcome related to pain intensity	Pain related
Outcome related to self-management of LBP, outcome related to ability to control pain by self	Self-management
Outcome related to activity and participation	Functioning
Outcome related to originality of exercises, clarity of diagnosis, level of psychological support received, success of manipulation	Physiotherapist dependent
Goals not achieved but still good outcome, no point in going to physiotherapy if not going to get rid of the pain, physiotherapist not blamed for poor outcome, physiotherapy a waste of time	Attitudes

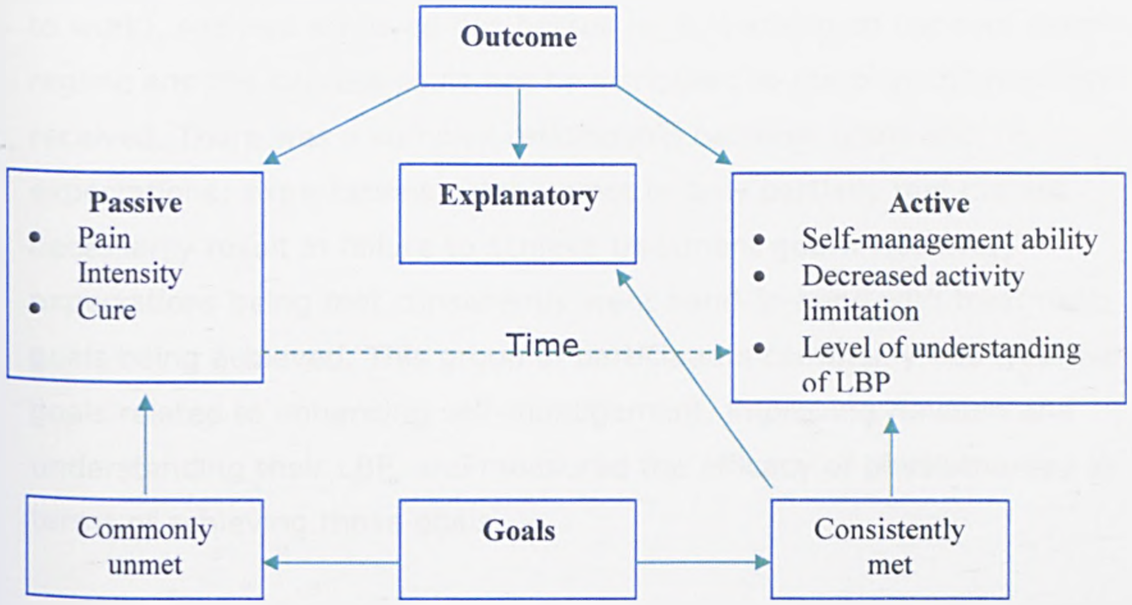


Figure 2.6.3: Relationship between participants' assessment of outcome and their initial goals of physiotherapy

Figure indicates passive goals commonly unmet, whereas active goals consistently met. Patients evaluated outcome in terms of passive, active or explanatory factors. Dotted line represents change in goals from passive to active during treatment, which occurred for a group of participants; i.e. treatment goals initially passive but outcome measured in terms of active factors.

Outcome was explored in the interviews in order to find out how participants determined whether physiotherapy had been helpful or not. Generally, treatment outcomes were in the same classes as the goals of physiotherapy. However, goals and therefore perceived outcome efficacy could change during the course of treatment, and there was a recurrent theme of goals initially being pain-related but the outcome of treatment being measured not only in terms of pain-relief but also in terms of activity and participation or self-management capability.

Goal attainment

As figure 2.6.3 displays goals relating to self-management, activity and participation, and understanding LBP were consistently met, with pain related goals more commonly unmet. One participant said her goal (pain-related) was partially achieved in that the physiotherapy had helped a bit, but that she hadn't been there long enough for it to be achieved fully.

Another participant said that although her goal was achieved (of returning to work), she had achieved this herself by embarking on her own exercise regime and the success could not be attributed to the physiotherapy she received. There was a complex relationship between goals and expectations; expectations being unmet or only partially met did not necessarily result in failure to achieve treatment goals. However, expectations being met consistently went hand-in-hand with treatment goals being achieved. This group of participants commonly had treatment goals related to enhancing self-management, improving function and understanding their LBP, and measured the efficacy of physiotherapy in terms of achieving those goals.

Passive outcomes

Participants with pain related goals commonly measured treatment outcome in terms of the amount of pain reduction they experienced. These goals were either achieved or not achieved, and the outcome was unaffected by whether the goal was complete or partial pain relief. A subgroup of participants who rated physiotherapy in terms of success of hands-on treatment had their goals achieved; however those with the more general goal of the physiotherapist "making them better" did not.

Active outcomes

Ability to manage LBP and prevent recurrence was also used in some cases to measure outcome. Self-management goals were all fulfilled. There were also some explanatory goals, described above. Although not used as the main measure of outcome by these participants, those with explanatory goals had them met in all but one case; a participant who stopped going to physiotherapy due to her appointments being cancelled by the physiotherapist and her subsequent difficulty in having them rescheduled. Activities such as being able to do household chores and being able to move around more easily were used to measure outcome, albeit less commonly than pain or self-management. All goals relating to functioning were achieved.

Attitudes

Some negative attitudes were expressed towards the outcome of treatment, illustrated by the following quotes.

> *"I don't see the point in going if I'm not going to be pain-free, I'm still going to have these pains every day and walking and that. Maybe this is what deterred me from going as well. You think to yourself, well, what's the point then?*
>
> (Participant 03, 50 year old female)

> *"I was hoping to get something that would ease the pain in my back! But...I think she was more interested in getting my leg. She says the nerve was needing stretched, which I don't think it is. I think it's nipped somewhere in my back and they can't see yet."*
>
> (Participant 18, 52 year old male)

However, a poor outcome was not always blamed on the physiotherapist, or met with dissatisfaction, as the following illustrates.

> *"No, no, I don't think there's less back pain... I don't feel that physiotherapy. I don't feel it did a great deal of good, but I don't think it was the physiotherapist's fault. I think she did, give me stretching exercises and things"*
>
> (Participant 15, 60 year old female)

Rarely, participants were unable to rate their treatment outcome, due having no defined goal of treatment, or a belief that they hadn't finished the physiotherapy process and were hoping to return for more treatment.

In summary, outcome was commonly measured in terms of the extent that participants' treatment goals had been met. However it was possible for goals to change and for an alternative factor such as self-management ability to determine efficacy. Active treatment goals such as enhancing activity, participation, and self-management skills were more commonly met than the more passive goal of pain-relief. There was a relationship between expectations being met and treatment goals being achieved.

In order to explain some of the above findings further they are now discussed in relation to the literature presented in section 2.2. Some of the implications for physiotherapy practice and further research are also considered.

2.6.2.4: Discussion

Content and delivery of physiotherapy

Treatment expectations

Much of the previous literature on expectations has focussed on what patients expect to achieve from physiotherapy rather than what they expect the process to be. However, most participants in this sample had expectations regarding the type of interventions they would receive, which were not always consistent with what the physiotherapist provided. In this study, the most common expectations were exercises and hands-on treatment, suggesting that this is what these patients perceive physiotherapists do for CLBP. Whilst exercises are generally recommended for CLBP (Mercer et al, 2006; Hayden et al, 2005; Bekkering et al, 2003), there is less agreement on hands-on treatments. Although recent guidelines (Mercer et al, 2006) recommend that combined manipulation and manual mobilisation *can* be used with CLBP patients, they do not recommend massage. Moreover, there is considerable disagreement between experts as to which patients are likely to benefit from combined manipulation and manual mobilisation (Mercer et al, 2006). The physiotherapists consulted by the participants in this study may therefore have been practising according to the available evidence, resulting in disappointment for some participants.

Hands-on treatment

There is an interesting subgroup to be considered here. The two participants who did receive hands-on treatment (and had expected it) had a very good treatment outcome, considered their goals to be fulfilled, were satisfied with their physiotherapy overall and considered themselves to be self-managing some months following discharge from physiotherapy. For these participants hands-on treatment clearly "worked". This is in keeping with previous studies which have also reported high levels of satisfaction from LBP patients for hands-on treatment (Layzell, 2001) and for chiropractors, who commonly employ such treatment techniques (Nyiendo et al, 2000; Pincus et al, 2000). However, these were also the only participants in the sample who requested referral to physiotherapy, suggesting they were knowledgeable about what might help their LBP and that they were motivated to try to do something about it. It therefore may be the motivation and expectation that physiotherapy would help them that resulted in the good outcome, rather than the treatment itself, a phenomenon found by previous researchers (Metcalfe and Klaber Moffett 2005b; Morlock et al 2002).

However, Kalauokalami et al (2001) found that expectations related to a specific treatment (acupuncture or massage in their study) were more predictive of outcome than average expectation or general optimism regarding improvement in LBP, and Linde et al (2007) demonstrated a significant association between higher outcome expectations (also from acupuncture) and higher levels of improvement. Does this mean that the participants who received hands-on treatment in this study had a good treatment outcome because they received the treatment that they believed would help? This would be an interesting question to address in further research, but there is clearly a need to elicit patients' expectations not only of outcome, but also of specific treatments. This would allow patients expectations to be considered in relation to the current evidence base regarding physiotherapy for CLBP and allow for treatment choice to consider patients' expectations.

Clearly this presents several challenges for physiotherapists. Where patients have high expectations of treatments that are not recommended by the evidence base it will necessitate discussion, explanation and alteration of expectations where possible. Where the evidence is equivocal or indeed good quality research is lacking, the decision regarding treatment choice will be a challenging one for the physiotherapist, until further research on effectiveness of different treatments for CLBP has been carried out and guidelines refined.

Other, less common, treatment expectations were advice on coping with LBP, electrotherapy, or group treatment. The latter two were directly influenced by previous experience; advice on coping strategies was not exclusively linked to previous experience however. Advice on LBP and how to cope with it is seen as an integral part of CLBP management by physiotherapists (Mercer at al, 2006; Bekkering et al, 2003). That it was a less common expectation again suggests that patients' perceptions of physiotherapy for CLBP are perhaps not yet congruent with current guidelines, and that this needs to be addressed in some way, as discussed above. When expected, coping strategies were not consistently delivered, and some patients in this study suggested that group treatment may have been a factor here suggesting that this treatment method requires further exploration. This is discussed further in section 2.6.3.

Delivery of physiotherapy

Regarding the delivery of treatment, expectations were of long sessions (longer than turned out to be the case), a large amount of contact with the physiotherapist, and a diagnosis to be made, or explanation provided. Previous authors have highlighted the importance of diagnosis to LBP patients when attending health professionals (Verbeek et al, 2004; Klaber Moffett et al, 2000), and the perceived value of tests and x-rays (Werner et al, 2005; Verbeek et al, 2004), also a common theme in this study. The findings relating to diagnosis are somewhat contradictory however. For some there was frustration from not receiving a diagnosis based on x-ray findings, however participants who wanted an explanatory diagnosis from the physiotherapist were satisfied with the explanation they received. This again highlights the importance of establishing individual patients' expectations regarding diagnosis and explanation. Long sessions do not appear to be specifically detailed in the literature; however Verbeek et al (2004) in their review of patients' expectations of LBP treatment found communication and consultation to be an important factor across professions. It may be that the long sessions and contact with physiotherapists expected in this study is a function of wanting a reasonable amount of time to allow for communication and consultation with the physiotherapist.

Duration of physiotherapy sessions

Participants wanted to spend these long sessions doing their exercises with the physiotherapist; clearly they expected exercises, but the way in which they were carried out was not as they expected or wanted. It is of note that those who expected long sessions or to have a large amount of contact (doing exercises with the physiotherapist) either had no previous physiotherapy experience or had experienced physiotherapy abroad which followed a model of intensive exercise-based rehabilitation. These patients' lack of experience or previous positive (in their minds) experience may have resulted in an "ideal" expectation (Staniszewska and Ahmed, 1999, p 369). Whereas patients with previous experience of NHS physiotherapy in this country may be more likely to hold "realistic" expectations (Staniszewska and Ahmed, 1999, p 369) influenced by an awareness of the political and economic factors associated with their physiotherapy provision. Ideal and realistic expectations were proposed by Staniszewska and Ahmed

(1999) in their study of cardiac patients, but the categories would seem appropriate in the context of this study also. Patients may ideally want to spend more time with their physiotherapist, but those with previous experience of waiting times and busy physiotherapy departments may perceive such expectations as being unrealistic.

Lack of expectations

Of course, some participants in this sample had no expectations of physiotherapy, which for some was due to having no previous physiotherapy experience. This is not a new phenomenon; Payton et al (1998) found that almost half their sample had no expectations of either the role of the physiotherapist or what to expect during physiotherapy. Results of the current study suggest that there is still a need for some patients to be informed about what to expect when they attend physiotherapy for the treatment of CLBP. This could involve information giving by the GP or consultant at the referral stage, by the physiotherapy department at the point of being contacted to offer an appointment or by the physiotherapist on the initial visit. The latter may be particularly relevant for those patients who self-refer, as this may be an increasing number considering the success of self-referral in Scotland to date (Holdsworth et al, 2007; 2006).

Information leaflets have been developed previously to inform patients of the process of outpatient physiotherapy. For example Roberts (2006) developed a leaflet explaining to the prospective patient several factors such as what to wear, how long the appointment would last and who they would be seen by. Most patients in Roberts' (2006) study evaluated the leaflet as helpful. Whether information in this format could be developed to inform CLBP patients of the probable content and delivery of physiotherapy would perhaps be worthy of further exploration.

For some, their lack of treatment expectations was attributed to a previously negative experience in physiotherapy. These patients had gone to physiotherapy on their GP's request, not expecting it to help. Unsurprisingly they did not rate their physiotherapy as helpful for their LBP, further evidence that negative expectation can adversely affect outcome (Metcalfe and Klaber Moffett 2005b; Morlock et al 2002). The question of why these patients would return to physiotherapy at all is of interest. The suggestion from the data was that they wanted to try new or different treatments, a reason for repeated medical care seeking in CLBP patients reported by McPhillips-Tangum et al (1998). However, several patients in this study implied that they did what their GP suggested unquestioningly because they "knew best" or because they didn't want to be non-compliant; this may explain why patients would attend physiotherapy despite believing it wouldn't help. This suggests a need to explore patients' motivations for attending physiotherapy in order to predict who may or may not benefit from being referred. Indeed, Metcalfe and Klaber Moffett (2005b) reported that patients who had received treatment for the same condition (degenerative lower limb condition in their study) were more likely to be dissatisfied with healthcare and therefore have low expectations of their current treatment. This again implies that physiotherapists need to explore previous physiotherapy and healthcare experiences and how they may influence the current treatment outcome.

Expectations of what physiotherapy would achieve

Pain relief

Previous research has found that patients with CLBP seek medical or chiropractic care with the expectation of receiving a diagnosis, pain relief, advice (Verbeek et al, 2004; McPhillips-Tangum et al, 1998; Sigrell, 2001) and improving mobility (McPhillips-Tangum et al, 1998). Patients with acute LBP were found by Grimmer et al (1999) to expect pain relief and advice from physiotherapists. The current study shows that the CLBP patients interviewed here consulted physiotherapists primarily with the expectation that pain-relief would be the outcome.

Advice

Secondary or less common expectations were those of advice and explanations, and enhancing activity and participation. Advice centred on dealing with LBP and being shown strategies for self-management and to prevent recurrence or deterioration. Explanation largely centred on diagnosis, whilst activity and participation was related to the home, work and social activities. These results are therefore in keeping with previous work on LBP, suggesting that patients want the same outcome from physiotherapy as they do medical care, and that both acute and chronic LBP patients have the desire of reducing pain and understanding their condition.

Self management

The fact that patients expected advice on self-management strategies in this study is encouraging, suggesting that some patients are willing to embrace the concept of being responsible for managing their condition, in line with current recommendations for chronic conditions (SEHD, 2005a). However, the predominance of pain-relief as an expectation in this and the studies mentioned above would suggest that there is still a perception that CLBP can be "cured" or relieved to some extent. Current thinking on CLBP is that the aim of physiotherapy is to enhance activity and participation and not necessarily reduce pain; but that coping strategies such as pacing, relaxation and goal-setting will allow patients to better control and live with their condition (Bekkering et al, 2003). This suggests that physiotherapists' and patients' goals of CLBP management may differ and lead to dissatisfaction with treatment outcome, as experienced by some patients in this study and previously (Verbeek et al, 2004). It also may help explain why patients frequently cite lack of pain relief as a dissatisfying feature of physiotherapy (Layzell, 2001). This suggests that there is a need to address public perceptions of the purpose of physiotherapy for CLBP. Indeed, general population surveys have shown that people commonly hold beliefs about LBP that are not in tune with current medical knowledge (Werner at al, 2005; Layzell, 2001; Klaber-Moffett et al, 2000), but that it is possible to alter these beliefs (Buchbinder et al, 2001). Therefore, strategies to inform patients of what to expect from physiotherapy for CLBP may be helpful, and could be delivered with relative ease and cost-efficiency in the form of a leaflet either at the time of referral to the service or on receipt of an appointment.

Facilitating change in expectations

There was a recurrent theme in this study of pain-related goals predominating at the start of physiotherapy, but the outcome being measured more in terms of self-management and activity. This suggests that it is possible for patients' expectations to change over the course of treatment, perhaps from "ideal" to more "realistic" expectations as described above. This study did not explicitly explore the mechanisms by which this took place, however the patients in this category all rated the advice they received, the level of individual attention and communication skills of their physiotherapists very highly. It may be possible therefore that with enough contact and adequate information and communication, patients' beliefs regarding what physiotherapy can achieve could be influenced within the timescale of a number of physiotherapy sessions.

There are two important implications for physiotherapy practice here. Firstly, as for expectations of the content and delivery of physiotherapy, it is vital to determine what patients' expectations of outcome are from the outset. Secondly, any mismatch between patients and physiotherapists expectations should be addressed during the course of physiotherapy, in light of the knowledge that expectations can change. This obviously poses a challenge to physiotherapists, and more research on the mechanisms that can affect expectations is clearly indicated, but having good communication skills and adopting a "patient-centred" approach are clearly factors. What a "patient-centred" approach might consist of is explored further in section 2.6.3.

Outcome

Treatment goals relating to self-management and functioning were all achieved. These can be viewed as "ideal" treatment goals (Staniszewska and Ahmed, 1999) since they are in agreement with current guidelines on the aims of physiotherapy for CLBP (Mercer et al, 2006; Bekkering et al, 2003) and this is therefore not a surprising finding. Likewise, considering the discussion on pain-relief above, it is unsurprising that pain related goals or those relating to the physiotherapist "making you better" were less frequently achieved. However, treatment success was most often rated in terms of amount of pain reduction in this study, in keeping with previous work on LBP (Evans et al, 2003), further evidence that patients' expectations of what physiotherapy can achieve need to be addressed. Manipulation, and the challenges presented due to the findings from this data, has been discussed above.

The achievement of treatment goals did not always go hand-in-hand with satisfaction in general. This confirms the findings of McCarthy et al (2005) who did not find a simple linear relationship between expectations and satisfaction in their multidisciplinary pain service patients. It may also be further evidence that the process of care is at least as important as the actual treatment itself, since patients can be dissatisfied with treatment but satisfied with their overall care (George and Hirsh, 2005; May, 2001). The process of care is also further explored in section 2.6.3.

2.6.2.5: Summary of expectations

The findings described and explained above can be summarised in three key points:

1. This research has demonstrated in a UK sample of CLBP patients that expectations regarding physiotherapy treatment and its outcome are not always congruent with the treatment and outcome actually experienced. This is in contrast to the finding in the pilot study (section 2.4), highlighting the importance of including the diverse sample in this study. It is however in agreement with research on LBP of shorter duration (Grimmer et al, 1999) and research on expectations of physiotherapy in general (Potter et al, 2003b), suggesting that the CLBP population hold similar treatment and outcome expectations to those with other conditions.
2. This research has demonstrated the need for physiotherapists to determine CLBP patients' expectations of treatment, diagnosis, and outcome. Where these expectations conflict with the aims of physiotherapy for CLBP, there is a need to attempt to change patients' expectations from ideal to more realistic status, since these expectations are more likely to be met and to be associated with both achievement of treatment goals and satisfaction. The mechanism by which this can be achieved needs to be the subject of further research.
3. This research has demonstrated in a UK sample of CLBP patients that expectations were influenced by previous physiotherapy experience, motivation for attending physiotherapy, and level of belief in particular treatments. The potential for influencing expectations should therefore be further explored in terms of influencing individual patients' expectations when they are first referred to physiotherapy, but perhaps by also influencing public perceptions of physiotherapy for CLBP.

The extent to which these findings can be generalised is considered in section 2.6.6, after the findings for the three remaining topics have been presented. Likewise, the specific implications for practice and education and recommendations for further research are considered in section 2.7, in combination with those of the remaining sections of data analysis. The focus now turns to patient-centred physiotherapy.

2.6.3: Patient-centred physiotherapy

This section relates to research questions three, four and five, which were:

3. What do patients perceive patient-centred physiotherapy to be?
4. Is physiotherapy provision for CLBP in Grampian currently patient-centred?
5. Could anything else be done to make physiotherapy provision for CLBP in Grampian more patient-centred?

Interview questions four and six to nine (Appendix 7) were designed to answer these questions since they related to the following topics. What participants thought of the physiotherapy they had received, what they thought of any advice or explanation they received, how involved they were and wanted to be in their physiotherapy, and whether they felt their physiotherapy fulfilled their individual needs.

The above interview questions therefore informed four subthemes in the index used to organise the data (table 2.5.4. p82); "views about physiotherapy", "advice/explanations", "involvement" and "individual". Fourteen further subthemes also emerged from the data and were included in the index. These subthemes contributed to the two main themes of "physiotherapy experience" and "process of physiotherapy" (table 2.5.4). Two subthemes have been analysed and discussed previously; "expectations" and "need for tests/x-rays" were analysed in relation to expectations of physiotherapy (section 2.6.2).

Due to some overlap in content, the remaining subthemes were consolidated into 11 themes for analysis. Each of these themes was assigned to a framework chart and analysed to produce numerous categories and classes of data. Tables 2.6.4a and b display the themes, categories and classes in which groups of categories were arranged. They also display which data contributed to which higher order classes, or dimensions, that emerged from further analysis. These dimensions are displayed in figure 2.6.4 and are the six dimensions that participants in this sample reported as being important in their physiotherapy encounter.

Table 2.6.4a: Patient-centred physiotherapy: categories and classes of data and the dimensions to which they contributed, subthemes 1 to 7

Subtheme (from index)	Categories (examples)	Classes	Dimension
Advice/ explanations	Pleased, helpful, well explained, individualised	Positive	1,2,3
	Dissatisfied, too simplified, unanswered questions	Negative	
	Access to advice post-discharge, "push" patients	Suggestions	
	No advice recalled, related to exercises only	Statements	
Exercises	Helped, not helped, nothing new	Satisfaction	1,2,4,6
	Pleased, interesting, felt stupid, lack of understanding	Attitudes	
	Individualised exercises in group, "push" patients	Suggestions	
	Factors affecting, desire for physio to "push" patients	Motivation	
	Factors affecting, desire for more frequent attendance	Compliance	
Interventions	Perceived effectiveness	Effectiveness	2,6
	Wanted more, less, none, different	Preferences	
	Didn't need, needed more sessions	Opinions	
Group	Swapping of information, dependency	Peer support	2,3,4,6
	Being addressed/not in group, barriers to group	Individual needs	
	Boring, helpful, waste of time, enjoyable	Opinions	
	Skill variability of physio, continuity	Competency	
	Thorough workout, too gentle, not progressed	Intensity	
Involvement	Patient-therapist communication, information	Communication	1,2,3,4,5,6
		Assessment	
	Examination, diagnosis, re-assessment	Decision-making	
	Power, needs of patient, choice	Physiotherapist	
	Continuity, time, approach of physiotherapist		
Individual	Patient-therapist communication	Communication	1,2,4,5,6
	Perceived appropriateness of treatments received	Intervention	
	Relevance of treatment, manner of physiotherapist	Positive	
	Lack of choice/continuity, not to needs/liking	Negative	
Contact	Wanted more frequent contact	Individual	4,6
	Contact just right		
	More one-to-one contact with physio	Group	

Key: 1=Communication; 2=Individual Care, 3=Information sharing; 4=The Physiotherapist, 5=Decision making; 6=Organisation of care

Table 2.6.4b: Patient-centred physiotherapy: categories and classes of data and the dimensions to which they contributed, subthemes 8 to 11

Subtheme (from index)	Categories (examples)	Classes	Dimension
What Patients Want	Continue, review, follow-up, direct access	Access	2,6
	Contact, duration	Quantity	
	Group discussion, self-management, diagnosis	Information	
	Intensity, interventions, individualised, continuity	Treatment	
Physiotherapist	Level of confidence in physio, tried hard, didn't help	Competence	1,4
	As described by patients	Personality	
	Listening, explaining, understanding, encouraging	Communication	
Duration	Enough/not enough sessions	Number	6
	Long/not long enough and reasons	Length	
	Sessions too far apart	Frequency	
Organisational issues	Stretched, friendly, local	Views	1,4,6
	Need for short waiting time	Waiting time	
	Communication problems regarding appointments	Communication	
	Direct access, flexibility	Access	

Key: 1=Communication; 2=Individual Care, 3=Information sharing; 4=The Physiotherapist, 5=Decision making; 6=Organisation of care

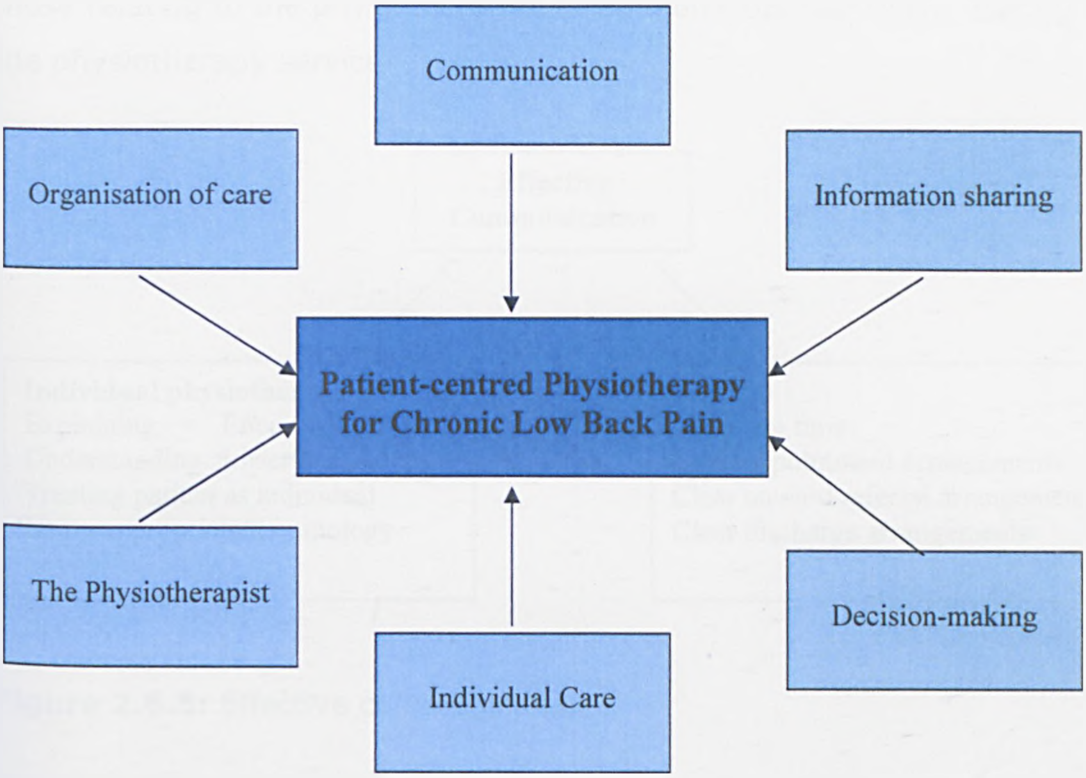


Figure 2.6.4: Six dimensions that participants reported as being important in their physiotherapy encounter

These six dimensions of importance to CLBP patients appeared to contribute to a concept of patient-centred physiotherapy for CLBP. Each of the six dimensions is now described and explained in detail.

2.6.3.1: Communication

There was not a specific interview question relating to communication. However, all participants talked about this topic during the course of their interviews. Most commonly communication was discussed in relation to the interview questions on advice, feeling involved in the treatment process, and the physiotherapy being guided by their individual needs (questions 6, 8, 9 & 10, Appendix 7). Additionally, communication was recurrently discussed when participants were describing their attitudes towards the individual physiotherapist/s who were involved in their treatment. A final, smaller, subgroup discussed particular issues regarding organisation of appointments. Figure 2.6.5 displays the factors that participants reported as being important for effective communication. These fell into two groups, those relating to the physiotherapist as an individual and those relating to the physiotherapy service.

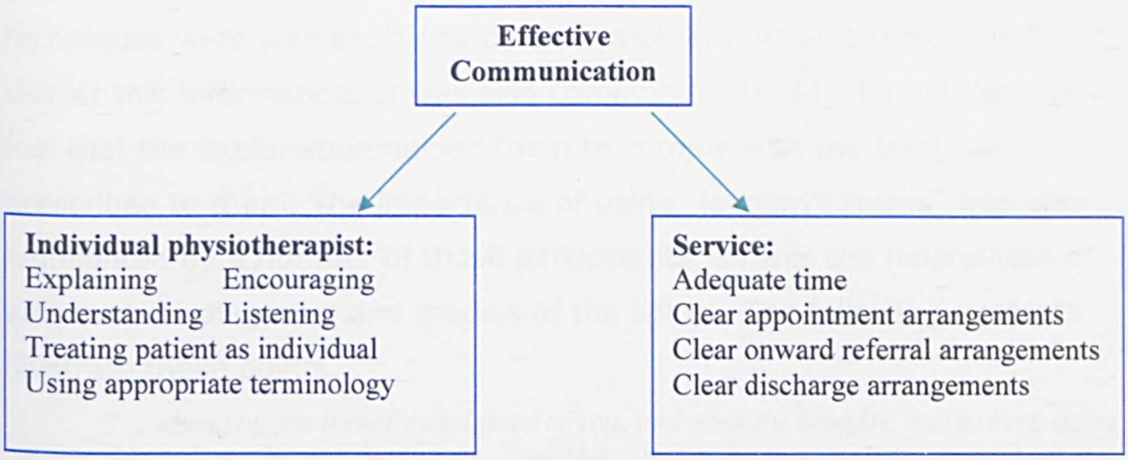


Figure 2.6.5: Effective communication

It was more common for participants to be generally satisfied with the communication between the physiotherapists and themselves than to be dissatisfied. However, this was recurrently qualified with a "but" and suggestions for how communication could have been improved upon. Analysis of the framework charts revealed that the participants who were dissatisfied with patient-therapist communication were dissatisfied with physiotherapy in general and considered their goals to be unmet. One participant was particularly dissatisfied with the written communication between the physiotherapist and herself (the booklet she received on LBP was "too simplified" and didn't relate to her pain) but on balance was still satisfied overall with the outcome of physiotherapy. However, there were other factors involved in these participants' dissatisfaction, and there were other participants who were dissatisfied with physiotherapy but not necessarily with the communication aspect.

Therefore, it would be too simplistic to suggest that poor communication caused these participants' dissatisfaction. However, the fact that all participants discussed communication suggests it was an important factor to them, and their views can be used to describe what patients consider effective communication to be, and indeed the types of communication they do not wish to be exposed to. These are now described in relation to the individual physiotherapist and the service.

Communication and the individual physiotherapist

Advice/explanation

Participants were commonly pleased when their diagnosis and treatment techniques were well explained by a physiotherapist who took time to deliver this information. It was also common for those who held this view to feel that the explanation helped them to comply with the treatment prescribed to them. The importance of using "layman's terms" was also highlighted by a number of these participants, as was the helpfulness of aids such as diagrams and models of the spine. The following excerpts illustrate these points.

> *"... when you got it really explained to you, and what the benefits, and to keep doing this, to keep the muscles in tone. You think, especially if you've got chronic back pain, you think well, I'll do anything if it's going to help ease it and make it easier for me to cope with, I'll definitely do it."* (Participant 5, 48 year old female)

> *"You know not everybody knows medical speak (...) But, if you have a good understanding in layman's terms...and because the physiotherapist explained it to me (...) Ever since then I've a clear understanding of what exactly is happening to my back when it goes out, what needs to be done, and how to get back on track."*
> (Participant 1, 39 year old male)

> *"... in the limited time and the resources they'd taken the time to TRY and explain things to you and asked how you felt about things as well, ken... as soon as I saw [Physiotherapists name], he got a model of the spine and he explained he showed me the bits. It makes it easier for me, it's clearer, you can actually see what he's speaking about"* (Participant 14: 41 year old male)

However, some participants did not appreciate such models or diagrams, highlighting the importance of communicating in the manner appropriate for each individual patient.

> *"Well, they showed me diagrams and skeletons and things like that and I was none the wiser, 'cause I was...it was too technical I suppose in a way..."*
> (Participant 4, 52 year old female)

Dissatisfaction, although less common, arose from not being able to understand the physiotherapist's technical information and a perceived lack of explanation of treatment options.

A group of participants were particularly dissatisfied with a form of written communication, "the back book", citing it as "too simplified", and "insulting" as one of the participants explains.

> *"If you have a really bad back, I'm telling you that book, somebody whoever wrote that they've never suffered like what I've suffered"*
>
> (Participant 2, 57 year old female)

This was a minority view, and since most participants had no recall of written information it was impossible to determine the true extent of this viewpoint. However, it does further illustrate the importance of advice and explanations (written or verbal) being relevant to and suitable for the individual receiving them.

Involvement

Most of the participants felt involved in their physiotherapy to some extent, however a subgroup felt that they were not involved in the process. Communication was one of the key factors associated with involvement. Participants recurrently cited the following as making them feel involved in their physiotherapy:

- Two-way discussions
- Good explanations
- Being listened to
- Being given the opportunity to ask questions

These are demonstrated in the following two excerpts which discuss the reasons for feeling involved.

> *"... She always asked me how I was getting on, how things were you know, how I was feeling. .. if I wanted to ask any questions I could of asked. And eh, if I'd any problems. .. Yes, she was helpful, and if I wanted to ask anything (...)"*
>
> (Participant 10, 59 year old female)

> *"I would have said it was a reasonable two-way process... I would say it was the right level. Rather than me just sort of turning up and saying you know, stand there, bend over, do this, you know how far can you bend... I came away feeling satisfied that something was being done and that I was involved in it.*... It was relaxed and friendly, but businesslike...You know...you felt at ease right from the start"
>
> (Participant 12, 64-year-old male)

A small group of participants attributed their lack of involvement to not being given an opportunity to fully discuss their needs with the physiotherapist and not being given adequate explanation of their treatment. This again illustrates the importance of effective communication, specific to the individual patient's needs, demonstrated in this excerpt.

> *"They tell you what you need. You know they think, well I think you need this, well, I think I need something else. You know, you can't sort of be abrupt and cheeky, so you think, oh well they think I need that, or sometimes you think: I don't need that, they don't understand what I need, you know they're not listening to me"*
>
> (Participant 3, 50 year old female)

Individual needs

This is discussed in detail later in this section. However, the physiotherapist listening, understanding, getting to know the patient, allowing the patient to explain their problem and allowing the patient to question them were recurrently cited in relation to whether the participants felt their treatment was tailored to their individual needs. The small group discussed above who felt that poor communication led to a lack of involvement in the treatment process also felt that their treatment was not related to their needs. However, it was more common for participants to feel their treatment was not individualised than to feel a lack of involvement. Clearly, communication is one factor in a complex relationship here.

The Physiotherapist

This is also discussed later in this section. Participants commonly had no particular complaints about the individual physiotherapists that they saw. Of these participants, there was a group who felt that being good at many of the aspects of communication described above was what made them pleased with the individual physiotherapist. Spending time with patients, listening, explaining and demonstrating, being encouraging and understanding were all important factors. Dissatisfaction was due to a perception that the physiotherapist didn't understand the participant's pain or address it adequately during treatment.

Communication and the physiotherapy service

A small group of participants had experienced problems with the organisation of appointments. For some this was related to appointments being cancelled (by the physiotherapist) and not being rescheduled, or being rescheduled more than once, resulting in the participants getting "fed up" and not going back. For others the confusion surrounded onward referral. One participant was sent for an x-ray and expected to be invited back for more physiotherapy following the results, being disappointed that she was never contacted. For another there was an expectation of a hydrotherapy referral which never materialised. Interestingly, the physiotherapy notes classed both these participants as "did not attend" suggesting the physiotherapists considered there to have been appointments arranged and missed. It was not possible to further investigate the reasons for these discrepancies but it is interesting to note the importance of effective communication throughout the whole physiotherapy process, not just the actual attendance's at the physiotherapy department.

Good communication appears to be important at every stage in the patient's journey from referral to discharge, and not only during the face-to-face encounter. Good communication appears to be one of the factors at play in making patients feel involved in their physiotherapy and perceiving their physiotherapy to be related to their individual needs.

2.6.3.2: Individualised Care

There was one interview question relating to whether participants considered their physiotherapy to be guided by their individual symptoms and what they felt they needed (question 9, Appendix 7). However, participants frequently began discussing the individual nature of their treatment much earlier in the interview, without prompting, in relation to their LBP history, expectations and general satisfaction with physiotherapy (questions 1 to 4, Appendix 7). This confirmed the importance of this to topic to the participants.

Participants' opinions fell into two broad groups: those who felt treatment was related to their individual needs, and those who didn't. The former group comprised those who were generally satisfied with physiotherapy as a whole and whose goals were either achieved, or if not achieved a qualifying comment about it not being the physiotherapist's fault was made. There was one exception here. One participant who felt the treatment was individualised was overall dissatisfied with the outcome and her goals were not met, however, she was pleased with the way the physiotherapist "tried to get to the bottom of her symptoms". This could suggest a link between overall satisfaction, goal attainment and a perception that treatment was individualised. However, the link is not as straightforward as suggested since the latter group (those who felt treatment wasn't related to their individual needs) comprised both satisfied and dissatisfied participants, and those whose goals were achieved and unmet. This again suggests a complex relationship between several factors and overall satisfaction, with different factors being of greater importance to some participants than others. There was an additional smaller group of participants with a more neutral opinion regarding individualised treatment. These opinions ranged from assuming all back pain and therefore treatment to be the same, to assuming that treatment was "geared to individual needs" but not having a further opinion, to being unsure whether treatment was geared to individual needs or "just exercise in general".

Within the two larger groups who expressed opinions regarding the individualised nature of treatment, these opinions related to two dimensions; the treatment itself and the way in which treatment was delivered. Figure 2.6.6 summarises the relationship between individualised care, which is described and explained below, and the previously discussed dimension of communication.

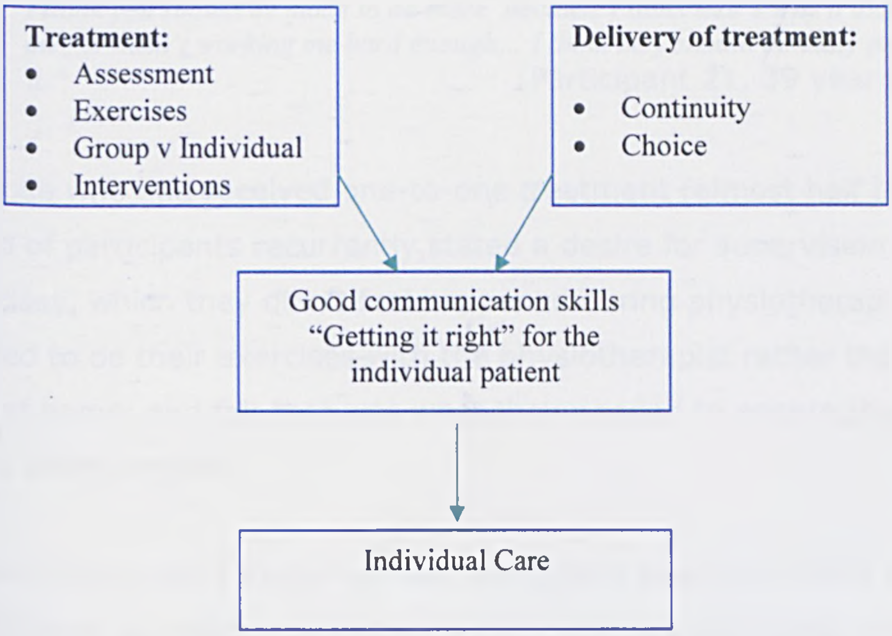


Figure 2.6.6: Dimensions of individualised care and relationship with communication

Individualised treatment

Exercises

Exercises and how they were/weren't adapted to the individual's needs was a common theme. This was unsurprising since most participants had received exercises as part of their physiotherapy. Those who described their exercises as making sense to them and being well explained felt that their individual needs were being addressed, again confirming the importance of good communication discussed previously. Those who felt their exercises did not address their individual needs commonly felt that the reasons for doing them didn't make sense or that they weren't pushed hard enough when doing them, as these participants explain.

> "*They gave me like a diagram out the computer and (...) she kept saying something about...opening up....em...something to do with stomach muscles, I can't remember what...Some kind of balance, you had to get the balance right, I can't remember...Core...core*
> ***Interviewer**: Core stability?*
> ***Respondent** Stability, that's it. And I haven't got a clue what she was speaking about! She kept going on about core stability...*"
> (Participant 4, 52-year-old female)
>
> "*You felt like you weren't doing anything. Like there was no movement but they'd say it was OK... But I felt like it wasn't doing anything. I felt stupid just lying there doing that. I think you should be made to do more. Because I think that's why it didn't work for me...It wasn't working me hard enough... I think they should actually push you to do it.*" (Participant 21, 39 year old female)

Of those who had received one-to-one treatment (almost half the sample) a group of participants recurrently stated a desire for supervision of their exercises, which they didn't feel happened during physiotherapy. They wanted to do their exercises with the physiotherapist rather than on their own at home, and felt that was what they needed to ensure they were doing them correctly.

Several participants explained that the type of exercise affects their compliance, admitting to doing only the exercises that fitted in with their lifestyle. This suggests that the physiotherapist needs to explore that lifestyle and what is acceptable or realistic to prescribe for the individual patient, as these participants describe.

> "*I think the impression a lot of people get is that, that physiotherapists in general give you, a, a recommended type of exercise, which is very specific to the back problem at hand. And these are the types of exercises that you would do on your living room floor. And because of that people haven't got the motivation to do this on a daily basis...*"
> (Participant 1, 39 year old male)

> *"I can do them when I'm sitting at my desk or in the car- and I do extra if I feel my back getting sore, it stops it from getting worse. I don't do them at set times or anything, just whenever. I can be lying in my bed and think, oh, I'll do some of the exercises, or when I'm sitting at my desk, 'cause they're really easy to do."*
>
> (Participant 25, 38 year old female)

Group rehabilitation

This is closely linked with exercises, since exercises were the mainstay of group rehabilitation. Almost half the sample had experienced group rehabilitation, either as their only treatment or in combination with one-to-one physiotherapy. There was a recurrent theme of participants who had received group rehabilitation feeling that their individual needs were not addressed in the group environment. Some examples are presented here.

> *"... fair enough you were all suffering from back pain, but we were all different, you know we might have all needed different exercises (...)...So, it was like just back pain, everybody had just one back pain, and we'll treat this one as we're all the same."*
>
> (Participant 3, 50 year old female)

> *"Being in a group situation, and the fact that being in a room together and sharing the experience together was OK but, as I say, you could be getting physiotherapy in the same room but your physical needs could be slightly different from mine, so, instead maybe not doing the exact same exercises the same amount of time"*
>
> (Participant 14, 41 year old male)

For two participants the group was unsuitable for them (in their opinion). This was due in one case to it being "boring" and a "waste of time". This participant admitted to disliking anything related to "going to the gym" and associated the group with this. For the other participant she felt "embarrassed" and "uncomfortable" in front of other people. Both stopped attending physiotherapy for these reasons.

Participants' dissatisfaction with the group was not related to the location of physiotherapy, indeed participants treated in the same department could have very differing views of the group rehabilitation. Rather it seemed to relate to the individual physiotherapists taking the group sessions, illustrated by the following.

> *"We felt some weeks it was a waste of time...I felt, some, sounds very critical, I felt some physio's were better than others when it came to the back class.*
> ***Interviewer:*** *So the physio's that were better then, how were they better?*
> ***Respondent:*** *They seemed to be more organised, I think that was the key...They would set aside a time, organised you there, someone else went somewhere ... And then she got you together at the end to do certain things. Give you some advice and things. And that sometimes didn't happen with the other ones. You sort of finished your exercises and they'd let you go if you want."* (Participant 21, 39 year old female)

Indeed the less common theme of feeling that treatment within the group *was* related to individual needs went hand-in-hand with being particularly satisfied with the individual physiotherapist involved, typified by this excerpt.

> *"You'd gone through maybe six different, six or seven different sets of exercises. And they were tailored to your...my problem. Each person had a sort of individual (...) with which exercises to do...I thought it was very professional, much better than you know previous."* (Participant 12, 64 year old male)

This suggests that the use of group rehabilitation may need careful consideration as to which patients it is suitable for and how to address the individual needs of patients in this environment. The consideration of which physiotherapists possess the appropriate skills to lead such groups may also require consideration.

Another small group of participants who felt that the group did address their needs particularly liked the support they received from the other patients in the group (sharing of information and feeling that they were not alone in their experience of LBP). These participants all expressed a desire to continue group treatment beyond the time they had received, or to return "every so often" for more group rehabilitation. Perhaps the group was a victim of its own success for these participants, or perhaps their individual needs relating to long-term support need to be addressed in some way. This theme is explored further in section 2.6.4.

Common to both group and one-to one treatment were participants who felt their treatment was both "too gentle" and that they were not "pushed" hard enough, and those who felt they had a "good workout" at physiotherapy. These were minority views but nonetheless confirm that whatever approach is taken to physiotherapy (group or one-to-one) individual adjustments and feedback from individual patients is important.

Assessment and interventions

There were interesting, although less recurrent themes relating to these factors. A group of participants felt that the thorough assessment of their symptoms that they received enabled the treatment to relate to their needs, again emphasising the importance that many patients seem to place on this aspect of the physiotherapy process. Participants who received interventions (such as electrotherapy or manipulation) were divided as to whether they perceived them as helpful or not. A small group wanted more machine treatment than they received, perceiving that to be what they needed, but another small group felt that the machines were not what they needed, and instead wanted treatment that gave them more contact with the physiotherapist (supervised exercise in these cases). As discussed in section 2.6.2 the two participants who received manipulation felt their treatment was "exactly what they needed".

Individualised delivery of treatment

Continuity

Seeing the same physiotherapist each session for some contributed towards treatment being individualised. This was due to a feeling that the physiotherapist got to know the patient and their individual needs well which led to them being treated as a "person not a number". Participants with this view commonly had received treatment on a one-to-one basis, whereas one of the reported drawbacks of group rehabilitation was often the lack of continuity with different physiotherapists taking each session resulting in a "lack of personal treatment".

Choice

Choice was a factor for two participants: one who felt there was no alternative to the group but felt strongly that it was not what she needed, and one who felt that the possible treatment options were not fully explored with her before receiving "heat" treatment which she considered ineffective. Choice and decision-making are explored in detail later in this section, but clearly individual patients may have individual needs regarding the amount of choice they expect or want.

Communication

As discussed previously the physiotherapist's communication skills were often reported as affecting participants' perceptions of whether their treatment was tailored to their individual needs. Listening to and getting to know the patient appears to be important, as does the patient perceiving that the physiotherapist understands their problem, or "takes an interest" as this participant describes.

> *"You know I think it was the fact somebody was taking an interest I found surprising! It was something I'd never, ever been offered before."*
>
> (Participant 12, 64 year old male)

When this failed to occur some participants felt quite strongly about it.

> *"It was one of the physio's here…at the end of every group where you just lie and relax. And she kept saying you just keep fidgeting about, and I said I just can't lie and relax. For me for some reason…it seems when I lie on my back… it's painful and I said it's sore, and she was like, no, no, no, I said it is it's sore, she was like typical man, you just can't lie and sit at peace for a minute. And I was so annoyed, ken, just, 'cause I said well I am in bloody pain.."* (Participant 14, 41 year old male)

> *"First two times they had wrote to my doctor and said I was better and I wasn't. I was actually worse. They never came to me and said, are you better or anything like that. But then they're writing back saying to the doctor, and it's totally wrong"*
>
> (Participant 21, 39 year old female)

In summary, the extent to which the participants felt that their physiotherapy was related to their individual needs was affected by several factors, with equal numbers feeling that their needs were or were not considered. Participants wanted exercises that made sense, fitted in with their individual lifestyle, were of the right intensity for them and that were well explained and supervised by the physiotherapist. Group rehabilitation appeared to be more acceptable to some participants than others. Individual attention within the group setting appears to be important, as does assessing for whom the group is a suitable environment and which physiotherapists should be leading them.

A thorough assessment was an important factor for some, whilst exploring expectations and perceived needs in relation to specific interventions may have been beneficial for others. The manner in which treatment is delivered was important for many. Continuity, offering the right amount of choice and good communication skills all affected the extent to which participants felt their individual needs were addressed.

2.6.3.3: Information sharing

Participants' desire for information was discussed in part earlier in this section particularly in relation to advice giving, involvement and treatment relating to the individual's needs. In addition, most of the participants at some point in their interview explained what they would ideally have wanted physiotherapy to be like ("what patients want", subtheme 8 table

2.6.4b) and one of the recurrent themes for these participants related to information. This highlighted the importance of information to these participants.

What participants ideally wanted was information on their diagnosis and what it meant for them and, for those who had experience of groups, more group discussions.

Diagnosis and its implications

A well explained diagnosis was important for many participants, and has been discussed previously. For some however, this extended to wanting to know what that diagnosis meant longer-term and where they should go following physiotherapy, for example:

> *"I think I would like more investigation into why. If it's just wear and tear, why...That's, you know, there's lots of lower back pain, but nobody can tell us why... And is it going to get worse? Or is it going to stay like this?*
>
> (Participant 15, 60 year old female)

> *"Maybe they could have suggested something else, you know...Maybe, as I say a follow-up and maybe they could suggest something else then, that you're not, that you don't know about. Or either that or when you go back and they say well this is it, this is all we can do. Then you know where you are."*
>
> (Participant 20, 53 year old female)

> *"I think by the middle or the end of my treatment I would have expected to know what was going on, what was wrong with my back...Yeah. I think, if it's curable or if it's not. If it's just going to be a long-term thing. I would like to have found out."*
>
> (Participant 22, 33 year old female)

For others this was more directly related to the diagnosis and a desire for more information on their condition, such as:

> *"I think a little bit more education, em, in the way of, what's actually going on in your back. I mean obviously in layman's terms, but, to be able to break it down to the general people and say well, look this is how your back's made up, em, this is what's actually happening to your back, and this is the areas you need to be looking at building up on, or, or, working with to try to prevent it."*
>
> (Participant 1, 39 year old male)

> *"I think [I'd have liked] some more insight into the back pain, and really find out what's going on, you know, and just really which would be the best treatment"*
>
> (Participant 3, 50 year old female)

These participants had a clear need for information on their condition that they felt was not provided in physiotherapy. Of course, the extent to which physiotherapists can provide such information may be a matter of debate.

Physiotherapists may avoid making statements regarding exactly what is wrong with the back or to what extent the pain can be cured, since exact diagnosis and prognosis is a problematic area in CLBP management. However, perhaps the types of information patients are looking for should be explored, and a discussion entered into on what information the physiotherapist can confidently provide.

Group discussions

There were mixed opinions on the benefit of group rehabilitation as discussed above. However, the most recurrent positive comment was that group discussion and sharing information with other patients was the most helpful part, and should be done more frequently. One participant who had experiences of groups taken by several different physiotherapists sums up this view.

> *"The last time I went, it was a bit better. Because the lady that was there she would have you come in, do your exercises. She would make sure you did it properly, go round everybody. And then the last ten minutes she would sit everybody down and ask them how their backs, and explain to us not to sit down, she did that bit...It was better that she was explaining to everybody and like asking everybody there their experience...I think it's helpful. And you learn as well by the other people speaking. Some of them are having the same problems as yourself. So you can relate. And they ask what they're doing to make themselves better and stuff, what they think helps."*
>
> *(Participant 21, 39 year old female)*

In summary, information is clearly an important part of patient-centred physiotherapy for CLBP. That it emerges as an important theme in relation to so many different aspects of the physiotherapy encounter (advice, involvement, individualised, diagnosis, group) confirms its importance, and the data presented above demonstrates that not all participants were satisfied with this element of their care.

2.6.3.4: The physiotherapist as a person

The individual physiotherapist and their variable communication and treatment skills (particularly in relation to group rehabilitation) have been mentioned above. Overall, there were two important aspects relating to the physiotherapist that participants recurrently commented upon: their competence and personality. The interview schedule did not include a question relating to the physiotherapist as a person, but only one participant failed to discuss either or both of these aspects of the physiotherapists with whom they came into contact during their treatment for CLBP.

Competence

It was uncommon for participants to be negative about their physiotherapists. Even those who were dissatisfied with their treatment in general and whose treatment goals were unmet said something positive about the physiotherapist. This usually took the form of saying the physiotherapist was "nice" despite lacking in knowledge, or that she "did her best". Of course, the fact that the participants knew the interviewer was a physiotherapist may have affected their responses and encouraged them to find something positive to say about the physiotherapist. However, not every participant was positive. Those participants who made negative comments felt that the physiotherapists didn't understand or address their pain adequately. A group of participants had experienced (group) treatment from more than one physiotherapist and held the view that "some were better than others" in relation to organisation and individual attention within the group. Most commonly though participants felt confident in the physiotherapists' abilities and the physiotherapists were not blamed for failure to achieve treatment goals as long as they "tried hard" and were "thorough". Indeed, just under half the sample described the physiotherapist as "the expert on LBP" at some point in their interview. These participants expressed a desire to see a physiotherapist directly should their LBP flare up in the future, because "they know what they're talking about" and "have a great depth of knowledge".

Personality

Whilst dissatisfaction was linked with abruptness, the more common theme of satisfaction was linked to the following qualities:

- Caring
- Friendly
- Making patients feel comfortable/at ease
- Nice/pleasant
- Professional
- Showing an interest in patients

Thus, the physiotherapist as a person, with their individual physiotherapeutic and communication skills and personality traits can have a profound effect on how patients view their physiotherapy. However, it is not a simple relationship and being "nice" does not necessarily mean patients will be satisfied with their physiotherapy. Most participants said that the physiotherapist was "nice", but fewer were overall satisfied with the treatment they received.

2.6.3.5: Decision-making

Only one of the participants did not discuss decision-making in relation to involvement in the physiotherapy process. The remainder commonly held the view that since the physiotherapist is the "professional" or "expert" they should decide what is best and the patients should do what the physiotherapist decides. This was very much linked with communication, since participants were happy for the physiotherapist to make all the treatment decisions as long as they were accompanied by good explanations, as these participants demonstrate.

> *"I tend to not question what the doctor or the nurse or the physio should say. You know if the doctor says you need these pills I'll take them, so if the physio said you need this Pilates class you know, then I was going to do it...Preferably with a "this is what you need because", which is what she did*
>
> (Participant 23, 48 year old female)

> *"I'm coming here for advice and the people that I would expect to see are professionals. So no, I came to listen and be told...She explained what was happening...I did feel involved 'cause I was having to do it. But, she was very good at explaining how to do it, how long to sit in each position and what it was actually doing, so she was very good"* (Participant 16, 48 year old male)

A small group of participants were not satisfied with their level of involvement in decision-making. This was related to the type of treatment they received, either group rehabilitation or a "heat pad". They felt that the treatment was not what they wanted, but felt that there was no choice and were forced to go along with it, as these participants explain:

> *"After the three consultations, I didn't realise there was a class sort of thing, and she says oh well you go to this class and you do these sort of things."*

When asked about whether she chose to go to the class:

> *"Well they didn't really ask me...well, they just did what they were doing and I went along with it...I think that's the reason I got bored...Yeah, cause they didn't ask what I*

> *thought, what I thought I wanted. They didn't ask me what they thought I wanted, they just did what they assumed was physiotherapy."*
>
> (Participant 4, 52 year old female)

> *"Well, I think it would have been fine to say maybe what treatments you could get…I mean I wasn't offered any other treatment. I didn't know what I was going to get when I went in, I had no idea of the kind of treatment I was getting. They just said, oh, put me on to this heat-lamp."*

And later in the same interview:

> *"…if they'd maybe explained that there was different types of treatment, em I mean that other lassie got acupuncture and she got another kind of treatment, I'd never even heard of it. And I think just more information about the kind of treatment you CAN get really."* (Participant 13, 51 year old female)

Another group of participants felt that they were not consulted fully prior to the physiotherapist deciding on the course of treatment. These participants felt that they were not pushed hard enough in their physiotherapy – both felt that they wanted supervised exercise of a high intensity and were not satisfied with the treatment they were given which was exercise of a more gentle nature. Both felt that if the physiotherapist had consulted with them more they may have received more appropriate treatment.

In summary, decision-making for most participants was best done by the physiotherapist as long as it was accompanied by adequate explanation of the decisions made. Therefore, communication skills and ensuring the explanation is tailored to the individual's needs are once again important factors. For those who felt they weren't given adequate choice, perhaps an opportunity to have treatment explained more fully may have helped, since these participants also reported that they felt they weren't listened to by their physiotherapist and didn't understand some or all of the physiotherapist's information. Listening to what the patients feel they need again seems to be a key factor here.

2.6.3.6: Organisation of care

How physiotherapy was organised was not specifically asked about, but was discussed by all except two participants. Several different aspects of organisation were discussed, not all by each participant, but they belonged to two main categories; access to physiotherapy and amount of physiotherapy.

Access to physiotherapy

Access in the future was the main theme discussed by participants who either expressed a desire to be able to access physiotherapy directly (without having to go to their GP first) or for some sort of follow-up or review appointment. Direct access was seen as a way of getting to physiotherapy more quickly, as this participant who wanted the opportunity to return when her back "flares up" describes.

> *"Seems a shame that you've got to go through your GP to get the physio. You can't get the physio unless you get referred by your GP. It would be fine maybe if you'd more access to the physio... 'cause I mean the doctors are busy as well. And I know the physio's are busy as well, but you would think maybe it would be more, a bit more flexible and a bit more accessible."* (Participant 13, 51 year old female)

This topic is discussed in full later in this section in relation to self-management (section 2.6.4), but in relation to patient-centredness, there seems to be a perceived need for some kind of longer-term relationship with the physiotherapist for many CLBP patients.

Several participants felt that they had to wait too long to access physiotherapy, whilst those who were seen in departments operating a "triage" system were particularly pleased with not having a long wait for their first appointment. Triage and self-referral are systems which are being increasingly investigated and used in musculoskeletal out-patient departments (Horsey et al, 2006; Holdsworth et al, 2006). Whilst neither are the focus of this project, it is interesting to note participants' views on both.

The final recurrent theme regarding access to physiotherapy was in relation to the organisation of appointments, which was discussed previously (p113).

Amount of physiotherapy

The number of sessions, duration of each session, frequency of sessions and contact with the physiotherapist were all recurrent themes.

Participants most commonly felt they had not attended enough sessions of either group or one-to-one rehabilitation. The reasons they gave varied from feeling that more input motivates them to adhere to their exercises, to a desire for more appointments in the first week or two to learn their exercises, to admitting that the enjoyment of attending physiotherapy made them want to continue. These participants had all received between six and ten physiotherapy sessions.

It was less common for participants to feel they had received enough sessions, however this topic was not discussed by all (due to not being a specific interview question), and therefore it is not known how some of the sample felt about this. The few who did feel the amount of sessions were "just right" were those who went with specific expectations, had them fulfilled and were highly satisfied with the outcome.

In relation to duration, it was common to feel that the group sessions were of the right duration, but there were two responses regarding one-to-one treatment. Those who felt the one-to-one sessions were long enough were also pleased with their physiotherapist's communication skills, and felt that there was enough time to talk to and explain things to their physiotherapist. Those who felt the sessions were too short wanted to do their exercises with the physiotherapist instead of on their own at home, and felt that the sessions were not long enough to do this. Some participants commented that the physiotherapists appeared rushed or busy, as the following quotes highlight.

> *"I think I would have liked maybe erm, a little more time doing exercises with them... Because it is very rushed in there, um, it's a very busy unit, and maybe eh, a little more time, maybe ten minutes, fifteen minutes of actually doing the exercises with them"*
> (Participant 9, 62 year old female)

> *"I felt it was a bit too rushed, but, I didn't blame her for that. You know I knew she had a time limit, you know. Em, and so that would probably be my only wish perhaps would be to have it maybe double the time"* (Participant 23, 48 year old female)

It was less common for participants to express an opinion on the frequency of appointments. Those who did felt that they were too far apart. They were either participants who wanted to do the exercises with the physiotherapist and who wanted reassurance that they were doing the right thing by attending more frequently, or those who wanted more electrotherapy.

Almost half the sample discussed contact with the physiotherapist. For those who received group rehabilitation this related to the lack of individual or personal contact with the physiotherapist, as previously discussed. For those who received one-to-one treatment it related to wanting more time with the physiotherapist actually doing the exercises.

In summary, the way physiotherapy services were organised was an important factor for most of the sample. Access to physiotherapy (both initially and following discharge) is an interesting area, which has links with other topical research themes. Getting the amount of physiotherapy right from the patient's perspective is perhaps more challenging. Communication again is a factor here, as is determining patients' expectations, and perhaps addressing the need for some type of longer-term relationship. The longer-term management of CLBP is discussed in detail later in this section (section 2.6.4).

Definition of patient-centred physiotherapy

Figure 2.6.7 summarises the six dimensions described and explained above. It displays the factors that this sample of CLBP patients have suggested are important in providing patient-centred physiotherapy. In addition, as discussed previously (2.6.2), determining patients' expectations of physiotherapy interventions and their delivery are also important factors in providing patient-centred physiotherapy; therefore expectations is also included in this representation of patient-centredness. Thus patient-centred physiotherapy, as perceived by this sample of CLBP patients, is a complex combination of many factors, each of varying importance to the individual patient, each facilitated by effective communication. Therefore, figure 2.6.7 represents a patient-generated definition of patient-centred physiotherapy for chronic low back pain. The following discussion compares these findings to previous work on dimensions of patient-centredness. Similarities and differences between the current findings and those of previously published research are highlighted and interpreted.

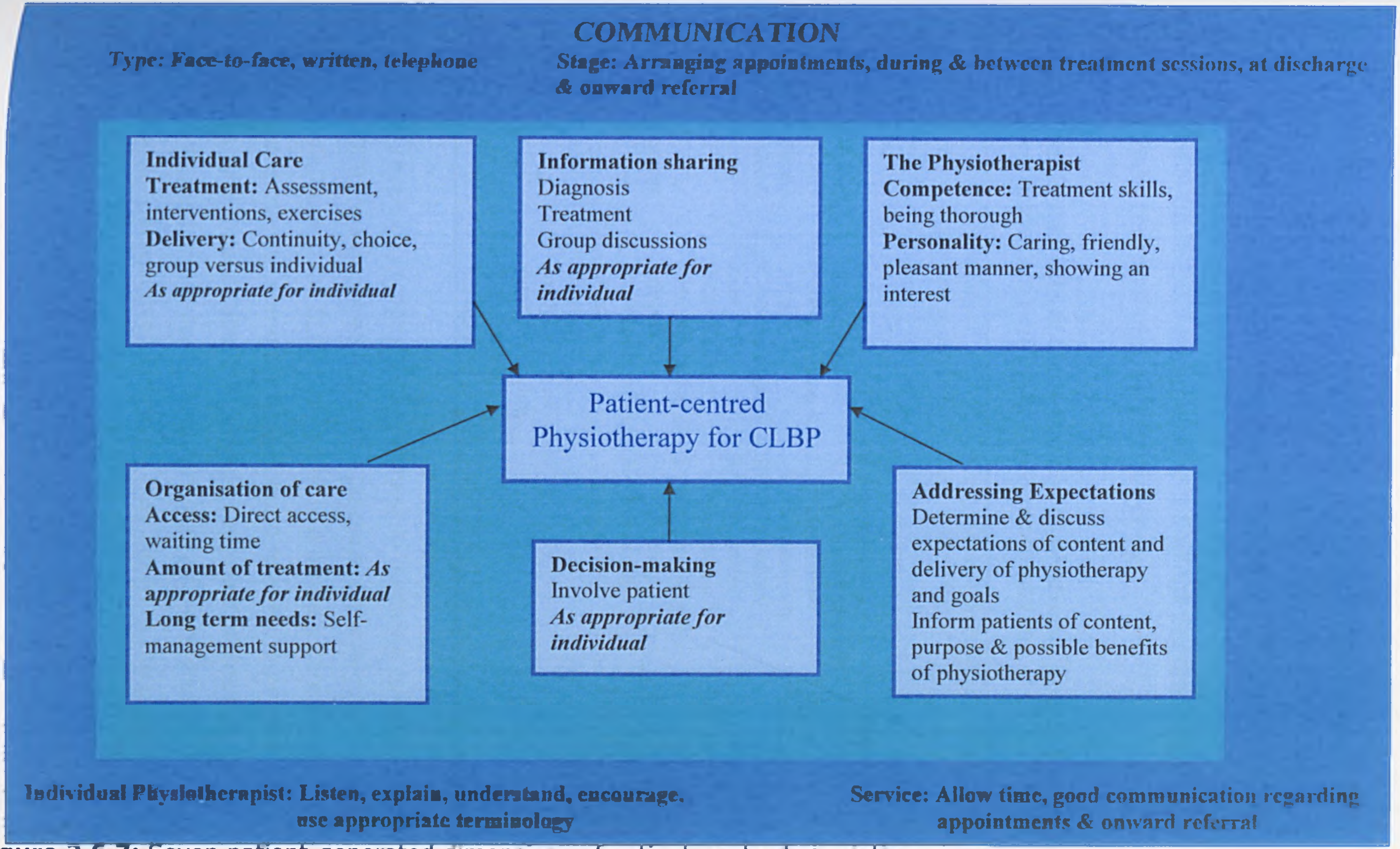


Figure 2.6.7: Seven patient-generated dimensions of patient-centred physiotherapy

2.6.3.7: Discussion

Comparison with previous concepts of patient-centredness

As discussed previously, the physiotherapy literature makes an abundance of references to patient-centredness, but has not thus far defined it as a specific concept in relation to physiotherapy practice (Blackledge, 2005). Therefore, it was necessary to draw on work done by other related professions, notably medicine, nursing and occupational therapy. The dimensions of patient-centredness that these occupations have proposed are displayed in table 2.6.5 and the current findings are discussed in relation to these concepts of patient-centredness.

Table 2.6.5: Comparison of study findings to previously published concepts of patient-centredness in non-physiotherapy professions

Medicine Mead & Bower (2000)	**Nursing Gerteis et al, (1993)**	**Occupational therapy Law et al (1995)**	**Current study**
5 dimensions:	7 dimensions	6 dimensions	7 dimensions
1. Biopsychosocial perspective	1. Respect for patients values & needs	1. Autonomy/choice	1. Communication
2. Patient as person	2. Co-ordination of care	2. Partnership/ responsibility	2. Individualised Care
3. Sharing power & responsibility	3. Information, communication & education	3. Enablement	3. Information Sharing
4. Therapeutic alliance	4. Physical comfort	4. Contextual congruence	4. The Physiotherapist
5. Doctor as person	5. Emotional support	5. Accessibility & flexibility	5. Decision-making
	6. Involvement of family & friends	6. Respect for diversity	6. Organisation
	7. Transition & continuity		7. Addressing Expectations

Much of the research on patient-centredness in medicine reviewed by Mead & Bower (2000) has occurred in general practice. General practice and out-patient physiotherapy for CLBP both occur in a primary care setting, therefore there may be some common ground relating to patient-centredness, and indeed table 2.6.5 would suggest that there is. The participants in the current study, unsurprisingly, did not discuss "biopsychosocial perspective". However, they did want the physiotherapist to understand *their* CLBP and be treated as an individual, not *a LBP patient*, which would be incorporated in the biopsychosocial perspective.

The remaining four dimensions from Mead & Bower's concept all relate to similar dimensions in the current study. "Patient as person" and "Doctor as person" relate to "individualised care" and "the physiotherapist" respectively, whilst "sharing power and responsibility" and "therapeutic alliance relate to "involvement", "communication", "information" and "decision-making".

The dimension relating to organisation in the current study does not appear in Mead & Bower's (2000) concept. Perhaps this is reflective of the way general practice and physiotherapy services are delivered, or perhaps it is related to patients' expectations of the two professions. Physiotherapy for CLBP commonly consists of a course of several treatments, whereas the research on patient-centredness in general practice may concern a single consultation (Krupat et al, 2000). Therefore, issues surrounding the way appointments are organised, including the waiting time, method of access, duration and frequency of sessions may be more relevant to physiotherapy. It may also be that patients' expectations are more easily fulfilled for a one-off consultation, whereas they have expectations of physiotherapy that are difficult for the service to meet (short waiting times, long appointment times, long courses of treatment). Expectations themselves are not a dimension in Mead and Bower's (2000) concept; however expectations of illness and medical care are incorporated in their dimensions of "patient as person" and "the therapeutic alliance".

There is less congruence between the current study and the nursing concept proposed by Gerteis et al (1993). "Respect for patients' values and needs" would be incorporated in the "individualised" dimension of the current study. "Co-ordination and integration of care", and "transition and continuity" would relate to "organisation" in the current study, and "information, communication and education" to "information" and "communication". The dimensions from Gerteis et al (1993) relating to physical comfort, emotional support, and involvement of family and friends perhaps fit less well with the current study. However, this may be due to the current study relating specifically to out-patient physiotherapy, with in-patients more likely to value these aspects. In addition, the dimensions of the professional ("physiotherapist") and "expectations" in the current study are not included in the concept proposed by Gerteis et al (1993).

The dimensions described by Law et al (1995) on which occupational therapists base their definition of patient (client) centredness (Whalley Hammell, 2001) have some similarities to the current findings. Most notably "accessibility and flexibility" ("organisation") is included in their concept, perhaps reflecting some similarities between the professions regarding service delivery. "Partnership/responsibility", "contextual congruence" and "respect for diversity" can be related to "communication", "individualised", and "decision-making" in the current study.

The main difference between the current study and the Occupational Therapy concept (Law et al, 1995) appears to be the emphasis on decision-making in the latter. Autonomy/choice relates to enabling clients to make decisions, as does enablement, which aims to facilitate that decision-making process. However, decision-making although present in the current study, had its emphasis on the patient wanting to consult an expert professional and have many decisions made for them whilst being kept informed. Olesen (2004, p194) suggested that patient-centredness performs well when taking a history, but may "destroy the patient's opportunity of experiencing the feeling of meeting a professional, knowledgeable and skilful dialogue partner (...) when it is a matter of deciding on present and future actions and treatment options." He suggested that there be a move towards "balanced, dialogue-centred medicine" (Olesen, 2004 p 194), which the current study, in relation to physiotherapy, would support.

It can be seen that although similarities exist, the findings from the current study do not exactly mirror any of the three studies in table 2.6.5, confirming the importance of defining patient-centredness in relation to a specific profession (Blackledge, 2005; Mead, 2000). However, there is a high level of agreement with Mead & Bower (2000), and it may be that incorporating "organisation" and "expectations" into their concept would enable it to be relevant to physiotherapy. The drawback of this however would be that the dimensions in the current study were patient-generated, and some would be lost if incorporated into a previous concept of patient-centredness. For example, "communication" was so overwhelmingly important to the participants in the current study, that rather than being implied in other dimensions, it is a dimension in itself. The dimensions in the current study are less abstract than the others, but the focus of the current study was to define patient-centredness from the patients point of view, and therefore the dimensions have remained as close to the language in which they were described as possible.

Each of the six dimensions proposed in the current study are now discussed in relation to the literature presented in section 2.2.3 previously. The implications for physiotherapy practice and further research are also considered.

Communication

The importance that CLBP patients place on effective communication was one of the dominant findings of this study. This is in agreement with previous studies in physiotherapy (Potter et al, 2003a; Trede, 2000). Communication was important in itself, but also a key factor in the other six dimensions reported here (table 2.6.5), with effective communication being an important factor in patients' satisfaction with these other dimensions. Mead & Bower (2000), Law et al (1995) and Gerteis et al (1993) all recognised the importance of communication, and several authors have suggested that healthcare practitioners need to improve their communication skills in order to deliver effective patient-centred care (Laerum et al, 2006; Potter et al, 2003a; Ostlund et al, 2001).

In the current study, there was a reasonable level of satisfaction with communication, which is encouraging. However, there were a high number of suggestions on ways to improve communication, and there were several participants who were dissatisfied with one or more aspects of communication. Therefore, these results suggest that communication could be improved upon in physiotherapy in Grampian.

Methods of achieving improvements in communication will require careful planning. It is not simply a case of putting everything into layman's terms, as this and previous studies have demonstrated (Trede, 2000). Nor is it likely to be as simple as producing guidelines or recommendations for physiotherapists to read, since passive implementation of guidelines alone does not alter practice (Grimshaw et al, 2001). Indeed several studies have shown that current physiotherapy practice does not always adhere to evidence-based recommendations for LBP treatment (Gracey et al, 2002; Li and Bombardier 2001; Foster et al, 1999). Therefore, as proposed by Bekkering et al (2005) it may be more beneficial to combine recommendations with training; in this case in communication skills for physiotherapists. Communication has recently been acknowledged as a skill that might benefit from training and development within the physiotherapy management of chronic pain patients (Klaber Moffett et al, 2006; Goldingay, 2006). Considering that effective communication with patients and/or their carers/relatives is a core standard of physiotherapy practice (CSP, 2005), it is perhaps surprising that more attention is not currently paid to development of this essential skill. It has been demonstrated that senior doctors can benefit from a formal course in communication skills (Fallowfield et al, 2002), and it may therefore be appropriate for such training opportunities to be made available to physiotherapists. Training itself would require careful consideration as to its duration and style of delivery, since a five hour education intervention on LBP management recently failed to alter physiotherapy management of LBP patients in a small group of physiotherapists (Stevenson et al, 2006). This suggests that perhaps a more intensive or longer-lasting type of intervention would be required in order to have beneficial effects on clinical practice.

There may be reasons linked with the design of the outpatient service that affect communication. West et al (2005) found that time, tools and training were all barriers to delivering patient-centred care in their study of hospital nursing, and it is conceivable that similar barriers may be present in out-patient physiotherapy. Perhaps offering longer appointments for CLBP patients could remove one of these barriers, affording more time for the two-way discussions, explanations and relationship building that CLBP patients clearly want from physiotherapy. Of course this would have implications on the physiotherapy service as a whole, particularly as there are other chronic conditions apart from LBP that may benefit from the same changes. However, it could be argued that by offering longer appointments and "getting it right" with respect to patient-centredness, patients' goals could perhaps be realised in fewer sessions overall. Therefore, short appointments may represent a "false economy" in terms of time and outcome. This would clearly need to be the topic of further research rather than speculating on potential outcomes.

Moreover, with the projected increase in people living with chronic conditions (SEHD 2005a), the prevalence of CLBP in society (Kent and Keating 2005), and the recent policy developments on enabling self-care of chronic conditions (SEHD, 2005b), it may be time to change the way in which physiotherapy is provided for such conditions. It could be argued that the current out-patient physiotherapy service is well designed for those with acute problems but not as well placed for dealing with chronic conditions such as CLBP.

This study has also highlighted that effective communication is not only important during the patient-therapist consultation, but throughout the process from referral to discharge or onward referral. Ensuring that patients' enquiries are dealt with in a timely, efficient manner and that patients are kept informed of what is happening could be a relatively straightforward method of improving satisfaction with physiotherapy. In addition, it was not only verbal communication that was discussed in this study. The need for appropriate forms of written communication, relevant to the individual's needs was highlighted, and relates to the next section concerning the patient as an individual.

Individualised Care

The importance of the CLBP patient being treated as an individual with unique symptoms and experiences was another dominant finding in this study, in agreement with the other concepts of patient-centredness (Mead & Bower, 2000; Law et al, 1995; Gerteis et al, 1993). The participants in this study wanted all aspects of their physiotherapy to relate to their needs as an individual. This included the actual treatment they received, the delivery of the treatment, the advice and information that complemented the treatment, and the level to which they were involved in decision-making, which is discussed below.

Therefore, individualising physiotherapy for CLBP is closely related to communication, since in order to deliver treatment that is relevant to the individual patient, it is necessary to get to know the patient and understand their needs, wishes and expectations. This echoes previous research in physiotherapy, where Trede (2000) found that patients "simply wanted to be listened to"(p430). Likewise, Ostlund et al (2001) in their study of "rehabilitation agents", which included physiotherapists, found that their participants wanted to be treated by somebody who understood them and their life situation and could adjust their rehabilitation accordingly. They also found that their participants valued continuity, echoed by the participants in the current study.

Individualising physiotherapy for CLBP is clearly also closely related to expectations, discussed in section 2.6.2. By understanding patients' expectations of physiotherapy (both the content and delivery of treatment, and what they hope to achieve) it might be easier to tailor the physiotherapy to their needs and expectations, or at least identify and begin to discuss areas of discrepancy between patient and physiotherapist.

Patient-centred physiotherapy for CLBP is therefore not "an approach" but a range of approaches that the physiotherapist should employ depending on the needs of the individual patient.

Information sharing

Only Gerteis et al (1993) include information as a separate dimension of patient-centredness, combined with communication and education, whilst Law et al (1995) discuss information in relation to enabling clients to make decisions. In the current study information sharing emerged as an important, and largely unsolicited, theme, and was related to individualising physiotherapy and fostering a good patient-physiotherapist relationship.

The participants in this study wanted information primarily on their diagnosis and what it meant for them, but wanted this to be done on an individual basis. This is in agreement with Trede (2000) who suggested that information needs to be "compatible with patients' experiences and beliefs" (p430).

Of course physiotherapists can not always explain an exact diagnosis, due to the often non-specific nature of CLBP (Danneskiold-Samsoe and Bartels 2004), but clearly patients have a need for such information. Therefore, physiotherapists should determine what patients do want to know and address these issues, even if it involves explaining that there is no definitive diagnosis and/or no definitive cure.

It is interesting to note that the discussion sessions, when they occurred, were the most (sometimes only) positive aspect of group rehabilitation, offering support and understanding from fellow CLBP patients. Surely this is a dimension that could easily be exploited in physiotherapy. Peer support is further discussed later in relation to self- management, as there are clear links between these areas.

The Physiotherapist

The effect of the personal qualities of the professional on the patient are recognised by Mead & Bower (2000) in their dimension "doctor as person". Previous studies have also shown that personal qualities of the physiotherapist can affect satisfaction ratings (Evans et al, 2003; May 2001). In this study, "the physiotherapist" incorporated both competence and personality. Participants wanted to feel confident in their physiotherapist's treatment ability and for their physiotherapist to be caring and treat them as an individual. The ideal physiotherapist could therefore be described as a "professional mentor" as proposed by Ostlund et al (2001, p290) in their socioemotional model of rehabilitation. They described a "professional mentor" as a rehabilitation agent who combines a supportive approach with individually chosen rehabilitation measures. The supportive approach would relate to personality factors in the current study, and the individually chosen rehabilitation measures to competence.

Potter et al (2003a) demonstrated similar findings in their study of patients attending private physiotherapy practitioners. The participants in their study ranked professional behaviour second only to communication ability when describing qualities of a good physiotherapist. Professional behaviour was a combination of having appropriate skills and knowledge, putting patients needs first, and treating each patient as an individual, also concordant with Ostlund et al's (2001) professional mentor. Therefore, rather than just being a "nice" person, the ideal physiotherapist combines positive personal qualities with an individualised approach to delivering effective treatment.

Resnik and Jensen (2003) found that expert physiotherapists (those whose patients reported an excellent outcome) were distinguishable by their patient-centred approach to physiotherapy. In their study, patient-centred was defined as incorporating therapist-patient collaboration, clinical reasoning, patient education and a good patient-therapist relationship. This is further evidence that individual physiotherapists are patient-centred to greater or lesser degrees, as the current study also suggests.

Decision-making

Decision-making is an implicit part of "sharing power and responsibility" in Mead and Bower's (2000) concept of patient-centredness, and as discussed above is an integral component of the Occupational Therapy concept (Law et al, 1995). It was therefore expected that it might be a dominant feature in this study. Harrison and Williams (2000) suggested that the out-patients in their study felt devalued due to their lack of involvement in decision-making regarding physiotherapy treatment. However, only five participants were interviewed in their study, approximately the same number who, in the current study, were dissatisfied with their level of involvement in decision-making. The majority of participants in the current study however had no desire to actively make decisions, since they wanted to consult an expert professional that made the decisions but provided adequate explanation for them, or as Olesen (2004) suggests, provided dialogue-centred care.

Therefore, as McKinstry (1992) and Krupat et al (2000) have previously suggested in relation to medicine, patient-centredness involves identifying how much the individual patient wants to be involved in any decision-making. Good communication, treating the patient as an individual and providing appropriate information are all involved in this process.

Decision-making is therefore not a dominant feature of patient-centred physiotherapy for CLBP, but one of several dimensions that requires adaptation by the physiotherapist to the needs and wishes of the individual patient.

Organisation

As discussed above, organisation is not a separate dimension in Mead and Bower's (2000) concept, but is present in both the nursing and Occupational Therapy concepts of patient-centredness (Gerteis et al, 1993; Law et al, 1995). Information on organisation was unsolicited but provided by almost all participants, confirming the importance of this aspect of physiotherapy management to these participants. Potter et al (2003a) in their study of private physiotherapy clients found that the clients ranked organisation second or third in importance when describing qualities of a good physiotherapist. They found that qualities such as the physiotherapist's personal organisational skills and punctuality, and convenience, accessibility and flexibility of appointment times were all important to the clients interviewed. These are similar to the issues identified by the non fee-paying participants interviewed in the current study, suggesting that these issues are common to both NHS and private physiotherapy patients.

Since access in the current study was largely related to future access, this is discussed with self-management (section 2.6.4). However, direct and timely access clearly has an effect on how patients view the physiotherapy service, lending more support to initiatives such as self-referral (Holdsworth et al, 2006) and triage (Horsey et al, 2003).

It would be easy to interpret the findings on duration of physiotherapy sessions in terms of patients wanting longer sessions and suggesting such changes to the service, as suggested in relation to communication above (page 134). However, how the time is used in each session is arguably of equal or greater importance. Participants in the current study were satisfied with the duration of sessions when their physiotherapist spent adequate one-to-one time communicating with them. Harrison and Williams (2000) suggested that lack of time can be interpreted by patients as a lack of interest in them and that physiotherapists who spent adequate time with the patients in their study made the patients feel they were important. Therefore, although patients generally desire longer sessions, sessions of any duration need to be used appropriately to ensure that the patient-therapist communication and contact time is optimal. Perhaps simple methods such as limiting interruptions, booking one patient at a time and adhering to appointment times to avoid the perception of being rushed would be beneficial.

The fact that most participants felt they did not receive enough sessions is perhaps unsurprising given the chronicity of symptoms of this sample. However, for many this was related to a desire for some continued longer-term relationship with the physiotherapist, which is discussed in section

2.6.4. However, there appears to be a need for appointment schedules to meet the needs of the individual patient.

2.6.3.8: Summary of patient-centred physiotherapy

The findings described and explained above can be summarised in three key points:

1. This research has presented for the first time a patient-generated definition of patient-centred physiotherapy for CLBP. It includes the six dimensions of decision-making, addressing expectations, individual care, information sharing, organisation and the physiotherapist, underpinned by the seventh dimension of communication. This definition has more in common with the primary care concept of patient-centredness (Mead and Bower, 2000) than the concepts derived from nursing (Gerteis et al, 1993) or Occupational Therapy (Law et al, 1995). However, the main difference is that this patient-generated definition explicitly involves patients' expectations of and the organisation of physiotherapy services.
2. The interpretation of the findings suggests that the physiotherapy service in Grampian is not consistently providing patient-centred physiotherapy and that it might benefit from some changes in order to make it more patient-centred according to the definition presented above. Therefore, addressing some of the organisational issues highlighted by this sample including the duration of appointments for CLBP patients, access to physiotherapy, dealing with enquiries and long-term support issues might be appropriate.
3. The interpretation of the findings suggests that there might be educational requirements for physiotherapists in Grampian. This primarily relates to education on the patient-generated dimensions of patient-centred physiotherapy for CLBP presented above, and on improving communication skills.

As previously stated (2.6.2) the extent to which these results can be generalised is considered in section 2.6.6, and the specific implications for the physiotherapy service, education and further research are considered in section 2.7. The focus now turns to self-management of CLBP.

2.6.4: Self-management

This section relates to research questions six and seven which were:

6. Does current physiotherapy in Grampian facilitate CLBP patients to self-manage their condition?
7. Could anything else be done in Grampian to facilitate CLBP patients to self-manage their condition?

Introduction

Interview questions ten to 14 (Appendix 7) were designed to answer these questions since they related to the following topics. How participants did or would cope with a flare-up of their symptoms, whether participants felt physiotherapy had influenced how they did or would cope, and their current and anticipated future consultation of health professionals.

The above interview questions therefore informed the theme of "long-term management" in the index presented in table 2.5.4. This section considers that data and describes the participants' self-management status (at the time of interview) and anticipated future management of symptoms. It describes and explains the strategies used by the participants to manage their LBP, the influence that physiotherapy did or did not have on these strategies and the participants' thoughts on support in the form of a longer-term relationship with the physiotherapist, introduced in section 2.6.3.6 (p125).

2.6.4.1: Current status

Framework charts relating to long-term management and its subthemes of strategies, consultation, post-discharge support and telephone support were analysed. A summary of the themes, categories and classes of data in which groups of categories were arranged is presented in table 2.6.6. A typology (Ritchie and Lewis, 2003) emerged from the data which described participants' current self-management status. This was a four-way classification in which participants were described as (1) self-managing but wanting access to physiotherapy in the future, (2) self-managing and not wanting access to physiotherapy in the future, (3) not self-managing and looking for a cure, and (4) not self managing and awaiting further investigation. These are displayed in figure 2.6.8, which demonstrates the relationship between goals, satisfaction, discharge and self-management status. Each typology is now discussed in turn.

Table 2.6.6: Categories and classes of data relating to self-management

Sub theme	Categories (examples)	Classes
Strategies	When/how often exercises, which exercises uses	Exercises as SMS
	Techniques used to control LBP (e.g. back-support)	Other techniques as SMS
	Strategies influenced by physiotherapist	Factors influencing SMS use
	Extent to which strategies self-determined	
	Influence of self, physio and/or others in strategies	Motivation to self-manage
	Motivation issues relating to long-term management	
Post Discharge Support	Self-managing/not self-managing, putting up with it	Current status
	Wants/doesn't want physio support in future	Future physiotherapy access
	Review appointments, return to group, more physio	Contact/review
	Cost of private groups/gyms, lack of advice/motivation	Barriers to self-management
Consultation	Chiropractor, acupuncture, osteopath	Health care practitioner consultation
	Orthopaedic consultant, chiropractor, Reiki, massage	
	Wants more treatment, wants to return every 6 months	
	Physiotherapist, GP, anyone who might help	
	No help to date, know all the exercises, waste of time	
	Thinks will self-manage from now	
Telephone Contact	Method of follow-up, motivational effect, frequency	Views on telephone support
	For quick advice, for reassurance, if forgot exercises	
	Prefer face-to-face, ?safety of telephone advice	
	Good idea	

Key: SMS = Self management strategy

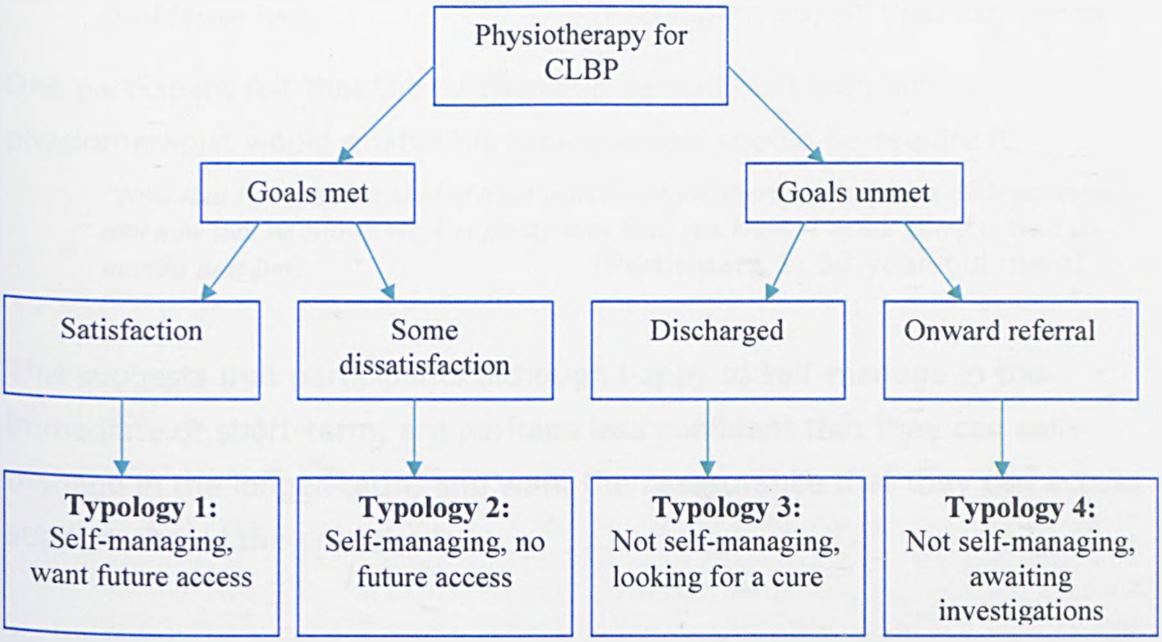


Figure 2.6.8: Four-way classification of participants' self-management status and relationship with goals, satisfaction and discharge status

1: Self-managing, want future access to physiotherapy

This largest group described themselves as self-managing but wanting access to physiotherapy as and when they should need it in the future. There were both pain-free participants and those with current symptoms in this group. They had in common satisfaction with physiotherapy and goals that were either achieved, or if not achieved no blame was directed at the physiotherapist.

Suggestions for future access fell into two categories; direct access and follow-up. A group of participants wanted direct access in the event of a recurrence or flare-up in symptoms. The reason for this was that the physiotherapist was seen by many as the expert in LBP and therefore the person to consult should difficulties arise, as these participants describe:

> *"I think if you have an increase in the pain, you should return to see the people who know"*
>
> (Participant 6, 28 year-old female)

> *"Oh, definitely [would return to physiotherapy if back flared up], because it was. Well, the trouble is you don't know, well I would know if it's the same bit I damaged, but eh...they can tell you what level of damage. That's the part I wouldn't have a clue on, I just know it's sore. But physiotherapists themselves can say oh, you've done it this time,*

> *or…you're always feared that something else that's not muscular. So, aye, I mean … I would come back."* (Participant 16, 48 year-old male)

One participant felt that the relationship he had built with his physiotherapist would enable his future access should he require it:

> *"Now that I've got that kind of trust with the physiotherapist in* [name of department]*, and now that he knows me, I'm pretty sure that, you know, I'm not going to wait six months next time."* (Participant 1, 39 year-old male)

This suggests that participants although happy to self-manage in the immediate or short-term, are perhaps less confident that they can self-manage in the longer-term, and want the reassurance that they can access support should they require it.

Another group wanted a formal follow-up by the physiotherapist. Some felt this would reassure and aid motivation to self-manage, for example:

> *"I think it would have been nice to say well, you know, get walking, do your exercises and we'll see you in a year. Even for just five minutes"*
> (Participant 8, 61 year-old female)

Suggestions on timing of follow-up varied from immediately following discharge to a few months post-discharge to one-year post discharge. One participant who had attended and enjoyed group rehabilitation felt that returning for a "top-up" every six months would be beneficial:

> *"It would be nice if every so often, you know, that you didn't have to go through your GP to be referred, if they had these back classes and it was a separate room from their day to day, like a separate thing, and every so often you could. I'm not saying every month or every two months, maybe every six months or so you could go back. It would just give you that more of an incentive to keep doing it"*
> (Participant 5, 48 year old female)

And one further participant who had received one-to-one treatment felt that being able to access a class once a month where her exercises could be checked and progressed would be beneficial:

> *"I did think it would be good if the physio's ran classes or something. I know some people go to Pilates, but I don't know if there's many classes around here, plus it would have to be late in the evening for me, or fit in with all my other things. But if it was a physio taking it…. It would help with the motivation, checking you're doing what you need to… I do think a class would be a good idea. Even once a month, just to refresh, have the physio say, yes you're doing fine and this is what you need to do next."*
> (Participant 25, 38 year-old female)

Participants were asked whether follow-up or contact with the physiotherapist could be via telephone rather than face-to-face. Those who wanted direct access commonly felt that telephone contact would not be a useful substitute, or that it may be helpful only if attending the physiotherapist subsequent to the telephone contact was an option.

Participants who wanted a formal follow-up however commonly felt that telephone contact would suffice, with the exception of one participant who wanted to return specifically to attend the group. Half the participants who were positive regarding telephone contact suggested that the patient being able to telephone the physiotherapist would be helpful, using it as a type of helpline for LBP, as this participant explains:

> *"It would be helpful. You know if you get physiotherapy and it cures your symptoms or whatever. If you start getting similar symptoms or other symptoms later on, if maybe there was somebody you could phone and say well, you know my background this is how I'm feeling, is there some of that exercises I should be starting again, or is there something else I could try"* (Participant 14, 41 year-old male)

The other half of this group suggested that the physiotherapist should contact the patient at pre-determined intervals as a form of motivation to continue self-management techniques and reassurance that they were doing the right thing.

> *"I think because you've got continuing back pain, it would be fine to be reviewed say every now and again. Reviewed to see, maybe even a phone call to say how's your back, how are you coping. I think that would work.*
> ***Interviewer:*** *And is this for sort of reassurance that you're doing the right thing, or//.*
> ***Respondent:*** *Aye…maybe…maybe just need a kick up the backside! To get you going."*
> (Participant 13, 51 year-old female)

One participant who suggested telephone follow-up spontaneously during his interview explained that e-mail contact for those who had access to a computer could perhaps be useful in order to send reminders to exercise and therefore motivate recently discharged patients:

> *"Maybe e-mail, just if somebody e-mailed you after a month and said "how are you getting on doing the exercises…Not necessarily face to face, just to gee you up a bit…Maybe over a period of about a year, then you know you get used to, yes I'm keeping doing them. You probably need some feedback from, again a message going back: got your message, I am doing exercises, which might not take long just for someone to skim through."* (Participant 12, 63 year-old male)

Clearly these participants acknowledge that they have a chronic condition and whilst they may be trying to self-manage in the immediate few months following discharge from physiotherapy they feel they need some type of longer-term relationship with the physiotherapist. This poses the interesting question of whether physiotherapy services can and indeed should attempt to meet this need, which is discussed later in this section.

2: Self-managing, no future physiotherapy

There was a smaller group of participants who were self-managing and clear in their intent not to consult a physiotherapist in the future. For some, this was due to them knowing the exercises and seeing no point in returning to the physiotherapist to be shown them again, as these participants explain:

> "*I wouldn't go back to physio or anything like that... The only reason is 'cause I've been a lot, so I know, so I would know what to expect and I would know what to do, so it wouldn't really benefit me. For somebody that hasn't been then yeah, but I've just been too much times.*" (Participant 21, 39 year-old female)

> "*I don't feel, even if it got bad just now, I don't think I would be rushing back to a physio. Because I've been there fairly recently, em, I know what I should be doing and all the rest of it, and I know the exercises, so...* [I would do them] *myself, and see if I can get it back.*
>
> (Participant 17, 58 year-old female)

These participants believed that treatment would be no different from one occasion to the other, and on inspection of the relevant framework charts, these participants did not perceive their treatment to have related to their individual needs. For the remaining two participants, one explained that she would want an x-ray rather than a physiotherapy consultation should her symptoms get worse, and one that he was more "putting up with it" than self-managing but wouldn't return to physiotherapy as it was a "waste of time". Interestingly, over half of this group felt that being able to telephone the physiotherapist for advice would be helpful, even though they did not wish further face-to-face contact with the physiotherapist, again suggesting that some sort of longer-term relationship with the physiotherapist may be required.

3: Looking for a cure

These participants either wanted to continue physiotherapy in the belief that "new treatments might be out" or that the physiotherapist would know what to do subsequent to their x-ray, or they were exploring other options (acupuncturists, chiropractors, osteopaths, reiki practitioners) in the hope of curing their symptoms where the physiotherapy had been unsuccessful. In addition there was one participant who considered herself not to have completed physiotherapy. She had stopped going due to mix-ups with her appointments and intended to seek re-referral to complete treatment. Therefore, rather than using healthcare providers as a component of self-management, these participants were still hopeful that someone would be able to "cure" their LBP for them.

Those who were looking for a cure included satisfied and dissatisfied participants, but they did have in common goals being unmet. Participants who were self-managing and wanting future access to physiotherapy had in common goals that were achieved, or if not, no blame was apportioned to the physiotherapist. It would therefore seem that goal attainment may be linked to self-management status. The type of goals did not differ between these two groups; therefore achievement of the goal irrespective of what that goal is appears to be the important factor. This group commonly did not discuss telephone contact due to their perception of still pursuing active treatment rather than self-management. Those who did discuss telephone contact would have used it to try to access further physiotherapy treatment.

4: Awaiting further investigation

Two of the participants were awaiting secondary care consultations (a neurology appointment, and possible surgery for one). Both felt that they would like to retain contact with the physiotherapist until they had these appointments. One wanted to continue attending the group since the exercises were difficult to do at home, but they did help to keep him mobile and flexible. The other wanted regular reviews by the physiotherapist to monitor her symptoms and give appropriate advice while she was waiting to be seen by the neurologist. Both felt that being able to access advice over the telephone would be helpful. This again raises the interesting question of whether physiotherapy services should be attempting to meet this perceived need, and is discussed later in this section.

Also on the topic of secondary care, three participants had attended an orthopaedic consultant as well as physiotherapy. All had been referred by their GP at the same time as referring to physiotherapy. All three found the orthopaedic assessment reassuring and helpful, even though it just confirmed that physiotherapy or exercise was the correct approach and it was over to them (the patient) to cope with their LBP. These three participants all described themselves as self-managing; one wanted future physiotherapy contact, the other two did not. This raises as interesting point as to whether some patients need the reassurance that they have been seen by a doctor in order to perceive that everything possible has been done for them and in order for them to adopt a self-management approach.

2.6.4.2: Self-management strategies

Participants in all four groups above described strategies they used either to manage their LBP or help them to put up with it. These strategies and the influence that physiotherapy had on adopting them are now discussed. There were numerous examples of strategies used by the participants. The categories and classes in which groups of categories were arranged for this section of analysis are summarised in table 2.6.7 and are explained below.

Table 2.6.7: Self-management strategies: categories and classes

Categories (examples)	Classes
Only exercises when sore, does exercises occasionally, does physio exercises daily, does self-taught exercises, would try exercises if back flared up, does enjoyable general exercise	Exercises
Back support, painkillers, hot bath, lies down, weight loss, just keeps going	Other techniques
Physiotherapy influenced certain strategies, physio's should/can suggest things others have found helpful, largely self-taught, mix of advice from various sources	Influence of physiotherapy
Motivation difficult, time constraints, some exercises easier than others, no motivation once stopped physio	Motivation

Exercises

Most of the sample used some form of exercise as a strategy to manage or put up with their LBP. There were two equal-sized groups relating to exercise; those who did the exercises they had been shown in physiotherapy and those who did their own exercises.

Those who did the physiotherapy exercises commonly did some of them sometimes, usually when their back was painful, suggesting that the use of exercises was reactive rather than proactive. The exercises that made sense to the participants and fitted in with their lifestyle were most likely to be continued. It was rare for participants to do all the exercises as shown, if they did they did them less often than the physiotherapist had suggested (commonly three times per day had been suggested; participants reported doing them once):

> *"It was suggested at the physio, you know, when you're on your back, the ones that you do lying, do them in the morning before you get up, or, both actually she said, at night when you go to bed, but I tend to only do one! (laughs), not both, at night time I'm too tired and too sore! (laughs)."* (Participant 05, 48 year-old female)

> *"I only do one lot in the morning first thing. Certainly on the course they were saying three times a day, which I think is probably not easy for everybody to do…I do it every morning, because I think it gets you going…* But I used to find difficulties with doing them at work" (Participant 12, 64 year-old male)

This confirms the need for exercise prescription and advice to be realistic and individualised and to relate to the patients' needs and circumstances as discussed in section 2.6.3.2 (p112).

Those who did their own exercises reported using general exercise such as cycling or most commonly walking, for example:

> *"…the kind of activities I try and incorporate in my everyday life, you know, it takes me out of the house, as I said, in a social atmosphere, walking in the hills, going for walks in the woods, anything like that, is undoubtedly beneficial all round"*
> (Participant 1, 39 year-old male)

A subgroup had worked out their own exercise programme, due to the physiotherapy not pushing them hard enough. A further subgroup reported attending exercise classes and/or a gym, which they had attended prior to receiving physiotherapy. It is interesting to note that none of the participants started attending a gym or exercise classes due to physiotherapy. In fact, participants whose physiotherapists suggested an exercise class didn't follow this advice due to reported time and financial constraints and being unsure as to which type of class would be suitable.

A small group discussed motivation in relation to continuing the exercises. They suggested that motivation decreased on stopping physiotherapy and that lack of time, boredom and exercising alone all provide barriers to exercising. It was suggested that it was easier to stay motivated to do some exercises than others, again highlighting the need for exercises to be acceptable for the individual they are being prescribed for.

Other techniques

There were many and varied strategies other than exercise used by participants, although these were less common than the use of exercise. Table 2.6.8 displays these strategies and whether they were self-taught or learned from the physiotherapist. It is interesting to note that most were reportedly self-taught, including lifting and bending, advice that could easily be expected to be part of a physiotherapy intervention for CLBP. It is difficult to draw conclusions from this data. Linking with section 2.6.3 (patient-centredness) it may imply that physiotherapists need to better equip patients with self-management strategies that are suitable for their individual needs. However, it may be that living with a chronic condition entails a certain amount of trial and error to find what works on an individual basis. Perhaps the skill is in striking the correct balance between the two.

Table 2.6.8: Other techniques used to control Low Back Pain

Self-taught	Physiotherapist taught
Back support	Adapting activities
Careful with lifting/bending	Heat
Chiropractor	Postural awareness
Hot bath	
Just keeps going	
Keeping mobile	
Lying down	
Massage	
Painkillers	
Weight loss	

2.6.4.3: Influence of physiotherapy

As has already been described for both exercises and other strategies, the sample fell into two main groups regarding the influence physiotherapy had exerted on how they currently managed their LBP. It had either not influenced them at all, or had influenced them in part (mainly regarding exercises) with trial and error or advice from others being the other influence. In contrast there was a small group of participants who felt physiotherapy had influenced their current self-management strategies. They felt this was due to the physiotherapist helping them to understand their LBP and making them more aware of what they could do to help themselves, illustrated by this participant:

> "*I think so, aye* [that physiotherapy influenced current self-management strategies]. *I think I'm more aware of it and you go back and think well, the physio. 'Cause she said, well it's like everything else. When you're feeling good you tend to do more, but of course when your back's fine, och right I'll go and clean the windows, clean the house and do all this. And then of course the next day, you've a sore back. So you tend to listen and say well I shouldn't just go like the clappers when you're better and just do a wee bit at a time."* (Participant 13, 51 year-old female)

For these participants, the adoption of a patient-centred approach by the physiotherapist, based on good communication and individualised advice giving, appears to have facilitated their confidence to self-manage.

2.6.4.4: Motivation

Motivation and barriers to self-management have largely been discussed above. Motivation to continue exercising following discharge from physiotherapy can be an issue for many patients (Dean et al, 2005), and may explain why so many participants expressed a desire for some sort of physiotherapy access or follow-up in the future. Participants who reported a lack of advice on discharge also wanted future follow-up. For them the barrier appeared to be uncertainty as to how to self-manage rather than lack of motivation.

One participant described a specific goal she had (to return to competitive horse riding) and the positive effect this had on keeping her motivated to do her exercises long-term. Goal setting was not specifically enquired about in the interviews; however it is interesting that only one participant offered this information. This perhaps suggests that goal setting, generally encouraged at the start of the treatment process (Arnetz et al 2004) should be re-visited with the patient on discharge.

The remaining barriers to self-management strategies concerned attending gyms or exercise classes (cost, time, suitability) and perhaps link with the expressed desire of a subgroup of participants to continue or return to the physiotherapy-led exercise groups for LBP.

These results are now discussed in relation to the literature presented in section 2.2.4 previously. The implications for physiotherapy practice and further research are also considered.

2.6.4.5: Discussion

Current status

Whilst the adoption of self-management strategies is an optimal outcome from physiotherapy for CLBP (Bekkering et al., 2003), this research suggests that in Grampian this outcome is not consistently achieved. This is perhaps unsurprising, since many authors recognise the challenge that the chronicity of LBP can present, and a considerable amount of research on methods of encouraging self-management strategies is being pursued with this client group (for example Udermann et al, 2004, Miller et al, 2004).

However, the predominant finding in the current research was that the participants described themselves as being self-managing but wanting access to physiotherapy in the future. Self-management has many and varied definitions as discussed in section 2.2.4. However, Lorig and Holman (2003) described the five key elements as; problem-solving, decision-making, resource utilisation, forming a patient/healthcare provider relationship and taking action. Therefore, rather than being seen as separate to medical care which has sometimes been the case (Gruman and VonKorff, 1999) self-management in this context is seen as complementary to the care provided by the healthcare provider (Bodenheimer et al, 2002a).

What the participants in this study described a desire for would appear congruent with the definition of self-management presented above where they have built up a relationship with the healthcare provider (physiotherapist) but want to utilise resources (physiotherapy) when they need them. How and when these resources are utilised in the future and whether the participants have been provided with the knowledge and skills to enable them to problem solve, make appropriate decisions and take appropriate action are therefore pertinent questions, and are considered here.

Resource utilisation

Participants in this study wanted either direct access to physiotherapy in the event of a flare-up or recurrence of LBP, or some type of review by the physiotherapist. Both are now discussed.

Direct access

Direct access was introduced in relation to patient-centredness highlighting the value that patients placed on being able to access services quickly and directly (section 2.6.3.6, p125). The predominant typology in this study was self-managing but wanting access to physiotherapy in the future and many of these participants wanted direct access in the event of a flare-up or recurrence of symptoms. However, whether such use of services would be appropriate is unknown. In order for effective self-management, which includes the appropriate use of healthcare services when they are required (Lorig et al, 2003), sufficient education on how to self-manage and how to decide whether to self-manage or seek help is clearly required. Therefore, direct access would only be appropriate if CLBP patients possessed the knowledge and skills to self-manage effectively, and utilise physiotherapy services appropriately. The fact that many participants in the current study described unclear or absent instructions on discharge, and that most self-management strategies were self-taught suggests that these participants might not fall into this category; this is further discussed below in relation to knowledge and skills.

Review/follow-up

Review by the physiotherapist was the alternative resource utilisation desired by the participants in this study. Review or active follow-up has been suggested as an integral part of self-management by some authors (Moore et al, 2000; Gruman and VonKorff, 1999) and therefore might be appropriate for physiotherapists to offer to their CLBP patients. The participants in this study suggested that follow-up would aid their motivation to continue exercise programmes and reassure them that they were "doing the right things" to self-manage their LBP, two of the very things that Gruman and VonKorff (1999) suggested follow-up should be used for. Gruman and VonKorff (1999) also suggested that follow-up can be in the form of return visits, telephone calls or electronic mail, all of which were suggested by one or more of the current study participants and which are therefore now discussed.

Review visits and telephone calls

There appears to be a lack of literature relating specifically to return visits aimed at enhancing self-management, but considerably more on the use of telephone calls as a method of reviewing patients' progress on self-management education programmes (Kutzleb and Reiner, 2006; Barbanel et al, 2003; Moore et al, 2000). The participants in this study who expressed a desire for follow-up all felt that telephone calls would be a suitable method, suggesting it might be a useful addition to physiotherapy aimed at enhancing self-management.

Telephone contact has been used successfully as a method of delivering a self-management intervention, combined with an internet programme, suggesting that it is an acceptable medium for CLBP patients to use (Buhrman et al, 2004). A physiotherapy telephone service has also been piloted for back pain patients who were awaiting their first appointment with the physiotherapist (Taylor et al, 2002). In this case patients with LBP (of any duration) were telephoned by a physiotherapist on receipt of their referral in order to give self-management advice that they could follow prior to their physiotherapy appointment. Patients reported high levels of satisfaction with this service. However, it does not seem to have been explored as a method of supporting physiotherapy patients post-discharge and would therefore be worthy of further research in terms of its feasibility, effectiveness in reassuring patients and encouraging continued self-management, and satisfaction to those who used it.

Telephone helpline

Some participants in the current study suggested that telephone use in the form of a "helpline for physiotherapy" that they could call would be preferable to follow-up calls initiated by the physiotherapist. This type of telephone intervention has been used in other medical conditions (Monninkhof et al, 2004, COPD), and an automated version has been successfully used with chronic pain patients (Naylor et al, 2002), suggesting that patients are willing to use such services. Clearly such a service would have resource implications, and further research on its feasibility and effectiveness would be required. Moreover, some such resources already exist. For example, BackCare, a charitable organisation, runs a helpline staffed by volunteers (BackCare, 2006). It may therefore be prudent to explore to what extent use of such resources should also be encouraged by physiotherapists.

Electronic mail

Electronic mail was also suggested in the current study as a possible method of follow-up to provide encouragement to self-manage, and has indeed been shown, in combination with educational materials on LBP, to be an effective method of decreasing pain and disability in LBP patients (Lorig et al, 2002). As mentioned above (Buhrman et al, 2004) combined internet and telephone contact has been used to provide a self-management intervention for CLBP patients, and may therefore be an acceptable medium. It may therefore also be worthwhile exploring this medium as a method of supporting CLBP patients to self-manage following discharge from physiotherapy.

Group rehabilitation

Some of the participants in this study wanted follow-up to involve further attendance at physiotherapy, commonly group rehabilitation. Cook and Hassenkamp (2000) also found this in their study of a back rehabilitation group. This finding might suggest that the participants were not ready to adopt self-management strategies, since they wanted to maintain their current relationship with the physiotherapist. Indeed, there were several participants "looking for a cure" who were clearly not ready to adopt self-management strategies and for whom the afore-mentioned methods of encouraging self-management would not be appropriate. In the same way that physiotherapists need to determine patients' expectations at the outset of physiotherapy (see 2.6.2), it might be necessary to determine their readiness to adopt a self-management approach. One possible method of doing this would be to use the Pain Stages of Change Questionnaire (Jensen et al, 2004; Kerns et al, 1997), in order to determine which patients may be suitable for such an approach. Of course, the challenge is then how to manage, or who should manage, those patients who are not ready for a self-management approach.

Barriers to self management

Some participants in the current study wanted to continue group rehabilitation. However others decided not to pursue group exercise following discharge from physiotherapy due to financial constraints and being unsure as to which classes were suitable for them; barriers to self-management previously reported by Jerant et al (2005) in patients with multiple chronic conditions. Exploring methods of making group exercise more affordable to CLBP patients on discharge and ensuring patients are informed of the suitability of classes on offer locally may therefore be appropriate avenues to explore in order to facilitate self-management. Those participants who expressed a desire for continued group attendance due to the support they received from other group members may benefit from being directed to other sources of support. For example the Pain Association (Pain Association, 2006) holds group meetings for those living with chronic pain, and it may be appropriate for physiotherapists to provide information on similar local and national sources of support and information on discharge from physiotherapy.

Onward referral

There was an interesting subgroup of participants in the current study who were waiting for consultants appointments and wanted to have some sort of contact with the physiotherapist until that time. These participants were clearly not expected to be truly self-managing as they were being referred for possible further intervention. However, this does raise the interesting question of what happens to such patients when they are discharged from physiotherapy, particularly as it may be some time until their further appointment. Perhaps it is not unreasonable for these patients to want some support in managing their condition until such time as they enter the secondary care service, particularly if telephone review could provide that support. However, whether this is a feasible role of the physiotherapy service would have to be explored.

Knowledge and skills

The above discussion has highlighted that many of this study's participants did not appear to have the knowledge and skills to effectively self-manage their CLBP. Of the self-management strategies used by the sample, most were reportedly self-taught, thereby questioning the role that physiotherapy played in facilitating self-management in this sample. The majority could also be classed as passive strategies (Blyth et al, 2006), with exercise being the only active strategy in widespread use. This is in agreement with the findings of Blyth et al (2006) who studied self-management of chronic pain in general. However, Blyth et al (2006) also reported that the use of active strategies was associated with reduced disability and health care usage.

Therefore, it would seem appropriate for physiotherapists to educate patients regarding additional active strategies such as adapting activities and posture, which were reportedly used by few participants in the present study in comparison to the more common use of passive strategies such as medication or heat.

The findings suggested that physiotherapists provided this sample of CLBP patients with one skill (exercises) but that many other possible self-management strategies were either self-taught or lacking entirely. For example, none of the reported strategies were cognitive, such as relaxation or distraction (Blyth et al, 2006). This might be due to the methods employed, since cognitive strategies were not specifically enquired about; participants were asked in general terms how they coped with their LBP. However few of the other strategies discussed were specifically enquired about either. Discharge advice was commonly not recalled as being thorough or in many cases relevant, resulting in patients working out their own strategies. Whilst working out strategies, or problem solving, is to be encouraged as a part of self-management (Lorig et al, 2003), adequate and individually tailored advice from the physiotherapist might enhance this process and help to prepare patients for adopting a self-management approach. Discharge was discussed in section 2.6.3 in relation to the need for well-organised discharge arrangements; these findings suggest that this extends to the need for the provision of adequate self-management advice.

Self-management education

In order to ensure that CLBP patients are prepared for self-managing their condition, it may be appropriate to incorporate elements of self-management education into physiotherapy treatment programmes for CLBP.

Lorig (2003) defined the purpose of self-management education as "to provide patients with the skills to live an active and meaningful life with their chronic conditions" (p699). As discussed in section 2.2.4 self-management education programmes designed to fulfil this aim have been shown to be effective for several chronic conditions such as asthma (Newman et al, 2004), diabetes (Newman et al, 2004) and arthritis (Warsi et al, 2003).

Such programmes developed for LBP patients have also demonstrated some success. VonKorff et al (1998) demonstrated decreased worry about back pain, increased confidence in self-management and improved Roland-Morris disability scores following a course of four two-hour classes led by lay volunteers. More recently, Moore et al (2000) demonstrated similar outcomes following two two-hour group sessions led by a psychologist plus one individual session and a follow-up telephone call. The self-management programmes studied by VonKorff et al (1998) and Moore et al (2000) both followed structured protocols and included some topics commonly covered by conventional physiotherapy low back pain rehabilitation groups (Klaber Moffett and Frost, 2000) or back schools (Glomsrod et al, 2001). Such topics were the nature of "red flags" indicating serious spinal pathology, pacing of activities, posture, and handling flare-ups. However, there were other areas that do not appear to be covered in any depth by conventional physiotherapy programmes, such as enabling patients to set personal goals, developing and implementing action plans by employing problem-solving techniques, and reviewing patients' action plans. These areas did not appear to have been covered to any extent with the participants in the current study, with exercise being the predominant physiotherapy-influenced self-management strategy as discussed above. It may therefore be that such skills and techniques need to be taught to CLBP patients by physiotherapists in order for the goal of self-management to be realised.

Self-management education is an intervention in its own right (Gray, 2004; Newman et al, 2004), requiring specific knowledge and skills on the part of the person delivering the intervention for it to be effective. Since one purpose of physiotherapy for CLBP is to enable patients to self-manage their condition (Bekkering et al, 2003), it would seem reasonable for physiotherapists to enhance their current practice by incorporating self-management education into the treatment of CLBP patients. This would clearly require training in the skills required in delivering such education, as suggested by Newman et al (2004) who highlighted the following areas as deficient in health care professionals training; "group facilitation, problem solving, goal setting and cognitive-behavioural techniques" (p 1534). Enhancing physiotherapists communication skills, discussed in section 2.6.3, might also enhance their ability to facilitate self-management. Kennedy et al (2005) demonstrated that communication skills training provided to gastroenterology specialists enhanced their patients' ability to self-manage inflammatory bowel disease.

How self-management education is best incorporated and the balance between physiotherapist-led interventions and the possible use of trained laypersons (VonKorff et al, 1998) would require further investigation. However, provision of such interventions might result in physiotherapy for CLBP not only being guideline-led but fulfilling patients' wishes for self-management education (see 2.6.3) and ensuring appropriate future use of physiotherapy resources by such patients.

2.6.4.6: Summary of self-management

The findings described and explained above can again be summarised in three key points.

1. This research has demonstrated in a UK sample of CLBP patients that adopting a self-management approach was not a consistent outcome following physiotherapy, and that many participants in this sample wanted support from physiotherapy in order to facilitate self-management. Considering that self-management is not a "one size fits all" intervention and needs to be tailored to the needs of the individual (Gray, 2004; Lorig and Holman, 2003; Klaber-Moffett, 2002) it is perhaps unsurprising that varied suggestions on the role of physiotherapy in facilitating self-management arose from the current study.
2. The interpretation of the findings suggests that the physiotherapy service in Grampian might benefit from some changes aimed at better facilitating self-management in CLBP patients. Changes to consider include providing self-management education, review appointments, future direct access and information on other sources of support. It may be necessary to utilise several of the interventions suggested in order to meet the varied needs and preferences of CLBP patients. Clearly further research is required to pilot such interventions before any recommendations can be made, and with the current drive towards self-management of chronic conditions (SEHD, 2005a) such research would be timely.
3. Due to the perceived need for self-management education demonstrated by the participants in this study and the body of literature supporting

self-management education as an intervention requiring skill to deliver, there appears to be an educational need in this area for physiotherapists.

As for the previous sections the extent to which these findings can be generalised and the specific implications for practice, education and research are considered in sections 2.6.6 and 2.7. The focus now turns to the final topic of enquiry, the importance of activity and participation to CLBP patients.

2.6.5: Importance of activity and participation

This section relates to research question eight, which was:

8. How important is activity and participation to CLBP patients?

There was no specific interview question designed to answer this research question, as discussed in relation to development of the interview schedule in section 2.4. Instead, participants generally began answering this in response to the introductory question where they were invited to describe their LBP and how they ended up at physiotherapy. In addition, several of the other interview questions generated data relating to activity and participation, as has been highlighted throughout the findings. Most notably the questions relating to goals, outcome and self-management generated data on activity and participation, and are discussed below. All the above data contributed to the theme of "functional limitations of CLBP", which was the umbrella term used at the data analysis stage for anything relating to activity limitations or participation restrictions.

The purpose of exploring activity and participation in this study was to determine whether activity limitations and participation restrictions were perceived as important by this sample of CLBP patients, and to understand the types of limitations experienced and the effect this had on the participants. This was in order to inform approaches to physiotherapy management that might be developed from the study's findings. A second purpose was that the types of limitations experienced by this sample would also inform the choice of objective measurements piloted in the second study (chapter 3).

As discussed above, activity and participation has already been analysed in the preceding sections. In particular some treatment goals were related to activities and participation such as improving specific movements, returning to work and enabling participation in leisure activities (section 2.6.2.2, p91). Treatment outcome was in some cases measured by the participants in terms of ability to do housework and to move around more easily (section 2.6.2.3, p93). Also, in relation to self- management, physiotherapists were less good at advising on the day-to-day aspects of living with CLBP than they were at prescribing specific exercises. Whilst exercises were the main self-management strategy taught to patients, many of the strategies patients actually employed to deal with their LBP on a day-to-day basis, some of which related to modifying activities, were self-taught.

In addition to these points, participants commonly discussed activity limitations and participation restrictions throughout their interviews. These are described here, after which all the data relating to activity and participation is summarised in answer to the research question. Since the importance of activity and participation to CLBP patients is closely related to the rationale for the second study, this is introduced here.

2.6.5.1: Activities and participation affected by Chronic Low Back Pain

All participants in the current study described the way in which their LBP affected activities and participation. As previously stated this was commonly in response to the introductory question "can you start by telling me about your LBP..." The diversity of activities affected can be seen in table 2.6.9, which displays the categories and the classes of data in which groups of categories were arranged.

Table 2.6.9: Activities and participation reported to be affected by Chronic Low Back Pain

Categories	Classes
Activities of daily living In/out of car/bed/chair, turning in bed, sleep, bending, lifting, sitting, standing, walking, driving, housework, shopping	Activity limitations & participation restrictions
Hobbies Recreational walking, cycling, golfing, gardening, horse-riding, looking after pets	
Employment Work	
Takes away independence, fear prevents participation in certain activities, tries not to think about it too much, just keeps going despite pain, desire to return to work provided motivation to get better	Attitudes and responses to limitations & restrictions
Limitations prompted to seek help, goals, outcome, Limitations were/probably were /were partly/were not addressed by physiotherapist	Physiotherapy and limitations & restrictions

All participants described their LBP as affecting activities of daily living, often focussing on how badly they were affected when their pain was at its worst. Most commonly affected were sleep, walking, and getting in or out of a bed, car or chair, illustrated by the following:

> *"Oh I get it steady, I just, I really can't sleep for it. I have to lie on one side and then. I mean the lady she, she showed me things, how to do things, but I mean it was second nature to myself because it was the only was I could sort of sleep you know..."*
> (Subject 04, 52 year-old female)

> *"I would probably say I can walk for half an hour, and then I start kind of waddling almost. I kind of go from one foot to the next, and really kind of stiffen up. My friends laugh at me. Look at you walking like that, I move my back and I'm getting stiffened up and. And I can't stand for any longer than about twenty minutes, without needing to kind of go, stretching and moving from foot to foot. So that's still bad."*
> (Subject 19, 29 year-old female)

> *"I was as sore, and I was bent and things, everything was painful. Even trying to get out of your bed, turning over, anything...I was no good going out in cars (...) too painful."* (Subject 2, 57 year-old female)

> *"One of the biggest ones* [Ways of measuring effect of physiotherapy] *was how you got out of your bed in the morning, or out of a chair. I found it a bit easier, you weren't quite so stiff. And when you are in pain, little things like that are. It's hard to explain to someone that's maybe never had it but, it does make, it's actually a massive difference. If you just get up and down and do simple things without..."*
> (Subject 14, 41 year-old male)

There was a recurrent theme of LBP affecting participation in activities such as recreational walking, cycling and gardening, as these participants describe:

> *"But I do, I do like walking and that, but I do find it a bit difficult now. Same with the bike, I can't go on the bike any more, 'cause I get really uncomfortable. I was always a great walker, I love walking, but I hardly go out now."*
>
> (Subject 3, 50 year-old female)

> *"I'd got to the point where I was, I couldn't stand up terribly easy, and it was, I know what had caused it, and it was a matter of just righting it*
> ***Interviewer:*** *Right*
> ***Respondent:*** *And that was with gardening, kneeling down in the garden...but gardening obviously there's not a lot I can do about that, you're either gardening or you're not and that does bring on my back pain"*
>
> (Subject 7, 52 year-old female)

Finally, there was a less frequent theme of work being affected by LBP. This was for some in terms of certain tasks being difficult or causing increased LBP, as in the following:

> .*"If I'm doing a lot of bending at work, then it does tend to aggravate it. And the way I'm bending's not sometimes the right way to do it."*
>
> (Subject 17, 58 year-old female)

> *"I find it hard working. I'm alright for a little while, you know, then the pain starts setting in, it gets worse and worse and you just...so I do, I find it hard."*
>
> (Subject 3, 50 year-old female)

For others their LBP had resulted in long-term sickness absence, as this participant explains:

> *"I think it was nine weeks off my work...until October 2002, I came off and I've never. I've tried to go back three or four times, but the longest I last is about three or four days. Well the last time I tried to go back, the more bending I was doing, it was like across the middle of my right thigh, it was as if somebody was tightening a vice round my thigh (...) I couldn't walk..."* (Subject 14, 41 year-old male)

2.6.5.2: Attitudes and responses to limitations and restrictions

Although not all participants expressed such attitudes, the following examples help to illustrate the effect that activity limitations and participation restrictions had on some of the participants. For some this was a profoundly negative effect:

> *"I was as sore, and I was bent and things, everything was painful. Even trying to get out of your bed, turning over, anything...I wouldn't like to go through that again. Because I never thought I'd walk again (...). I would say this is the worse it has ever been...So it, it takes too much independence away from you."*
>
> (Subject 2, 57 year-old female)

> *"And your depression because your family don't really, they don't really understand. I think they get fed up of it saying do that for me and do that for me...Felt like you were putting too much pressure on them. And you felt lazy, you felt like they were thinking you were lazy, things like that. And you're wanting to do things but they're thinking, oh I bet she can't. It's horrible. Unless they've had it themselves. It's horrible, you just feel guilty for some reason."* (Subject 21, 39 year-old female)

For some, the desire to return to normal functioning provided them with motivation to help themselves, as this participant explains:

> *"Em, at the time, they wanted to put me on, em, disability, and I went...I'm not disabled...I've got a pair of hands, I can still work. I've been working since I think I was about thirteen, and there was no way I was going to be sitting around on, you know, incapacity benefit or whatever for the rest of my life...That was the driving force behind it. I was determined that I was going to get back into the workplace"*
> (Subject 1, 39 year-old male)

Finally, for others, it appeared to be a case of ignoring their LBP as much as possible and just "getting on with it" in order for it not to interfere with their activities:

> *"Doing hairdressing if I've got a busy day, a lot of people my back is really sore when I go home. Just everything. Lying in my bed. Sitting I start getting uncomfortable. I suppose it does affect, affect me every day but like I said I just put up with it. I've just got to try and get on with it."* (Subject 22, 33 year-old female)

> *"Except when I'm walking, the pain goes. But if I'm standing too long, its back. If I sit the wrong way it's back. If I'm doing a lot of work, and I go home at night, I sit down to watch television or have my supper, it tells me it's there. But I just, I just keep going. It's all I can do, I can't do anything else, I just keep moving as best as I can. That's it."*
> (Subject 18, 52 year-old male)

2.6.5.3: Physiotherapy and limitations/restrictions

Goals and outcomes have been discussed previously (see section 2.6.2,). However, many participants who did not specifically have goals or outcomes related to activity and participation did discuss limitations and /or restrictions and whether they felt they were addressed in physiotherapy or not.

Two groups emerged relating to whether activity limitations and/or participation restrictions were specifically addressed by the physiotherapist during treatment. Commonly participants felt that their limitations and restrictions were not addressed by their physiotherapist. Included here are participants who felt they were partly addressed but nothing "new" was learned from the process and those who "assumed" that limitations and restrictions were discussed at their first assessment but had no real recall of that discussion, suggesting that there was no significant effect of this assumed discussion. Some participants expressed disappointment that the physiotherapist had not assessed particular activity limitations, such as walking, as this participant explains:

> *"I thought she* [the physiotherapist] *might have watched me walking a bit because I was limping a bit and the way I walk when my back's really sore. Because it's the lower lumbar area. The way I walk I try and walk so that bit doesn't move. So you tend to swing a bit, and you try not to move that bit when you're really sore. I've a funny way of walking (laughs) I can't quite describe it."*
>
> (Participant 5, 48-year old female)

Less commonly participants felt that limitations and restrictions were addressed by the physiotherapist. The activity limitations that participants were given advice on included sleeping position (the most frequent), work issues, sporting activities and housework. Participants were generally satisfied with the advice given, as this participant demonstrates:

> *"...It was something really, really easy and simple. The physio said, well I mean she said well, just stand with your back straight, don't twist your back, and just drag it* [vacuum] *towards you. Um, again I thought this is just so simple, why haven't I thought about it myself, and it does, yes it certainly does* [help]*."*
>
> (Participant 7, 52 year-old female)

However, this was not necessarily related to overall satisfaction with physiotherapy in general or with goal achievement. There was no difference between groups in the types of limitations and restrictions reported. A combination of activities of daily living, hobbies and employment were present in both groups. Likewise, there was no difference between groups in relation to overall satisfaction or goal attainment. This might have conflicting interpretations. Perhaps the approach of the individual physiotherapist was related to whether functional activities were addressed or not rather than any other factor. However, it might mean that the physiotherapist addressing limitations and restrictions had no effect on satisfaction or goal attainment. This in turn could be interpreted as either physiotherapists addressing limitations or restrictions being of no consequence and therefore not important to carry out. However, it might suggest that physiotherapists were not effective at addressing activity limitations and participation restrictions even when they did attempt to do so.

2.6.5.4: Discussion

Activities and participation affected by CLBP

Previous studies have described a similar diversity of activities affected by CLBP (Walsh et al, 2003; Layzell, 2001). In the present study sleeping, walking, and rising from a bed, car or chair were the most common activities to be affected. Walsh et al (2003) also reported high numbers of patients whose sleeping and walking were affected. Most of the self-report tools commonly used to measure activity limitations and participation restrictions in LBP patients include items on walking and sleeping (for example, Quebec Back Pain Disability Scale (Kopec et al, 1995), Roland Morris Disability Questionnaire (Roland and Morris 1983), Oswestry Disability Index (Fairbank et al, 1980)). The current research supports their face validity with sleeping and walking being common limitations in this sample.

Rising to stand was not identified as a limitation by Walsh et al (2003), but the individual activities of sitting and standing were identified as problematic by their sample. Their study evaluated the Canadian Occupational Performance Measure, which involved a semi-structured interview designed to identify functional limitations. Sample activities used as prompts during the interviews included both sitting and standing, but not the movement of rising from a sitting (or lying) position. This may have affected the reporting of limitations, whereas in the current study participants freely reported limitations without the use of prompts. While many participants did cite sitting and standing for periods of time as being problematic, it was more common for the movement of rising from a bed, car or chair to be discussed.

Both sitting and standing are also commonly enquired about in the self-report tools (Kopec et al, 1995; Roland and Morris 1983; Fairbank et al, 1980), whilst rising to stand is enquired about in some (Kopec et al, 1995; Roland and Morris (1983), but not all. The current findings therefore again support the face validity of those questionnaires that explore rising to stand, and support the more widespread inclusion of these measures.

Attitudes towards limitations & restrictions

The attitudes expressed by the participants in the current study are in keeping with previous research that has reported the effect of CLBP on individual's lives. Particularly with reference to psychological effects such as depression (Layzell, 2001) and different methods of coping with LBP such as "just getting on with it" (Borkan et al, 1995).

Physiotherapy and limitations & restrictions

It is interesting to note that the participants in the current study commonly felt that physiotherapy did not address their limitations or restrictions, since recent guidelines suggest that treatment should be addressing these very things (Bekkering et al, 2003). The problems of implementing guidelines to effect change in practice have already been discussed (p133) and this finding provides further argument for combining guideline implementation with specific training.

The fact that a small number of participants did feel that physiotherapy addressed their particular activity limitations and participation restrictions suggests that it is possible to do so. Since there were no important differences detected between those who did and didn't feel their limitations and restrictions were addressed, perhaps adopting a patient-centred approach to assessment and treatment of CLBP patients would help identify limitations of importance to the patient and methods of addressing them. However, as discussed above there are alternative interpretations of this finding. Perhaps the most plausible interpretation is that the physiotherapists were not effective at addressing activity limitations and participation restrictions. This would suggest that either training is required to do this effectively, or alterations to the service such as more time to spend exploring such limitations and restrictions with participants is required in order for it to be effective. This relates to the previous section on self-management (2.6.4) and the suggestion that training is required for physiotherapists in delivering self-management education. Self-management education involves providing patients with problem-solving skills (Lorig, 2003). CLBP patients commonly have problems relating to activity and participation, as this and previous studies have demonstrated. Therefore, self-management education for CLBP needs to provide patients with the skills to address their activity limitations and participation restrictions. Therefore, as proposed for self-management, training in addressing and helping patients to address activity limitations and participation restrictions might well be necessary. For the physiotherapy service to provide self-management education and to effectively address activity and participation there might also be changes to the service that would be beneficial.

Previous sections have suggested that some CLBP patients have specific activity or participation related goals that they wish to achieve from attending physiotherapy (section 2.6.2.2, p91), and that outcome is at times measured in terms of activity and participation (section 2.6.2.3, p94). This suggests that not only physiotherapists, but patients themselves do recognise the importance of restoring activities and participation to the highest levels possible, as suggested by Bekkering et al (2003).

2.6.5.5: Summary of importance of activity and participation

There are again three key points that summarise the findings presented above:

1. This research has demonstrated in a UK sample of CLBP patients that activity and participation are important issues. Activity limitations and/or participation restrictions can have a profound effect on CLBP patients, can provide a focus for attending physiotherapy and can also provide a means for patients to evaluate its efficacy.
2. A diverse range of activity limitations and participation restrictions were reported by this sample, with the most common limitations being sleeping, rising to stand and walking.
3. This group of participants felt that physiotherapy commonly did not address their activity limitations and participation restrictions, although the few participants for whom they were addressed suggest that it is possible for physiotherapists to do so. The findings suggest that training might be required for physiotherapists to effectively address activity limitations and participation restrictions, particularly in relation to self-management.

2.6.6: Study strengths and limitations

There are several strengths and limitations of this study, which can be considered in four categories: overall research method, reliability, validity and reflexivity.

Overall research method

The qualitative interview approach to this study allowed the perceptions of the participants to be explored in some depth, providing greater understanding of the issues concerned than may have been possible with alternative methods. Quantitative questionnaires were briefly considered in section 2.4.1; however their use in this study would have explored only the issues anticipated by the researcher and not necessarily those of importance to the participants. An example of the benefit of the qualitative interview approach can be seen in the findings relating to patient-centred physiotherapy (section 2.6.3). Here many themes arose from the data that were not pre-determined or anticipated, therefore reflecting the views of the participants rather than those anticipated by the researcher. Another example of the benefit of the qualitative approach is in relation to expectations of physiotherapy (section 2.6.2). Rather than simply stating what patients' expectations of physiotherapy were, by exploring the topic in the interviews it was possible to gain some understanding of the relationship of these expectations to other factors such as previous physiotherapy experience and motivation to attend. This is unlikely to have been possible using questionnaires due to the limited scope for exploring issues in depth.

The qualitative methods used in the study were influenced by applied social policy research as discussed in section 2.4.4. A key feature of this approach is the influence of factors traditionally associated with quantitative design, such as reliability and validity (Snape and Spencer, 2003). The way in which reliability and validity were addressed in this study is therefore now discussed.

Reliability

Reliability in qualitative research concerns the extent to which the findings would be reproduced in a study using similar methods (Lewis and Ritchie, 2003). Due to the nature of qualitative research it is unlikely that identical results would be reproduced precisely in another study (Tobin and Begley, 2004). However, there would be little point in carrying out this research if there was not some relevance outwith the study sample. It is not the purpose of qualitative research to generalise to the wider population, but it is the purpose to demonstrate that findings "*can* be transferred and *may* have meaning if applied to other individuals, contexts and situations" (Finlay, 2006, p 20). Therefore, as Mays and Pope (2000) suggested, it is intended that the current research has been presented in a sufficiently detailed manner for the reader to judge to what extent the findings may apply in similar settings.

As previously discussed (section 2.5.7, p83) in keeping with the method of data collection used in this study, it was possible to take several steps to increase reliability of the findings (Lewis and Ritchie, 2003). The sample was selected in order to be representative of the types of CLBP patients attending physiotherapy departments in Grampian and in order to reduce sample bias. Therefore both those who completed and failed to complete treatment were included, as were those from several different clinical sites and those who had experienced different methods of treatment delivery. This type of sampling leads to "symbolic representation" (Ritchie et al, 2003, p83) since the participants are chosen to both "represent" and "symbolise" features that are relevant to the study. This definition helps to highlight the difference in sampling between qualitative and quantitative methodologies. The former sample to represent the "character" of the population (Ritchie et al, 2003, p83) and the latter to statistically represent the population distribution.

The small sample size might historically have led to a conclusion of inability to generalise to a wider population (Finlay, 2006). However, due to the method of sample selection and its "symbolic representation" of CLBP patients attending physiotherapy in Grampian, it is possible to generalise to physiotherapy for CLBP in Grampian, and readers will doubtless recognise the issues discussed from their experience with CLBP patients in other geographical settings. Nevertheless, the views of a small group can never represent the "truth" and further research would be required both to confirm the findings of the current study, and establish to what extent the perceptions reported are present in a large group of CLBP patients (May, 2001). This could take the form of a larger interview study, or alternatively a questionnaire study based on the findings presented here. This could capture the extent of agreement of a larger sample of CLBP patients with the perceptions of those interviewed in this study, therefore allowing broader generalisation.

The self-selection of participants is a possible limitation of this study, as it may have resulted in a biased sample of those who felt particularly strongly about their physiotherapy experience. This is difficult to overcome since self-selection is an inevitable part of ethical research (May, 2001). The fact that there were several views and both satisfied and dissatisfied subjects suggests that there was no particular bias. However, those who were interviewed were only 18% of those who were invited to take part, and the views of those who declined to be interviewed remain unknown. There were some differences between those invited to participate and those who took part, illustrated in table 2.5.2, and discussed in section 2.5.3. The sample did represent an older and more predominantly female group than those invited to take part. However, several measures were taken to maximise reliability. The fieldwork was conducted in a consistent manner. The interview schedule (used for all but the first two interviews) aided this process and ensured that subjects were asked the same questions on the same topics throughout the data collection process. The data was subjected to systematic and comprehensive analysis, which has been described in previous sections of this chapter. The evidence has been presented in the form of codes, themes, categories and classes of data that were developed, and in the form of quotations from a range of subjects, in order to support the interpretation presented. The reporting of both the data collection and analysis phases resulted in transparency of the research process, which is encouraged in qualitative research (Tobin and Begley, 2004). Finally, all perspectives were identified. Disconfirming and negative cases were sought and presented. This was particularly relevant, since for many of the topics a range of views were apparent, and each was presented, irrespective of the number of respondents who held the particular view.

It has been suggested that good qualitative research should be in keeping with previous studies (May, 2001). There was no work with which to compare CLBP patients' suggestions for long-term management strategies;

however the current findings showed similarities to previous work both on expectations of treatment delivery and on activity limitations and participation restrictions. There were also similarities with medical, nursing and occupational therapy fields on patient-centredness. This further enhances the reliability of this study.

Validity

The definition of validity used in this study, introduced in section 2.5.7, is "the accurate reflection of the phenomena under study as perceived by the study population" (Lewis and Ritchie, 2003, p 274). Several steps were taken, also described in section 2.5.7, during data collection and analysis to ensure that the data was an accurate representation. The sample selection and comprehensive analysis methods discussed above contributed to the validity of the data. As did the reporting of the findings, which clearly displays the analytic steps taken and the meanings applied to the data which have remained true to the meanings applied by the participants.

Validation

Validation is the process by which the validity of the findings can be checked (Lewis and Ritchie, 2003). These can be internal to the data or external, using other sources to verify findings.

Internal validation

Within the framework analysis method it was possible to take steps to ensure internal validity of the findings (Lewis and Ritchie, 2003). Descriptive and explanatory accounts of the data were developed using a constant comparative method where data were compared and checked across themes and individuals. For example, when developing the typologies relating to self-management (section 2.6.4) several alterations were made during the constant-comparative process until the final typologies emerged. Likewise, deviant case analysis was used, where outliers were not ignored or forced into classes, but used to enhance understanding of the theme. For example the view on written communication (section 2.6.3) was included to aid understanding of the topic despite it being a minority view. In addition, the design of the interview schedule ensured that the patients' perspective could be gained since it was flexible enough to allow them to discuss what was of importance to them. There were no new themes emerging well before the end of the data collection process, ensuring that saturation of the data had been reached.

External validity

This was discussed in section 2.5 (p82). In this study triangulation in the form of multiple respondents and analysts (for verifying the coding index) was used, but not member validation due to time constraints.

Reflexivity

Reflexivity refers to an understanding of the researchers role in producing the data and their meanings (Green and Thorogood, 2004). The main consideration here was the fact that participants were being interviewed by a physiotherapist about their physiotherapy experience, a factor that may have affected the outcome of the study. Steps were taken to limit this, such as the researcher dressing out of uniform and introducing herself as "the researcher" on the day of interview and physiotherapy departments not being used to conduct the interviews. However, for ethical reasons, when asked directly the researcher did disclose the fact that she was a physiotherapist and this information had also been provided on the letter inviting the subjects to take part. However, this knowledge did not prevent negative viewpoints about physiotherapy from being disclosed, and as previously discussed a wide range of views were presented by the subjects.

In summary, the size and nature of the sample and the effect of the researcher were potential limitations of this study. However, due to the rigorous methods of data collection and analysis utilised there can be confidence that the data presented here is both reliable and valid. There can also be confidence that the results are relevant to the physiotherapy service for CLBP in Grampian, and perhaps to other physiotherapy services that encounter similar types of CLBP patients.

2.7: Conclusion

2.7.1: Key findings

This study demonstrates that CLBP patients in Grampian appear to expect exercises and/or hands-on treatment, long sessions of one-to-one contact with the physiotherapist, and for pain-relief to be the primary treatment outcome. It appears from this study that these expectations are currently not consistently met in Grampian. This research presents a patient-generated definition of patient-centred physiotherapy for CLBP. Patients appear to perceive patient-centredness as a complex combination of the seven dimensions defined in this study, with communication central to achieving patient-centredness. According to this definition, it appears that physiotherapy in Grampian is not consistently patient-centred. Several suggestions for enhancing patient-centredness emerged from these findings and are presented below (2.7.2). This study also suggests that CLBP patients in Grampian are not consistently facilitated by physiotherapists to self-manage their condition following discharge from physiotherapy. Several suggestions for facilitating self-management emerged from the findings, and are also presented below. Finally, these results suggest that activity and participation are important to CLBP patients, and are therefore important to address in physiotherapy, but that this does not appear to consistently occur in Grampian at present.

2.7.2: Implications

Some of the implications for physiotherapy practice and education, and suggestions for further research that this study highlighted, have been introduced in the summaries of the four topics of enquiry presented in section 2.6. Here the study is considered as a whole and the implications arising from the findings considered fully.

Implications for physiotherapy practice

1. This research has highlighted the need to inform patients of the content, purpose and potential outcome of physiotherapy for CLBP, in order to foster realistic expectations. This might be achieved by providing written information at the time the referral to physiotherapy is made, or perhaps at the first physiotherapy appointment in both verbal and written format. The effect of providing information in this way on expectations and subsequent outcome would need to be evaluated and is discussed below.
2. The need for physiotherapists to determine CLBP patients' treatment and outcome expectations at the outset of the physiotherapy process, and to evaluate whether these expectations are ideal or realistic was confirmed by this research. This might be included as part of the

initial physiotherapy consultation, where patients are given adequate time to explain their expectations and discuss them with the physiotherapist. Where expectations conflict with the aims of physiotherapy for CLBP, there appears to be a need for physiotherapists to attempt to influence patients' expectations. The mechanisms by which this might be achieved require further research and are discussed below.

3. The need for physiotherapists to more consistently adopt a patient-centred approach to managing CLBP patients was highlighted by this research. This might involve addressing the seven dimensions of patient-centred physiotherapy presented in this research. The findings suggest that key areas to address in clinical practice are:
    - Enhancing communication skills. This would require both education, and research to evaluate its effectiveness, both of which are discussed below.
    - Dealing with patients' enquiries in a timely and efficient manner. This could perhaps be addressed by reviewing protocols and raising awareness with physiotherapy and administrative staff.
    - Adequately informing patients about arrangements for discharge and onward referral. This might again be addressed by reviewing protocols and raising awareness, and be evaluated via patient satisfaction surveys following discharge from physiotherapy.
    - Determining and addressing CLBP patients' individual information needs. As with expectations, these might be determined at the initial consultation, given adequate time and physiotherapist communication skills. Gaining this knowledge at the outset and reviewing the patient's needs throughout the physiotherapy process might then adequately address their information needs.
    - Determining to what extent CLBP patients wish to be involved in the decision-making process. This might again be determined at the outset of physiotherapy, as with expectations and information discussed above, and be facilitated by adequate time and communication skills.

    - Addressing organisational issues such as access to physiotherapy and duration of appointments. Access might be addressed in the ongoing work on direct access to physiotherapy services and triage systems within physiotherapy. The effect of increasing the duration of physiotherapy appointments would need to be evaluated in terms of patient satisfaction, outcome, and the total number of appointments required.

4. There appears to be a need for physiotherapists to more consistently assess and address CLBP patients' individual activity limitations and participation restrictions during physiotherapy. This might again be facilitated by adequate time and communication skills.
5. There appears to be a need for the physiotherapy service to address the self-management education and support needs of CLBP patients. The findings suggest that key areas to address in clinical practice are:
    - Providing self-management education to CLBP patients. This has implications for both education and research and is therefore discussed below.
    - Providing adequate and individually tailored discharge advice. This might be addressed by reviewing protocols for discharge and raising awareness amongst physiotherapists.
    - Providing CLBP patients with information on sources of support outwith physiotherapy. For example written information with contact details for patient organisations, charities, and suitable local exercise groups.
    - The possibility of providing routine review appointments for CLBP patients. These could be face-to-face or over the telephone and their feasibility, clinical effectiveness and cost-effectiveness would need to be evaluated. These are also discussed below.
    - The possibility of providing future direct access to CLBP patients. This again links with the recent research on direct access to physiotherapy services and its impact on clinical and cost effectiveness would need to be evaluated.

Implications for education

Undergraduate education

1. The core undergraduate curriculum may need to be enhanced with respect to patient-centredness and communication skills in order to adopt a patient-centred approach early in the physiotherapist's career.
2. The core undergraduate curriculum may need to be enhanced with respect to self-management education strategies and their theoretical underpinnings, in order to equip physiotherapists with the necessary skills to deal with an increasing number of patients with chronic conditions.

Postgraduate education

There appears to be a need for postgraduate education in three key areas:

1. **Patient-centredness:** This might be achieved through dissemination of these research findings and education sessions on this patient-generated definition of patient-centredness, including the implications for practice detailed above.
2. **Communication skills:** This might be achieved through attendance on postgraduate courses aimed at enhancing communication skills, which have benefited other professional groups.
3. **Self-management education:** This might also be achieved through attendance on postgraduate courses that teach the principles of self-management education.

Suggestions for further research

This study has highlighted that further research is warranted in the following areas:

1. A larger study might be useful to further develop a theoretical model of patient-centred physiotherapy for CLBP on which practice and research could be based. This could either involve a study using similar methodology to this one but recruiting a larger and more diverse sample from several geographical locations, or a questionnaire study targeting a large diverse sample to establish the level of agreement with the patient-generated definition developed in this study.
2. It might be useful to further research the relationship between the perceived benefit of particular treatments for CLBP and treatment

outcome. This would allow for increased understanding of the role of treatment expectations in determining treatment outcome.

3. Strategies to inform patients of the content, purpose and potential outcome of physiotherapy for CLBP could be piloted in order to evaluate their effect on patients' expectations and subsequent satisfaction with and outcome of treatment. Strategies to research include information provision by the referring practitioner (GP or consultant), and information giving by the physiotherapist at the initial consultation. Related to this is the potential for media campaigns to influence the public's perceptions of physiotherapy for CLBP, which might also be beneficial to research.
4. Further research on methods by which patients' unrealistic expectations can be influenced by physiotherapists might help to understand this complex area. Strategies aimed at educating physiotherapists on particular communication techniques might be relevant here, as might information-provision for patients as discussed above.
5. Some of the implications for clinical practice and education suggested in relation to patient-centredness would need to be evaluated in order to determine their effect on patient satisfaction and effectiveness of physiotherapy, and also their feasibility in terms of service delivery. These include educational strategies aimed at improving communication skills, and lengthening the duration of physiotherapy appointments for CLBP patients.
6. Some of the implications for clinical practice and education suggested in relation to self-management would also need to be evaluated in terms of their clinical and cost-effectiveness. These include educating physiotherapists in self-management education, providing self-management education to CLBP patients, providing review appointments to CLBP patients, providing a telephone "helpline" for CLBP patients, and providing future direct access to CLBP patients. Providing self-management education would need to include a comparison of different styles of delivery such as layperson led, clinician led and internet based. Providing review appointments would need to explore both face-to-face and telephone reviews.

This concludes the qualitative component of this thesis. The following chapter turns its focus to the objective measurement of walking and STS.

Chapter 3: Objective measurement of Chronic Low Back Pain patients

3.1: Introduction

This chapter presents the study on objective measurement of CLBP patients. As the first stage in exploring the potential for gait and STS to provide suitable outcome measures for CLBP patients, the presence of impairments of gait and STS in a sample of CLBP patients was determined. This chapter first presents a critical review of the literature relating to this study. Three substantive areas are reviewed. Firstly outcome measurement in CLBP, with an emphasis on objective measurement. Secondly, gait analysis in CLBP patients and finally STS analysis in CLBP patients. This literature review highlights the gaps in the current knowledge base and therefore the need for this study to be conducted, and justifies this study's aims and objectives. Justification and description of the methods used in this study follow the literature review. Extensive pilot work was undertaken to establish the most suitable measurement tools; this is also summarised in the methods section. Thereafter, the study's findings are presented and interpreted.

3.2: Literature review

3.2.1: Outcome measurement in Low Back Pain

This section discusses the importance of outcome measurement in LBP patients and reviews the measurement tools currently available for use with this patient group. The literature does not always differentiate between LBP of acute and chronic duration with regard to outcome measures, therefore the term LBP and not CLBP is used throughout. The tools are reviewed in relation to the domains of the ICF that they address (WHO, 2001), a concept introduced in chapter one. The need for augmenting current outcome measures with objective measurement tools is highlighted, and the reasons why gait and STS might prove suitable as objective measures are presented.

3.2.1.1: Importance of outcome measurement in Low Back Pain

Generally speaking, an outcome measure quantifies change in a patient's status over time (Liebenson and Yeomans, 1997; Kane, 1994). A physiotherapy outcome measure may further be considered to be a test or scale which is administered and interpreted by the physiotherapist and which accurately measures a particular attribute of interest; one which is expected to be influenced by the physiotherapy intervention (Mayo, 1994). An outcome measure can record changes in physical, psychological or social well being (Kendall, 1997). Outcome measurement is being increasingly employed in physiotherapy to establish baselines, set treatment goals, plan treatment programmes and monitor patients' status and the quality of treatment they receive (Kirkness and Korner-Bitensky, 2002; Liebenson and Yeomans, 1997).

Outcome measurement is particularly important in LBP for two further reasons. The difficulties surrounding diagnosis of the LBP patient are well documented. Pathological findings on scans or x-rays often fail to distinguish between those with and without LBP (Beattie, 1996), and symptoms alone are not always a reliable indicator of pathology (Poitras et al, 2000). Therefore, the use of standardised measures can aid in the diagnosis and treatment planning stages. Secondly, there is still a lack of consensus on the optimum physiotherapy treatment for LBP (Kirkness and Korner-Bitensky, 2002; Van Tulder at al, 1997), with current physiotherapy guidelines (Mercer et al, 2006) largely relying on expert opinion or recommended good practice due to the lack of quality research evidence available. This makes ongoing evaluation of treatment approaches vital, in order to strengthen the evidence supporting specific physiotherapy interventions for LBP patients. Clearly, outcome measurement has a role to play here in quantifying the effects of physiotherapy on both individuals and groups of patients.

The importance of outcome measurement and outcomes research in the management of LBP is evident from the numerous publications on the topic in recent years (e.g. Muller et al, 2004; Schaufele and Boden, 2003; Bombardier, 2000; Kopec, 2000). Most of these authors concede that there is as yet no ideal core set of measures for this population (Muller et al, 2004; Bombardier, 2000), necessitating ongoing research in this area. However, there is general agreement that to evaluate treatment outcome in LBP patients, five types of measure are required: Back-specific function, generic health status, pain, work disability and patient satisfaction (Bombardier, 2000). For LBP of longer duration psychological status is also important to measure (Mercer et al, 2006).

3.2.1.2: Domains of measurement

The ICF (WHO, 2001) was introduced and its terminology defined in chapter one (see tables 1.1 and 1.2). This review considers whether the available outcome measures relate to impairments, activity limitations or participation restrictions as defined by the ICF (WHO, 2001). In addition, it is possible for an outcome measure to be subjective: defining the patient's account of his complaint (Maitland et al, 2001), or objective: recording demonstrable physical findings (Waddell et al, 1992). This further classification is also considered.

There are numerous outcome measures available for use with CLBP patients; some of these are listed in tables 3.2.1a and b. These tables are not intended to be exhaustive, but to provide an overview of the range of outcome measures available for use. These outcome measures were identified from an online database of outcome measures for physiotherapists (CSP, 2004) and by conducting an electronic literature search on AMED, Cinahl, Embase, and Medline covering the period from 1994 to 2007 and using the keywords low back pain, outcome measure and physiotherapy. It can be seen from tables 3.2.1a and b that both impairment and subjective measures are predominant, and that there is only one purely participation measure. These criteria are now considered in detail.

Impairment

Tables 3.2.1a and b demonstrate that there are both subjective and objective tools available to measure impairments, or "problems in body function/structure" (WHO, 2001). Pain severity appears to be the most commonly used measure, and can be in the form of a simple scale such as the visual analogue scale or a questionnaire such as the McGill Pain Questionnaire (Melzack, 1975). This is congruent with the findings of expert panels on LBP who recommended the use of a pain measure with LBP patients (Ehrlich, 2003; Bombardier, 2000). The CSP (Mercer et al, 2006) suggest that the visual analogue scale is the most commonly used measure in UK physiotherapy departments, and it is routinely used in Grampian, where this study was conducted.

Table 3.2.1a: Examples of outcome measures for Chronic Low Back Pain patients; pain and functioning/disability

Outcome measure	Description	WHO Classification	Subjective/ Objective
PAIN			
Pain diaries	Patient-completed diary of pain symptoms	I	S
Pain medication use	Self-report of medication use	I	S
Pain scales	Numeric, verbal or **visual analogue scale**	I	S
Pain severity questionnaires	Self-report questionnaires e.g. Brief Pain inventory, McGill Pain Questionnaire	I	S
FUNCTIONING/DISABILITY			
Baecke Physical Activity Questionnaire	Self-report of physical activity levels	A	S
Low Back Pain specific questionnaires	Self-report of limitations of functioning e.g. **Oswestry Disability Index, Roland-Morris Low Back Pain Disability Questionnaire**, Quebec Back Pain Disability Scale, Functional Rating Index	A (P in some cases)	S
Lumbar mobility	Therapist conducted tests e.g. fingertip to floor, inclinometer, schober's test	I	O
Objective tests of activity	Used alone or as part of a "battery of tests" e.g. endurance/speed walk, timed STS, shuttle walk test	A	O
Quality of life questionnaires	Generic self-report questionnaires e.g. Euroqol, SF-36	I/A/P	S
Straight leg raise	Therapist conducted test	I	O
Trunk strength	Duration of isometric contraction of trunk flexors/extensors	I	O
Work loss	Self-report of work days lost due to LBP	P	O

Key: I= Impairment, A= Activity limitations, P= Participation restrictions, S= Subjective, O= Objective

Measures highlighted (blue) are those believed to be most commonly used in physiotherapy departments in the UK (Mercer et al, 2006)

Table 3.2.1b: Examples of outcome measures for Chronic Low Back Pain patients; psychological status and "other"

Outcome measure	Description	WHO Classification	Subjective/ Objective
PSYCHOLOGICAL STATUS			
Fear Avoidance Beliefs Questionnaire	Self-report of fear of pain associated with physical activities	I/A	S
Self-efficacy	Self-report to measure self-efficacy beliefs for pain and function e.g. Chronic pain self-efficacy scale	I/A	S
Somatic and depressive symptoms	Self-report questionnaires e.g. Distress Risk Assessment Method (DRAM), Hospital Anxiety and Depression Scale (HADS)	I	S
Tampa Scale for Kinesiophobia	Self-report of fear of movement and re-injury	I	S
OTHER			
Compliance with exercise	Exercise diary	A	S
Global Improvement	Numeric rating scale of perceived improvement	I/A	S
Goal attainment Scaling	Setting and measuring of patient-determined goals	I/A/P Depending on goals	S/O Depending on goals
Number of recurrences	Self-report of recurrence of LBP	I	S
Satisfaction	Rating scale of satisfaction with treatment	?	S

Key: I= Impairment, A= Activity limitations, P= Participation restrictions, S= Subjective, O= Objective

Spinal mobility is another commonly used impairment measure in both research and clinical practice (Jousset et al, 2004; Rainville, 2004a; Oberg et al, 2003; Kirkness and Korner-Bitensky, 2002). However, several authors have demonstrated poor correlation of traditional range of motion measures with patients' self-report of disability.

For example Nattrass et al (1999) studied the relationship between spinal range of motion (measured with a dual arm inclinometer and long arm goniometer) and patients' self-report of disability (measured with the Oswestry Disability Index (ODI; Fairbank et al, 1980)) in 34 CLBP subjects. They found little correlation between the ODI and either range of motion measure.

Pearson's correlation coefficients for the inclinometer and Oswestry were –0.22 to –0.38, whilst those for the goniometer and ODI were –0.22 to –0.45. Sullivan et al (2000) reported similar findings in their study of 81 CLBP patients, reporting a Pearson's correlation coefficient of –0.25 between lumbar spine range of motion and the Roland-Morris Low Back Pain Disability Questionnaire (RDQ; Roland and Morris, 1983). These findings could question the validity of spinal range of motion tests such as fingertip to floor, Schober's and inclinometry with this population. The validity of inclinometry has been further questioned by the outcome of studies comparing them to "gold standard" measuring techniques such as radiography (Littlewood and May, 2006). The backache index (Farasyn and Meeusen, 2006), a system of clinician-scoring of range and pain felt during spinal movement in five directions, correlates reasonably well with the ODI (Spearman's correlation coefficient 0.62). However, it quantifies movement as either full or reduced; therefore its ability to detect small to moderate changes in range might be questioned.

Trunk strength is another test of impairment, but appears to be most commonly used for research purposes rather than in clinical practice (Kirkness and Korner-Bitensky, 2002). Measures of psychological status are also impairment measures, since impairment refers to problems in body functions, which include psychological functions. An in-depth study of psychological status questionnaires is outwith the scope of this review however, due to this study's focus on objective measurement. Finally, some of the "other" measures also clearly incorporate impairment, such as global improvement, number of recurrences and goal attainment scaling (Fisher and Hardie, 2002). These are dependent on the criteria that CLBP patients choose to rate their perceived improvements or goals, and whether they view recurrence in terms of impairment or activity limitation.

Activity limitations

Activity limitations, or "difficulties an individual may have in executing activities" (WHO, 2001) has become increasingly more important to measure with the development of rehabilitation programmes for CLBP patients whose aim is to increase functioning (e.g. Jousset et al, 2004). These programmes do not necessarily aim to reduce pain or restore impairments, but they do aim to increase patients' activity levels. Several patient-completed, and therefore subjective, questionnaires are available to measure activity limitations, as tables 3.2.1 a and b show. Beattie and Maher (1997) demonstrated that the most commonly used are the RDQ (Roland and Morris, 1983), ODI (Fairbank et al, 1980) and Quebec (Kopec et al, 1995), and the RDQ is in routine use in Grampian. They are easy to administer and score and the psychometric properties are well documented for these most commonly used questionnaires. They are therefore widely recommended as both research and clinical outcome measures (CSP, 2004; Ehrlich, 2003, Resnik and Jensen, 2003; Bombardier, 2000). The Baecke physical activity questionnaire appears to be less widespread in its use, which is perhaps due to its more generic nature. It is not exclusively aimed at LBP patients, and therefore the questionnaires detailed above may be viewed as more appropriate. The quality of life questionnaires also address some aspects of activity limitations, also in a subjective self-report manner. The objective tests listed in tables 3.2.1a and b are discussed below (section 3.2.1.3).

Participation restrictions

Participation restrictions are "problems an individual may experience in involvement in life situations" (WHO, 2001). The ideal measurement of involvement in life situations may well be through direct observation of the CLBP patient in their everyday environment; clearly a method which is impractical for routine use due to the resources required to undertake such a measurement approach (Harding et al, 1994). This may explain why work absence is the commonly used measure of participation restriction in CLBP, and is recommended as a core outcome measure with LBP patients (Bombardier, 2000). Participation in leisure activities would be another appropriate measure (Grotle et al, 2004) however it was not found in the search detailed above. Generic health status measures such as the Euroqol and SF-36 (Ware and Sherbourne, 1992) incorporate some measures of participation, as do some of the questionnaires outlined above (Sigl et al, 2006), whereas Goal Attainment Scaling (Fisher and Hardie, 2002) might measure participation depending on the goals chosen by the patient. It appears most practical that one of these measures of participation should be used to measure treatment outcome with respect to this health domain.

3.2.1.3: Objective measurement

Many of the measures discussed above and listed in tables 3.2.1a and b are self-report and therefore subjective in nature. However, it has been suggested that outcome measurement for CLBP should include an objective, quantifiable element (Wittink et al, 2003). There are two main reasons for this. Firstly, the low correlation between impairment measures and self-report of disability mentioned above has questioned the validity of traditional objective measures of impairment and led to suggestions that objective measures of activity should be used instead of objective measures of impairment (Simmonds et al, 1998). Secondly, there are limitations of the self-report instruments used to measure activity limitations. The primary limitation is that there can be discrepancies between how subjects believe they perform and how they actually do perform; therefore the instruments may not provide a real reflection of the patient's activity limitations (Smeets et al, 2006a). For example, Reneman et al (2002) studied 64 CLBP patients, finding that three commonly used self-report measures (RDQ, ODI and Quebec) classified them as moderately to severely disabled. However, a "Functional Capacity Evaluation" which involved testing the patients on 14 activities including lifting, carrying, kneeling, walking and stair climbing classified them as able to work at a moderate to heavy physical intensity. Consequently there was small to moderate correlation between the self-report measures and functional evaluation (Spearmans rank correlation coefficients -0.2, -0.52 and -0.50 for RDQ, ODI and Quebec respectively). Therefore, it has been suggested that self-report instruments combined with objective measures of activity will provide a more complete assessment of the CLBP patient (Wittink et al, 2003).

For the reasons presented above, several researchers have worked to develop objective measures of physical performance (Magnussen et al, 2004; Simmonds et al, 1998; Harding et al, 1994). The objective measures developed have largely been "batteries of tests". These test batteries include speed measures such as timed walking, stair climbing and sit to stand, and endurance measures such as lifting and the Sorensen fatigue test (Ljungquist et al, 2003; Novy et al, 2002, Simmonds et al, 1998). Elements of these batteries have been used to evaluate multidisciplinary rehabilitation programmes (Walsh et al, 2003; Fisher and Hardie, 2002) but there is no evidence of a battery of tests being used as a routine outcome measure in the physiotherapy management of CLBP. This may in part be due to a battery of tests taking 45 minutes to one hour to complete (Simmonds et al, 1998).

The Back Performance Scale (Magnussen et al, 2004; Strand et al, 2002) is a shorter (5-item) battery of functional tests designed to measure activities which require mobility of the trunk. These activities comprise putting on a sock, picking a piece of paper up from the floor, sitting up from a lying position, forward bending in standing and lifting a box from floor to table. Each activity is scored by the physiotherapist, the sum of scores giving the overall activity limitation. Test-retest reliability of the five items varied in one study, with kappa values of between 0.55 and 0.83 (Magnussen et al, 2004), suggesting moderate reliability of the items. Intertester reliability was however very high (kappa values 0.95 to 1.00) suggesting that physiotherapists can be taught to score the items in a similar way. The same study demonstrated concurrent validity with a high correlation between the Back Performance Scale and one self-report measure (Spearmans correlation coefficient 0.825 for "Der Funktionsfragenbogen Hannover"). However, there was a more moderate correlation with the more commonly used RDQ (Spearmans correlation coefficient 0.454). Despite the apparent usefulness of the Back performance Scale, like the batteries of tests above there is no evidence of its routine clinical use. The authors state it is a "test battery of daily physical functioning, including five tests of activities requiring mobility of the trunk" (Magnussen et al, 2004 p903). However, the score is based on ability to perform each test, which may imply but does not measure restriction of mobility in the trunk. It may therefore be relevant to explore tests of daily physical functioning that incorporate some measurement of trunk mobility.

The discussion so far appears to support the development of objective tests of activity for use with the CLBP population, which are acceptable for clinical use in terms of their ease of use for both patients and clinicians, and the time required to conduct them. Indeed, European guidelines on CLBP management recommended the following. "More research is required to develop relevant assessments of physical capacity and functional performance in CLBP patients, in order to better understand the relationship between self-rated disability, physical capacity and physical impairment"(Airaksinen et al, 2004, p6).

3.2.1.4: Potential objective measures for clinical use

Gait (walking) analysis has been proposed as an outcome measure for LBP patients attending physiotherapy (Al-Obaidi et al, 2003). Gait analysis might provide a suitable alternative to a lengthy battery of tests, whilst providing useful objective information on a fundamental daily activity. Walking is an activity that is executed routinely by CLBP patients, indeed the patient completed questionnaires highlight its relevance by including questions on how LBP is affecting patients' walking. Walking is often incorporated in rehabilitation programmes for CLBP patients (Jousset et al, 2004; Rainville et al, 2004b; Frost et al, 2000), with goals of the programmes including increasing walking speed and endurance. Methods of measuring the extent to which these goals are met could therefore involve objective gait analysis.

Gait analysis has several suggested uses with the LBP population including a screening tool for surgical candidates (Khodadadeh & Eisenstein, 1993), a tool to understand limitations in functioning in specific spine pathologies (Morag et al, 2000) and an objective tool to study chronic pain patients (Keefe & Hill, 1985). However, its wider use as an assessment tool and outcome measure for the physiotherapist treating CLBP patients has not been extensively investigated.

Sit to stand (STS) is another daily activity arguably executed routinely by CLBP patients. Measures of STS performance have also been proposed for use with LBP patients (Harding et al, 1994) and have been used to measure outcome in clinical trials of treatments for CLBP patients (Smeets et al, 2006b; Weiner et al, 2003). However, the use of STS as a routine outcome measure in the clinical environment does not appear to have been extensively investigated either.

As discussed above, it may be relevant to explore tests of daily physical functioning that incorporate some measurement of trunk mobility. Little work has been done in this area, however there is some literature regarding trunk mobility (spinal kinematics) during both gait and STS. Measurement of spinal kinematics during these two daily activities might provide objective measures of impairment during activity, which might overcome the limitations of traditional measures of impairment, which are arguably conducted in a manner that does not reflect daily functioning.

Due to the suggestion that gait, STS and spinal kinematic analysis might enhance the measurement of LBP patients, the literature concerning these areas is now reviewed. The literature on gait, STS and spinal kinematics during both activities in asymptomatic subjects is briefly considered, and the literature concerning CLBP subjects considered in more depth.

3.2.2: Gait analysis

3.2.2.1: Analysis of normal gait

Gait refers to "the manner or style of walking"(Whittle, 2002, p 43) and there are seven key aspects of this walking manner or style that can be measured. These are briefly described below in order to provide definitions for the review of literature concerning gait analysis in LBP.

I. Speed

Speed is considered by many to be the most important gait measure because it provides a global indicator of impairment (Wall, 1999) and because almost all other gait measures are speed dependent (Andriacchi et al, 1997). Walking speed for healthy adults is around 1.4m/s, or 3mph (Kirtley, 2006; Wall, 1999), reducing to around 1.3m/s in the seventh decade (Bohannon, 1997).

II. Spatial parameters of gait

These are the relative placements of the feet during gait. Stride length is the distance from the point of heel contact to the next heel contact by that foot, and each stride is made up of two steps (left and right). Step width is the side to side distance between the two feet, and step angle is the angle between the direction of progression and a reference line on the sole of the foot (sometimes termed toe out or toe in angle). Normative values for the spatial parameters from three recent studies are displayed in table 3.2.2 (Menz et al, 2004; Al-Obaidi et al, 2003; Bilney et al, 2003). All three studies employed GAITRite, a reliable and valid tool, and used samples of adult subjects without impairment. Values reported are for preferred walking speed.

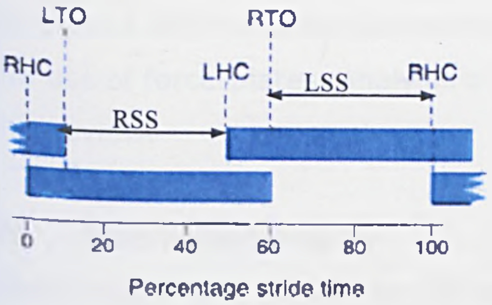
Table 3.2.2: Spatial and temporal parameters: reference values

Parameter	Al-Obaidi et al (2003)	Bilney et al (2003)	Menz et al (2004)
Speed (m/s)	1.26	1.46	1.43
Cadence (steps/min)	106.35	114.74	110.77
Stride Length (m)	1.30	1.53	1.55
Single Support (s)	NR	0.40	NR
Double Support (%GC)	NR	23.30	NR
Right Step Width (cm)	NR	NR	8.59
Left Step Width (cm)	NR	NR	8.01
Right Step Angle (°)	NR	NR	6.73
Left Step Angle (°)	NR	NR	5.01

Key: NR= Parameter not reported by study; %GC= Percentage of gait cycle

III. Temporal parameters of gait

The temporal parameters describe the timing of stride and step events, subdivided into several components as figure 3.2.1 illustrates. Stride and step times can be measured, however cadence is often used to reflect step time and is usually reported as steps/min. In healthy adults walking at preferred speed a stride usually lasts 1s with equal right and left step duration, therefore cadence is around 120 steps/min (Wall, 1999). Each stride can be further broken down into stance (foot in contact with the ground) and swing phases, and stance broken down into double support and single support phases as figure 3.2.1 shows. Normal stance is usually 60% of the gait cycle, and swing 40% (Wall, 1999). Stance involves two double support phases of 10% each and one single support phase of 40%, since single support corresponds to contralateral (opposite) swing phase (Wall, 1999). Table 3.2.2 displays some of the normative values for the temporal parameters from three recent studies. It should be noted that studies usually report on selected temporal and spatial parameters, and rarely on all possible measurements, usually due to both the nature of the enquiry and the measurement tool employed.



Key: RHC = Right Heel Contact, LTO = Left Toe Off, LHC = Left Heel Contact, RTO = Right Toe Off, RSS = Right Single Support, LSS = Left Single Support.
Adapted from Physiotherapy, 8, Wall, J.C and Crosbie, J. Temporal gait analysis using slow motion video and a personal computer, pp109 – 115, copyright (1997) with permission from the Chartered Society of Physiotherapy.

Figure 3.2.1: Temporal parameters of the gait cycle illustrating key phases of single and double support.

IV. Angular displacements: Kinematics

Kinematics refers to the measurement of gait in terms of angles, displacements, velocities and accelerations of body segments and joints (Kirtley, 2006). Angular kinematics of the lower limb joints are most often reported in gait analysis studies, and are displayed as graphs displaying the angular displacement throughout one gait cycle, a gait cycle being the time from initial contact of one foot to the following initial contact of that foot. Kinematics can be measured using two or three-dimensional systems, the latter becoming increasingly more common (Kirtley, 2006). Kinematic analysis allows the angular displacement of the joints to be calculated in the three anatomical planes; sagittal (flexion/extension), frontal (abduction/adduction or right/left side flexion) and transverse (internal/external rotation). Kinematics of the spine during gait has also been investigated by some authors (Saunders et al, 2005; Rice et al, 2004; Feipel et al, 2001; Callaghan et al, 1999; Syczewska et al, 1999; Crosbie et al, 1997a; 1997b). These studies are discussed in detail in section 3.2.2.2.

V. Kinetics

Kinetics is the study of the forces causing movement (Wall, 1999). Forces commonly measured in gait analysis include the ground reaction force (GRF) and joint moments. Since the focus of this study is on gait analysis that could be carried out in the clinical environment and measurement of forces requires the use of force-plates, analysis of kinetics is considered outwith the scope of this review.

VI. Electromyography

Electromyography (EMG) can be used to study patterns of muscle activity during the gait cycle and some studies have used EMG to study co-ordination of lumbar muscle activity in LBP patients (Lamoth et al, 2006a; 2006b; Vogt et al, 2003). However, as for kinetics, the focus of this study is gait analysis that could be carried out in the clinical environment. Therefore, EMG analysis is considered outwith the scope of this study.

VII. Energy consumption

Energy consumption during gait is a somewhat complex measure, usually inferred from oxygen consumption (Whittle, 2002). Again, this is not the focus of this study and therefore considered outwith the scope of this review.

3.2.2.2: Gait analysis and Chronic Low Back Pain

Speed and endurance measures

Walking speed and endurance have been recommended as outcome measures for LBP patients (Smeets et al, 2006a; Lee et al, 2002; Simmonds et al, 1998). Some authors have incorporated these in their evaluation of treatment approaches for LBP (Walsh et al, 2003; Weiner et al, 2003; Frost et al, 1995;). Novy et al (2002) suggested that physical performance tasks can be grouped into two factors, speed and co-ordination, and endurance and strength, therefore the use of both speed and endurance gait measures would seem appropriate. Harding et al (1994) demonstrated excellent inter-rater and test-retest reliability of both a 10-minute walk (Inter-rater Intraclass Correlation Coefficient (ICC) 0.994; test-retest Pearson correlation coefficient 0.944) and timed 20-metre speed walk (Inter-rater ICC 0.999; test-retest Pearson correlation coefficient 0.987) in a group of chronic pain patients, of whom 54% had CLBP. The walking speed and endurance of 30 patients was repeatable over a 12-week period, and in the full study of 431 patients, significant improvements in both measures were demonstrated following completion of a chronic pain management programme with the improvements being maintained at one month follow-up.

These findings suggest that the 10-minute walk and timed 20-metre speed walk are reliable and valid measurements for chronic pain patients. Despite these findings, Harding et al (1994) dismissed using the 20-metre speed walk since some subjects took up to 15 minutes to complete the test. This effect was presumably due to the influence of chronic pain behaviour in their sample. They sampled patients attending a chronic pain management programme, with an average duration of symptoms of 10.2 years and with over half out of work due to their condition. Therefore, they might be expected to be at the more severe end of the symptom severity/ disability scale. However it is anticipated that CLBP patients presenting for physiotherapy treatment, who are the focus of the present study, would fall into the majority group who took 10 to 20 seconds for this test.

Indeed, Simmonds et al (1998) investigated 44 patients with non-specific mechanical LBP, finding that they could complete a 50-foot (15.24m) timed walk in less than 30 seconds (mean 8.36s), confirming the practicality of this test with LBP patients. They demonstrated excellent day-to-day (ICC 0.80), test-retest (ICC 0.99) and interrater reliability (ICC 0.99) of this test in their sample. Although the mean duration of symptoms of their sample (12.4 months) would be defined as chronic, there was a large range for this variable (1 to 72 months), therefore it is not known exactly what percentage of the sample were CLBP patients, with symptoms over three months duration. This presents a limitation in terms of generalising from these results to the CLBP population.

Validity of these tests with LBP patients is supported by the differences in both speed and endurance shown between normal subjects and patients with LBP. Patients have been shown to walk significantly slower, and with reduced endurance compared to subjects without LBP (Novy et al, 2002; Simmonds et al, 1998; Simmonds and Claveau, 1997) as table 3.2.3 illustrates. It can be seen from table 3.2.3 that when asked to walk as fast as possible, LBP patients in these studies walked at approximately normal speeds, usually considered to be around 1.4m/s (Kirtley, 2006). However, this is still somewhat slower than asymptomatic controls walking at their fastest speed. In addition, LBP subjects also walked more slowly than asymptomatic controls when walking at their preferred speed, and covered less distance in five minutes compared to asymptomatic controls. Simmonds & Claveau (1997) found inter-subject differences within their sample of 23 LBP patients; those with sharp leg pain walking significantly slower than those with dull back pain in the 70 foot (21.34m) speed walk (1.33m/s compared to 1.78m/s, p0.01). It may therefore be possible that different gait deviations will be observed depending on symptom severity and distribution. This might mean that gait analysis could be useful in classifying LBP patients, in addition to identifying deviations from normal.

Table 3.2.3: Results from studies on speed and endurance of gait in low back pain patients, chronological order

Author	Year	Test	LBP	Control
Simmonds and Claveau	1997	70 foot (21.34m) walk, fast	1.67m/s	2.18m/s
Simmonds et al	1998	50 foot (15.24m) walk, fast	1.39m/s	1.82m/s
Simmonds et al	1998	50 foot (15.24m) walk, preferred	1.01m/s	1.20m/s
Simmonds et al	1998	5 minute walk	427.74m	518.17m
Novy et al	2002	50 foot (15.24m) walk, fast	1.39m/s	NA

Key: NA= No control group for this study

Shuttle walking test

The shuttle walking test, developed for patients with pulmonary disease, has also been suggested for use with CLBP patients as a measure of activity limitation. It has been shown to be reliable, repeatable and responsive to change (Armstrong et al, 2005; Taylor et al, 2001), and CLBP patients have been shown to walk considerably shorter distances during the test than healthy control subjects (Taylor et al, 2001). A recent study (Campbell et al, 2006) however concluded that the shuttle walking test was of limited clinical use. This was partly due to the test being less responsive to change than other measures of disability (Oswestry and SF-36). However they also reached this conclusion due to the number of dropouts, which suggested that the test was not particularly liked by patients. This again highlights the need for objective tests to be acceptable to both the patient and clinician in terms of time and ease of completion.

The studies presented here on speed and endurance measures of gait in LBP (Novy et al, 2002; Simmonds et al, 1998; Simmonds and Claveau, 1997) have confirmed that subjects with LBP do walk more slowly and demonstrate less endurance than asymptomatic controls, thereby supporting the face validity of these tests in LBP patients. They have also demonstrated that simple tests of speed and endurance are reliable between raters and test days and are sensitive to change. What these studies fail to consider however, is how aspects of gait apart from speed and endurance are affected by LBP, and whether other parameters may be more sensitive to change and may therefore enhance assessment of the LBP patient, or provide more sensitive outcome measures.

Comprehensive gait analysis

Some other aspects of gait, in addition to speed and endurance, have been investigated in relation to LBP, as tables 3.2.4 a and b illustrate. Due to the small total number of studies concerning comprehensive gait analysis in LBP patients, those dating back to 1980 are included in this review. These studies are now reviewed in detail.

Subjects

Several of the earlier studies in tables 3.2.4a and b concerned specific patient groups, commonly surgical candidates (Morag et al, 2000; Khodadadeh and

Eisenstein, 1993; Shelokov et al, 1993; Khodadadeh et al, 1988). These patients may display gait abnormalities peculiar to surgical candidates, and potentially different from non-specific CLBP patients being managed by the physiotherapist. One study concerned a single-subject (Herzog et al, 1987) in order to evaluate chiropractic treatment for a particular "syndrome". It did demonstrate significant changes in ground reaction force following the treatments, suggesting that this may be a useful evaluation of manipulative treatment. However, it is not possible to generalise from this study to the wider population of CLBP patients.

Table 3.2.4a: *Studies on gait analysis in Low Back Pain, chronological order; 1980 to 2001*

Author	**Year**	**Control(LBP) subjects**	**Gender**	**Age**	**Category/Duration of LBP**	**Parameters measured**	**Equipment used**
Thomas et al	1980	(15)	M+F	30-56	CLBP > 6 months	Selected spatial and temporal	NK
Keefe and Hill	1985	18 (18)	M+F	Mean 38.5	CLBP >6 months	Spatial and temporal	Pressure sensitive insoles 5 metre walkway
Herzog et al	1987	(1)	M	Mean 34	Right "sacroiliac joint syndrome"	Kinetics	Videocameras Force platform
Khodadadeh et al	1988	20* (30)	M+F*	Mean 48*	Surgical candidates	Spatial and temporal, kinetics	Video with timing device Kistler force plate 6.1 metre walkway
Khodadadeh and Eisenstein	1993	20* (30)	M+F*	Mean 48*	Post surgery (fusion +/- nerve decompression)	Spatial and temporal, kinetics	Video with timing device Kistler force plate 6.1 metre walkway
Shelokov et al	1993	(7)	NK	NK	Surgically treated spondylolisthesis	Trunk and lower limb kinematics	Digitised video recording (2-dimensional)
Arendt-Nielsen et al	1995	10 (10)	M+F	Mean 39	CLBP > 2 years	Spinal EMG	Pressure sensitive insoles EMG Treadmill
Rowe and White	1996	10	Majority F	Mean 29	Nurses who had experienced one or more episodes of LBP	Spatial and temporal, trunk kinematics	Isotrak Footswitches 12 metre walkway
Moe-Nilssen et al	1999	20	Majority F	Mean 26	Normals Experimentally induced pain	Trunk kinematics	Logger Accelerometer 12 metre walkway
Morag et al	2000	16 (16)	Majority M	Mean 34;39**	Surgical candidates Herniated L4-5 or L5-S1 disc	Trunk and lower limb kinetics	3-D optical system Force plate 10 metre walkway
Selles et al	2001	6 (6)	M+F	Mean 30	CLBP > 1 year	Trunk kinematics	2-D camera system accelerometers; treadmill

Key: *Same subjects used for both studies, ** Two sub-groups of subjects, NK = Not known, EMG = Electromyography

Table 3.2.4b: *Studies on gait analysis in Low Back Pain, chronological order; 2001 to 2006*

Author	**Year**	**Control (LBP) subjects**	**Gender**	**Age**	**Category/Duration of LBP**	**Parameters measured**	**Equipment used**
Vogt et al	2001	22 (34)	M+F	Mean 34	CLBP	Trunk kinematics	3-D Ultrasonic movement analysis system Treadmill
Lamoth et al	2002	19 (31)	M+F	Mean 38	CLBP	Trunk kinematics	3-D optical system Treadmill
Al-Obaidi et al	2003	24 (31)	M+F	Mean 37	CLBP > 7 weeks	Spatial and temporal	GAITRite system
Taylor et al	2003	8 (8)	M+F	Mean 33	Acute LBP	Trunk kinematics	3-D optical system Pressure sensitive insoles Treadmill
Vogt et al	2003	16 (17)	M	Mean 36	CLBP	Hip kinematics Spinal and lower limb EMG	Electrogoniometer EMG Treadmill
Lamoth et al	2004	12	M+F	18-25	Normals Experimentally induced pain	Trunk kinematics, spinal EMG	3-D opttical system EMG Treadmill
Taylor et al	2004	11 (11)	NK	Mean 39	Acute LBP	Trunk kinematics	3-D optical system Pressure sensitive insoles Treadmill
Lamoth et al	2006 a	12 (12)	M+F	NK	CLBP	Trunk kinematics, spinal EMG	3-D optical system EMG Treadmill
Lamoth et al	2006b	14 (19)	M+F	Mean 38	CLBP	Trunk kinematics, spinal EMG	3-D optical system EMG Treadmill

Key: *Same subjects used for both studies, ** Two sub-groups of subjects, NK = Not known, EMG = Electromyography

Two of the studies investigated the effects of experimentally induced pain on normal subjects (Lamoth et al, 2004; Moe-Nilssen et al, 1999) and two studied patients with acute LBP whose symptoms were present for less than seven days (Taylor et al, 2003; 2004). Whilst these studies aid the understanding of the process by which gait may become altered, they both concern short-lived pain and can therefore not be generalised to CLBP subjects. The time period which defines LBP as chronic, 12 weeks or longer, is an important factor here, as it may take some time for the body to make adaptive changes to activities such as gait, which may not occur, or which may occur differently in the acute state. This was demonstrated by Taylor et al (2003) whose acute LBP subjects could adapt stride length and spinal kinematics in order to walk at an increased speed, findings which contrasted with those of Selles et al (2001) whose sample were CLBP subjects. These findings are discussed further in section 3.2.2.4 below.

Of the ten studies that have analysed patients with more general CLBP, most have utilised treadmill walking (Lamoth et al, 2006a; 2006b; Vogt et al, 2003; Lamoth et al, 2002; Selles et al, 2001; Vogt et al, 2001; Arendt-Nielsen et al, 1995). This could arguably alter the subjects' natural gait pattern, partly due to changes in stride length as a result of the limited length of the treadmill belt (Whittle, 2002), and may not be generaliseable to level overground walking, which CLBP patients are more likely to perform on a daily basis. Indeed, kinematics of the spine and pelvis have been shown to differ in amplitude during treadmill gait compared to level overground walking (Vogt et al, 2002). This might become less of an issue with the increasing use of instrumented treadmills for gait analysis, which appear to provide data more similar to overground walking (Riley et al, In Press).

Another study on CLBP (Keefe and Hill, 1985) used a very specific group of patients who required pain management intervention. Therefore, it is not known whether CLBP patients who do not require this type of intervention would replicate the alterations in spatial and temporal parameters seen in their sample.

Only two studies have concerned CLBP patients attending physiotherapy (Al-Obaidi et al, 2003; Thomas et al, 1980). Thomas et al (1980) stated that significant improvements in velocity, cadence and stride length were obtained following a course of in-patient physiotherapy. The hospital-based setting of this study may have had the advantage of controlling several variables and limiting threats to reliability. However, the methods used to measure the gait changes are not stated, making replication or verification of these findings impossible. Also, it is more common for CLBP patients to be managed as outpatients; the typology of patients who require hospital admission to manage their CLBP may arguably be quite distinct from those attending outpatient physiotherapy departments. Al-Obaidi (2003) in contrast recruited thirty-one CLBP patents from physiotherapy departments in Kuwait City. Although the average duration of symptoms was twenty weeks, they included patients with LBP lasting just over seven weeks, which deviates from the more usual definition of chronic pain as lasting for twelve weeks or longer (IASP, 1986). This might explain why velocity and step lengths were the only parameters affected in their study. By the authors own admission (Al-Obaidi et al, 2003) gait parameters can vary between different cultural populations; therefore it would be useful to replicate this study in a UK population.

It would therefore appear that patients with non-specific CLBP, defined in accordance with the IASP and being managed conservatively by the physiotherapist in the UK, have not been extensively investigated with respect to the role gait analysis may have to play in outcome measurement.

Gait analysis tools

Methods have varied in the studies to date as tables 3.2.4a and b show. These range from relatively simple techniques such as pressure-sensitive insoles to the more complex three-dimensional optical systems. This reflects the spectrum of technology available for gait analysis (Bell, 1996).

The footswitches or pressure-sensitive insoles favoured by Keefe & Hill (1985) are limited to analysing temporal data, and although shown to be reliable, are felt by some to be most useful for augmenting other gait measures (Hausdorff et al, 1995). Arendt-Nielsen et al (1995), Rowe & White (1996) and Taylor et al (2004) used them in this way to describe timings of EMG activity and lumbar movements in their studies.

Video can be a useful tool, particularly when enhanced with a timing device such as the frame-counter used by Khodadadeh & Eisenstein (1993). Timing devices such as this or using slow-motion playback with a stopwatch or computer mouse-button (Wall and Scarbrough, 1997; Wall and Crosbie, 1996) have been used with some success in normal populations. However, they are prone to error in measuring the short double support phases (Stillman and McMeeken, 1996; Wall and Crosbie, 1996). They are also limited to measurement of the temporal parameters. In contrast, the GAITRite system used by Al-Obaidi et al (2003) measures both temporal and spatial parameters using a series of pressure sensors embedded in a walkway, providing a relatively simple method of capturing several gait parameters simultaneously.

Digitising is another way of enhancing video, which allows for measurement of joint kinematics, as used by Shelokov et al (1993) to measure trunk and lower limb angles in patients with spondylolisthesis. This is suitable when kinematics is the only parameter of interest, but the method may be limited due to the selective nature of the gait analysis.

Angular kinematics can also be measured by electrogoniometers (Rowe, 1999), and Isotrak, an alternative to standard electrogoniometers, was successfully used by Rowe & White (1996) to measure spinal kinematics during gait in nurses who had reportedly recovered from an episode of LBP.

Accelerometers have been used in LBP subjects to measure both lumbar spine accelerations and arm and leg swing (Selles et al, 2001; Moe-Nilssen et al, 1999). However, due to the limited analysis they can perform, and the many alternative tools available, they have not gained widespread use (Whittle, 2002; Wall, 1999).

Kinematic analysis can also be performed with two or three-dimensional optical systems, as used in most of the more recent studies in tables 3.2.4a and b. The advantage these systems have over goniometers or accelerometers is the ease with which many joints and directions can simultaneously be measured. Two-dimensional systems are more prone to errors and therefore three-dimensional systems are now considered the standard for this type of gait analysis (Kirtley, 2006).

Force platforms as used by Herzog et al (1987) and Khodadadeh & Eisenstein (1993) allow analysis of the ground reaction forces during gait, and when used in combination with kinematic systems allow calculation of the forces causing motion, providing a more complete analysis (Harris and Wertsch, 1994).

Cottalorda (1999) stressed the importance of matching the gait analysis technique to the goal in question, partly due to the range of tools discussed above. It could be argued that when analysing CLBP patients presenting for physiotherapy treatment, the analysis technique should be one suitable for use in the routine clinical environment; indeed this will be vital if gait analysis is ever to be adopted as part of physiotherapists' clinical practice. Clearly, two and three-dimensional camera systems and force platforms are more suited to the gait laboratory setting than to clinical use. Of the tools used in the studies reviewed above, accelerometers, footswitches, the GAITRite system, Isotrak, and video could arguably be portable enough for use in the clinical setting. However, it could conversely be argued that in order to determine the gait parameters of interest in CLBP patients the most accurate measurement tools or the "gold standard" should first be utilised, thus ensuring high accuracy and reliability of any results. Clearly, two and three-dimensional camera systems and force platforms would be the measurement tools of choice in this situation. Therefore, consideration of all the above tools, along with the gait parameters of interest to a study, will determine the most appropriate gait analysis tool/s to address the research questions of interest.

Parameters measured in Low Back Pain

The results from the studies on gait and LBP listed in tables 3.2.4a and b are discussed. Four studies are omitted from this evaluation for the following reasons. Herzog et al (1987) can not be generalised due to being a single case study. The main focus of the studies by Arendt-Nielsen et al (1995) and Vogt et al (2003) were on EMG activity, which is not the focus of this study. Rowe and White (1996) were investigating subjects who had recovered from LBP, and therefore not measuring the actual effects of a current episode of LBP on gait.

Spatial parameters

Table 3.2.5 displays the results from the three studies that have reported stride and step length in CLBP patients. The values in parenthesis are the corresponding measures for the normal subjects in each study. Both parameters show a reduction in CLBP patients. As previously stated, the methods used to measure the gait changes in Thomas et al's (1980) study are not stated, making replication or verification of their findings impossible. Both Keefe and Hill (1985) and Al-Obaidi et al (2003) used standardised and repeatable measurement protocols, the latter using equipment with a well documented high level of reliability. Al-Obaidi et al (2003) also investigated the relationship between actual and feared pain and disability and gait parameters. They demonstrated in their sample that fear of pain and disability beliefs were related to gait performance, but that actual pain intensity was not. However, the results of both studies cannot be generalised to CLBP patients defined in accordance with the IASP and attending physiotherapy in the UK, as discussed above. Therefore, the effects of CLBP on the spatial parameters of gait should be the subject of further research. CLBP subjects with symptoms of more than 12 weeks' duration and who are receiving conservative management from out patient physiotherapists should be investigated using a standardised measurement protocol. The relationship between the spatial parameters and CLBP subjects' self-reported pain and disability levels should be investigated further to better understand the relationship between reported and actual impairment (Airaksinen et al, 2004).

Table 3.2.5: Mean spatial parameters of gait reported in previous studies on chronic low back pain.

Parameter	**Thomas et al (1980)**	**Keefe and Hill (1985)**	**Al-Obaidi et al (2003)**	
Stride length (m)	1.15 (1.40)	0.98 (1.35)	NR	
Step length (m)	NR	L: 0.51 (0.69) R: 0.55 (0.76)	Men L: 0.59 (0.70) R: 0.55 (0.71)	Women L: 0.42 (0.65) R: 0.50 (0.65)

Values for CLBP sample followed by values for control sample (in parentheses)
Key: NR=Not reported by study; All differences between CLBP and controls significant ($P<0.05$)

Temporal parameters

Table 3.2.6 displays the changes in temporal parameters, with their corresponding normal values in parenthesis. Speed is the only parameter to have been reported in all four studies, confirming the results of previous authors who have reported reduction a in walking speed in LBP patients (Novy et al, 1999; Simmonds et al, 1998: Simmonds and Claveau, 1997). Al-Obaidi et al (2003) are the only authors to report values for the right and left limbs separately. Khodadadeh and Eisenstein (1993) studied CLBP patients who were undergoing spinal surgery, therefore their results cannot be generalised to CLBP patients being conservatively managed, as it may be argued that surgical candidates' symptoms will be more severe than those being managed with physiotherapy alone.

The problems of generalising from the three other studies in table 3.2.6 were discussed above. Therefore, the effects of CLBP on the temporal parameters of gait should also be the subject of further research. As for the spatial parameters this should involve CLBP subjects with symptoms of more than 12 weeks' duration and who are receiving conservative management from out patient physiotherapists. A standardised measurement protocol should be used, and the relationship between the temporal parameters and CLBP subjects self-reported pain and disability levels should be investigated to better understand the relationship between reported and actual impairment (Airaksinen et al, 2004). Al-Obaidi et al (2003) are the only authors to have investigated this to date, as discussed in relation to spatial parameters above.

However, the limitations of this study were also discussed above; suggesting that further study of the relationship between self-report of symptoms and the temporal parameters is indicated.

Table 3.2.6: Mean temporal parameters of gait reported in previous studies on chronic low back pain.

Parameter	Thomas et al (1980)	Keefe & Hill (1985)	Khodadadeh & Eisenstein (1988)	Al-Obaidi et al (2003)
Speed (m/s)	0.91 (1.37)	0.68 (1.18)	0.74 (1.34)	Men 0.98 (1.26) Women 0.73 (1.16)
Cadence (steps/min)	93.7 (116)	NR	90 (120)	Men 101.8 (106.4) Women 94.5 (106.8)
Stance (s)	NR	L: 0.94 (0.83) R: 0.98 (0.79)	L: 1.01 (0.72) R: 1.00 (0.63)	NR
Swing (s)	NR	L: 0.42 (0.32) R: 0.46 (0.36)	L: 0.45 (0.38) R: 0.44 (0.38)	NR
Double support (s)	NR	NR	L: 0.22 (0.12) R: 0.21 (0.12)	NR
Single support (s)	NR	L: 0.44 (0.37) R: 0.43 (0.41)	NR	Men L: 39.4% (40.0%) R: 35.2% (40.3%) Women L: 38.6% (40.3%) R: 35.1% (40.3%)

Values for CLBP sample followed by values for control sample (in parentheses)
Key: NR=Not reported by study

Kinematics

Ten of the studies in tables 3.2.4a and b have analysed angular kinematics during gait. These are reviewed in full in section 3.2.2.4 below.

Joint forces and moments

Khodadadeh and Eisenstein (1993) demonstrated significantly reduced vertical ground reaction force in surgical candidates, and Morag et al (2000) demonstrated alterations in external moments at the hip and knee in patients with known lumbar disc herniations. Reduced vertical ground reaction force has also been demonstrated in a small sample of CLBP patients attending physiotherapy (Cooper, 2002). However, as discussed above (section 3.2.2.1) the focus of this study is on gait analysis that could be carried out in the clinical environment and therefore EMG activity and GRF analysis is considered outwith the scope of this review. These findings are therefore not discussed further.

In summary, although gait analysis in CLBP has been the topic of some research, there is a need to investigate further a sample of UK subjects defined as chronic by a 12 week or longer duration of symptoms, and subjects who are being conservatively managed by the physiotherapist. The relationship between gait and subjects' self-report of symptom severity is an under-researched area, and one that will aid the understanding of the relationship between actual and reported limitations of functioning. It is therefore these areas that should be the topic of further research.

3.2.2.3: Spinal kinematics during normal gait

As for normal gait above (3.2.2.1) a description of spinal kinematics during gait in subjects without LBP is presented here in order to provide definitions for the review of literature concerning spinal kinematics in LBP patients.

Thorstensson et al (1984) first described movements of the trunk during walking and running in their small study of ten healthy male subjects. Their measurement equipment was limited by modern standards with only two cameras to detect light-emitting diodes attached to the lower limbs and spine. In addition, their subjects were walking/running on treadmills which may have affected their gait pattern (Whittle, 2002; Vogt et al, 2001). However, they were able to describe basic kinematics in both frontal (side flexion) and sagittal (flexion/extension) planes, and their responses to alterations in speed. For walking, they demonstrated that linear displacement of the trunk showed two vertical oscillations per gait cycle, with the lowest point just after heel contact and the highest point in the middle of single support. Lateral linear displacements showed one full oscillation (from one side to the other and back) during a gait cycle, with the trunk moving towards the left at left heel contact reaching its extreme position during single support. Lateral angular displacements (side flexion) of the trunk likewise showed one full oscillation per gait cycle, initially flexing to the side of heel contact. Forward-backward linear displacement demonstrated two oscillations per gait cycle, moving forward at heel contact and throughout double support, reaching its extreme at the transition to single support, with peak backward displacement at the end of that phase. Forward-backward angular displacements (flexion/extension) showed peak flexion at heel contact, then tilting backwards during double support until the beginning of single support.

These findings were supported by Krebs et al (1992), who used the same measurement tools but had three cameras, and were therefore able to also report on transverse plane kinematics (rotation). They found that the trunk was 180° out of phase with the pelvis, reaching a maximum at around 10% of the gait cycle such that the ipsilateral (same side) shoulder was posterior to the heel-strike limb and almost directly over the foot at mid-stance. This has been shown to occur at higher speeds of walking (around 1.5m/s) by other authors, whereas at slower speeds of around 1.2m/s the reverse occurs and the pelvis and thorax are relatively in-phase, or both segments move in the same direction (Lamoth et al, 2002; Selles et al, 2001). In addition, Krebs et al (1992) described trunk kinematics for two frames of reference (room and pelvis), finding that differences in joint range were apparent between these frames of reference. This suggests that studies on spinal kinematics should carefully choose the frame of reference of most relevance to the movements being studied. Taylor et al (1999) supported this finding in their study of treadmill gait.

The range (maximum angle minus minimum angle) of spinal oscillations during gait are small, with table 3.2.7 displaying the values from several studies, including those discussed above. Table 3.2.7 also highlights the differences in the results that are obtained with different reference systems (pelvis and room) and with treadmill compared to overground walking. It can be seen that measuring lumbar kinematics relative to the room and measuring treadmill rather than overground walking may underestimate the kinematic values.

The findings of Thorstensson et al (1984) and Krebs et al (1992) were augmented by those of several others (Saunders et al, 2005; Callaghan et al, 1999; Syczewska et al, 1999; Crosbie et al, 1997a; Rowe and White, 1996). All used modern three-dimensional optical motion analysis systems with high levels of accuracy; typically errors less than 0.5mm (Callaghan et al, 1999). Crosbie et al (1997a) studied the largest number of subjects (108), placing markers not only on the lower limbs, pelvis and lumbar spine as in previous studies, but also on the upper and lower thoracic spines, being the first authors to report on these upper spinal movements. They described lumbar spinal motion relative to the pelvis, and table 3.2.7 demonstrates that they confirmed the small total displacements reported by previous authors.

Table 3.2.7: Three-dimensional lumbar kinematics in degrees reported in studies on healthy subjects; chronological order

Author (year)	**Sagittal plane (flexion/extension)**	**Frontal plane (side flexion)**	**Transverse plane (rotation)**
Thorstensson et al (1982)	2-12	2-9	NR
Stokes et al (1989)	NR	4.9	4.7
Krebs et al (1992)	2-8 (relative to room) 2.5-12.6 (relative to pelvis)	5.4	9
Rowe & White (1996)	2.3	4	6.6
Crosbie et al (1997a)	3.5	9	4.5
Callaghan et al (1999)	3.12-3.14	3.11-4.9	4.21-4.55
Feipel at el (2001)	6-7	11-12	13-16
Vogt et al (2002)	3.3 (treadmill) 4.4 (overground)	2.6 (treadmill) 3.9 (overground)	7.8 (treadmill) 8.2 (overground)
Rice et al (2004)	3-8	8-26	13-31
Saunders et al (2005)	3	5	4

Key: NR=Not reported by study

Crosbie et al (1997a) suggested that pelvic motion responds to the needs of the subject to advance the lower limbs and transfer body weight from one supporting side to the other, whilst the spinal segments demonstrate complementary movements to those of the pelvis. The same authors (Crosbie et al, 1997b) also demonstrated that as speed, and therefore step length, increased, spinal motion demonstrated increases in range, suggesting that the spine has an important role to play in allowing adaptation to occur. For example side flexion increased by 38% in male subjects and 21% in females. This finding has been replicated by several authors (Saunders et al, 2005; Callaghan et al, 1999; Taylor et al, 1999) confirming the important role of the spine in relation to speed adaptation during gait.

All the studies reported above agree on sagittal plane motion of the lumbar spine (flexion/extension), as described above. There have been some conflicting results for both frontal (side flexion) and transverse (rotation) planes however. Whilst Thorstensson et al (1984) and Crosbie et al (1997a) described side flexion as occurring towards the weight-bearing limb, Rowe and White (1996), Callaghan et al (1999) and Saunders et al (2005) described it as occurring to the contralateral (opposite) side at heel strike. This might be due to the different experimental designs employed. Thorstensson et al (1984) and Crosbie et al (1997a) attached markers at the third lumbar vertebra (L3), and analysed motion at L3 itself and between L3 and the pelvis respectively. Rowe and White, (1996), Callaghan et al (1999) and Saunders et al (2005) analysed the lumbar spine as a rigid unit with markers attached at the junction between the twelfth thoracic and first lumbar vertebrae (T12/L1) and the sacrum. This suggests that different kinematic patterns can be observed for different sections of the spine and this must be considered in the design of a study and when comparing results to those of previous research. Similarly, Crosbie et al (1997a) described rotation occurring towards the swing side during single support, whilst Rowe and White (1996), Callaghan et al (1999) and Saunders et al (2005) described rotation towards the side of heel contact.

The studies discussed so far all considered the lumbar spine as a rigid segment. Syczewska et al (1999) however, by attaching markers at several spinal segments, including T12, L2, L4 and S2 (second sacral vertebra) were able to demonstrate small (approximately 2^{o}) intersegmental movements in addition to the oscillating motion of the spine as a whole. This work was done on a fairly small sample however and their findings do not appear to have been the subject of further research to date.

Feipel et al (2001) investigated the range of kinematics and coupling of rotation and side-flexion, finding that the previously reported coupling of opposite rotation with lumbar side flexion (Hindle et al, 1990) did not consistently occur during gait in their sample.

Rice et al (Rice et al, 2004) took a different approach to measuring spinal kinematics, considering the spine not in segments, but as one functional unit placing markers on the upper thorax and pelvis. The inclusion of thoracic motion in their overall measurements would therefore account for the increased side flexion and rotation (table 3.2.7) displayed by their sample.

In summary, there is general agreement on the patterns and ranges of lumbar spinal motion during gait as described above. There are discrepancies depending on the measurement protocol, frame of reference, and anatomical area of interest, all of which require careful consideration in the design of a study on spinal kinematics during gait. A final consideration is marker placement for spinal kinematic measurement. There have been several systems used to date, with no consensus on which should be used (Chockalingam et al, 2005). This is an important further consideration in study design and is discussed in section 3.4.

3.2.2.4: Spinal kinematics during Chronic Low Back Pain gait

The studies that have analysed spinal kinematics during gait in either LBP patients or subjects with experimentally produced LBP (tables 3.2.4a and b) are reviewed here. Omitted from this review are the two studies concerning surgical candidates (Morag et al, 2000; Shelokov et al, 1993). Due to the specific diagnoses in these two studies (herniated lumbar discs and spondylolisthesis) their results are unlikely to relate to non-specific CLBP patients. Therefore, nine studies are included in this review. Some general comments are made, followed by a discussion of each relevant study in turn

Subjects

Only five of the studies in tables 3.2.4a and b have involved patients with non-specific CLBP. The remainder have studied the effects of acute LBP (Taylor et al, 2004; Taylor et al, 2003), or experimentally produced LBP (Lamoth et al, 2004; Moe-Nilssen et al, 1999). The results of these studies can therefore not be generalised to CLBP patients as discussed above (p199) due to the pathological and physical differences between these two populations. None of the studies have involved CLBP patients being managed by the physiotherapist; therefore there is a need to study spinal kinematics during gait in this population.

Gait analysis tools

Moe-Nilssen et al (1999) employed accelerometry, whereas the remaining seven studies have used either two or three-dimensional motion analysis systems. These systems provide accurate and reliable data and three-dimensional systems are considered the gold standard in the study of motion analysis. No studies have used measurement equipment which could be considered suitable for use in the routine clinical environment. All of the studies with the exception of Moe-Nilssen et al (1999) have analysed treadmill walking, which as previously discussed may lead to an altered gait pattern and kinematics not representative of level overground walking. Therefore, there is a need to study spinal kinematics during gait that is not highly controlled by the speed or length of a treadmill.

Parameters measured

Moe-Nilssen et al (1999) were interested in linear accelerations, whereas the remainder have studied either amplitude of spinal motion (Taylor et al, 2004; Taylor et al, 2003), the relationship between thoracic and lumbar rotations (Lamoth et al, 2006a; 2006b; 2004; 2002; Selles et al, 2001) or a combination of both parameters (Vogt et al, 2001). This has an influence on the application of any results and is an important consideration for a study on lumbar spinal kinematics during gait. The results and implications of the nine studies on acute, chronic or experimental LBP are now considered in turn.

Moe-Nilssen et al (1999) demonstrated in their sample of 22 mostly young, female subjects that experimental pain resulted in reduced lumbar accelerations during gait, suggesting that there was some kind of adaptation to motor performance in the presence of pain. However, this study did not investigate the angular kinematics of the lumbar spine in order to explain the hypothesised adaptation, and it is not clear whether the same results would be seen for CLBP patients compared to the normal subjects with short-lived, experimentally produced pain studied here.

Selles et al (2001) studied six CLBP subjects and six healthy control subjects using two-dimensional motion analysis (Selspot). They demonstrated that at increasing speeds their control subjects changed from an in-phase relation between thorax and pelvis rotation (both moving in the same direction) to an out-of-phase relation (segments moving in opposite directions). This did not occur in their CLBP subjects who still demonstrated in-phase relation at the higher speeds. This difference was statistically significant ($p<0.001$). Clearly the small sample sizes and the use of treadmill gait represent limitations of this study, but it does give some insight into possible alterations of the gait pattern in CLBP patients.

Vogt et al (2001) used ultrasound microphones to study pelvic and thoracic kinematics in a sample of 34 male and female CLBP subjects and 22 controls without LBP. They demonstrated no difference in the overall patterns or amplitudes of motion in all three planes (sagittal, frontal and transverse), but did demonstrate increased intersubject variability (although not statistically significant) in the CLBP subjects, suggesting a trend towards individual adjustments in walking behaviour, perhaps as a result of pain. A limitation of this study was that the treadmill speed was controlled at around normal walking speed (4.5km/hr), therefore it is not known how these subjects would have behaved in response to increases or decreases in speed, as investigated by Selles et al (2001) and discussed above. It would therefore seem appropriate that any further study of CLBP gait should include both fast and slow walking speeds. They also only included subjects with pain "between T12 and the gluteal folds" (p 1910). Whether their results would have been different had subjects with leg pain been included is not known, but CLBP patients generally consist of those both with and without leg pain (Krismer and van Tulder, 2007).

Lamoth et al (2002) studied varying speeds of treadmill gait in 31 male and female CLBP subjects and 19 subjects without LBP using a similar protocol to that of Selles et al (2001). They reported that a quarter of the CLBP subjects maintained an in-phase relation in thorax-pelvis rotation at higher speeds. The remainder of the CLBP subjects did move towards an out-of-phase relation, but this was less marked than in the control group. The range of both pelvic and thoracic rotation however demonstrated no significant differences between CLBP subjects and controls. These findings again suggest that CLBP subjects may have problems with co-ordination of thorax-pelvis rotations. The CLBP subjects were those who had sought medical care for their condition. However, it is not known whether they were managed in primary or secondary care, and pain was measured but not self-reported disability. Therefore, the subgroup of CLBP patients to which these results can be generalised in unknown.

Lamoth et al (2004) further investigated phase relations and kinematic amplitudes, but this time using saline injections in pain-free subjects to investigate the effects of experimentally induced pain and fear of pain on these parameters and also on EMG activity of erector spinae. Although they found some alterations in EMG activity, they found no changes in kinematics for either state (pain or fear of pain). They concluded that the gait patterns seen in LBP patients probably evolve over time, rather than being the result of an immediate pain effect. This further supports the need to study spinal kinematics in CLBP subjects rather than experimentally inducing pain that may not resemble that experienced by CLBP subjects.

Two recent studies on spinal kinematics in LBP subjects have concerned acute LBP, defined as pain of less than seven days duration (Taylor et al, 2004; Taylor et al, 2003). Both studies used small samples of LBP subjects (eight and 11 respectively) walking on a treadmill, and both used three-dimensional motion analysis tools (Peak) with markers placed at L1 and the sacrum. In the first study (Taylor et al, 2003) the effect of increasing speed on the amplitudes of lumbar and pelvic kinematics were investigated in the acute phase and six weeks later when all eight subjects' symptoms had resolved. They demonstrated a significant increase in pelvic tilt (side flexion) (p=0.04) and lumbar side flexion (p=0.04) when changing from self-selected to fast walking speed in acute LBP subjects compared to when symptoms had resolved. This was associated with an increase in stride length (p=0.0008). There were no significant differences between acute LBP and control subjects. The authors suggested that their subjects had reduced their pelvic and spinal movement and stride length in adaptation to the acute LBP and therefore could increase all three parameters in order to increase walking speed; a strategy not available to them in the resolved state. This would need to be confirmed in a larger study, but does again suggest that spinal kinematics are affected by LBP. Clearly these results cannot be generalised to the CLBP population, but support further investigation in this area.

The second study by Taylor et al (Taylor et al, 2004) used the same protocol on 11 acute LBP subjects. The kinematic findings were as for the previous study. However, they also reported on the relationship between kinematics and self-report of symptoms. They found a statistically significant negative correlation between pain level and amplitude of pelvic tilt (Spearman's correlation coefficient-0.71, p=0.02) and lumbar side flexion (Spearmans correlation coefficient-0.74, p=0.02). There were also non-significant negative correlations between pain level and rotation (pelvic and lumbar) and between self-report of disability (Roland-Morris Questionnaire) and the movements of pelvic tilt, rotation and lumbar side flexion. Since this was a small sample of acute LBP subjects and therefore not representative of the CLBP population, there is a need to investigate the relationship between spinal kinematics and self-report of pain and disability in a sample with chronic symptoms.

The most recent work by Lamoth et al (2006 a; 2006b) has concerned subjects with LBP of chronic duration. In one study (Lamoth et al, 2006b) they recruited 19 subjects from exercise therapy practices in the Netherlands; the first study to consider subjects who might be similar to physiotherapy candidates in the

UK, since it might be speculated that exercise would be prescribed for patients of similar symptom severity and disability. In both studies they demonstrated a reduction in stride length in CLBP patients compared to control subjects ($p<0.05$), in the absence of reductions in thoracic, pelvic or lumbar kinematic range. They also demonstrated that CLBP patients were less able to move from an in-phase pattern of pelvic-thoracic and pelvic-lumbar kinematics to an out-of –phase pattern with increasing speeds, confirming the findings of Selles et al (2001) and Lamoth et al (2002). They further investigated phase relations in the frontal plane, demonstrating that unlike transverse rotations, side flexion was more variable in the CLBP patients. They also demonstrated elevated activity of the lumbar erector spinae muscle in CLBP patients during the swing phases of gait, and hypothesised that this represented an attempt by the CLBP subjects to stiffen their spine in response to the increases in walking speed.

Clearly these results suggest that there are differences in spinal kinematics present in CLBP patients that might not be present in the acute or experimental state. However, since both studies concerned treadmill gait, there is a need to investigate the effect of CLBP on level, overground walking.

In summary, despite the nine studies reviewed above, there remains a need for further research on spinal kinematics during CLBP gait. Phase relations between spinal segments (thoracic, lumbar, pelvic) have received most attention to date, with several studies confirming that CLBP affects the ability to move from an in-phase to an out-of phase thorax-pelvis pattern with increases in speed. However, only one study has concerned patients that might be similar to CLBP patients being managed by physiotherapists in the UK. Perhaps more significantly, none of the studies reporting on spinal kinematics have analysed level, overground walking. Since treadmill gait might underestimate spinal kinematics, and is not the most common form of gait conducted by CLBP patients, spinal kinematics during level, overground walking in CLBP patients warrants further research. The studies reviewed above suggest that important aspects to consider in future studies might include phase relations, the effects of altering walking speed, and correlation with patients' self-report of symptoms. However, due to the knowledge generated on phase relations in recent years it might be most relevant to investigate the remaining aspects in a further study.

3.2.3: Sit to Stand analysis

3.2.3.1: Analysis of normal Sit to Stand

In comparison to gait sit to stand (STS) has received somewhat less attention, with the absence of a clearly agreed definition, despite the general agreement that it is an important activity of daily functioning (Janssen et al, 2002). However, four key aspects of STS have been measured in normal subjects and are briefly described below in order to provide some background and definitions for the discussion of STS in CLBP patients.

Temporal parameters

The time taken to perform STS is reported in most studies, and is approximately 1.8 to 2.0 seconds for normal subjects (Tully et al, 2005; Hanke et al, 1995; Nuzik et al, 1986). However, these studies have used variable methodology and definitions of the start and end of the STS manoeuvre remain problematic.

Phases of Sit to Stand

Early research considered the entire STS manoeuvre as one movement phase (Baer and Durward, 1999). However, several researchers have proposed methods of identifying more than one phase of movement. Two discrete phases based on trunk motion (flexion and extension) were identified by Nuzik et al (1986), whereas three phases (weight shift, transition and lift) were identified by Millington et al (1992). The availability of full biomechanical analysis systems allowed the definition of further phases of STS. Schenkman et al (1990) provided a definition of four phases named flexion-momentum, momentum-transfer, extension and stabilisation. These are frequently used in studies of STS (Janssen et al, 2002) and are summarised in table 3.2.8.

Table 3.2.8: Four phases of Sit to Stand

Phase	Name	Beginning	End	Features
I	Flexion-momentum	Initiation of movement	Just before Lift-off*	Trunk & pelvis anteriorly rotate Upper-body momentum generated Femurs, shanks, feet stationary
II	Momentum-transfer	Lift-off*	Maximum ankle dorsiflexion	Centre of mass travels anteriorly and upwards Momentum transferred from upper body to total body Maximum ankle dorsiflexion, trunk flexion, hip flexion and head extension reached
III	Extension	Just after maximum ankle dorsiflexion	Hip first ceases to extend	Maximum hip extension, knee extension and trunk extension reached
IV	Stabilisation	Just after hip first ceases to extend	All motion associated with stabilisation from rising completed	Difficult to identify due to sway during quiet stance

*Lift-off defined as time at which buttocks first begin to leave chair and identified as point at which force vector begins to increase in weight-bearing direction
Source: Schenkman et al (1990)

Schenkman et al (1990) used a combination of kinetic and kinematic parameters to identify the four phases, necessitating the use of a force plate and therefore not easily carried out in the clinical environment. However, alternative methods of identifying "lift-off" are possible, such as switches on the edge of the seat as used by Coghlin and McFadyen (1994), suggesting that these definitions might be clinically useful.

Kralj et al (1990) similarly identified four phases (but named them differently) and in addition defined two further phases at the beginning and end of the STS cycle, naming these quiet sitting and quiet standing. Kerr et al (1994) used a combination of accelerometry and goniometry to identify seven events during the STS manoeuvre based on forward lean, vertical displacement and knee extension. This method does not appear to have been adopted as frequently as that of Schenkman et al (1990).

Angular displacement (kinematics)

Kinematics of the lower limbs (hip, knee and ankle) and trunk are most commonly reported in the sagittal plane only, based on the assumption that the body is maintained in symmetrical alignment during the STS manoeuvre (Baer and Ashburn, 1995). The trunk has generally been considered as one functional unit, with little research on the kinematics of defined anatomical areas such as the lumbar spine. This is discussed in detail below (3.2.2.3).

Kinetics

Joint forces and ground reaction forces during STS can all be measured and have aided the understanding of normal STS. Similarly, EMG activity during STS has also been measured. However, the focus of this study is on STS analysis that could be carried out in the clinical environment and therefore these parameters are considered outwith the scope of this review.

Methodological considerations

Methodology employed in studies of STS has been highly variable to date, resulting in a difficulty in comparing the results of different studies. Factors such as chair type and height, speed, foot position and arm movement have all been found to affect STS (Janssen et al, 2002). Therefore, one or more of these variables is commonly controlled in studies of STS (Bernardi et al, 2004; Chou et al, 2003; Sibella et al, 2003; Papa and Capozzo, 2000; Gross et al, 1998). Indeed, Janssen et al (2002) suggest that standardisation of the STS protocol is required and suggest that chair type, height, foot position and use of armrests should be controlled in future studies. However, others argue that STS studies should measure "natural" STS, and recommend controlling as few variables as possible (Shum et al, 2005; Baer and Ashburn, 1995). Clearly, these arguments need to be considered in the design of any study on STS.

3.2.3.2: Sit to Stand analysis in Chronic Low Back Pain

Speed and endurance measures

As for gait, timed measures of STS performance have been used as outcome measures with CLBP patients. For example, the evaluation of percutaneous electrical nerve stimulation in elderly CLBP patients included a timed chair rise test (Weiner et al, 2003). The same test was also used as part of a battery of physical performance measures in a recent randomised controlled trial comparing different treatments for CLBP (Smeets et al, 2006b).

Harding et al (1994) demonstrated excellent inter-rater reliability (ICC =1.0) and test-retest repeatability (Pearson's correlation coefficient =0.841) of a two-minute STS test in a large sample of chronic pain patients. However, it appears that speed rather than endurance tests of STS have predominated in more recent work and been incorporated as outcome measures in clinical trials (Smeets et al, 2006b; Weiner et al, 2003).

Timing of five repeated STS manoeuvres conducted as quickly as possible has received the greatest attention, perhaps since LBP patients have been shown to perform this test five seconds slower than pain-free subjects (Simmonds et al, 1998). Inter-rater reliability of this measure is high, with ICC's of 0.89-0.99 having been reported (Simmonds et al, 1998). Similarly, high levels of test-retest repeatability have also been reported (ICC 0.91; Smeets et al, 2006a). However, in the first study to report on the limits of agreement using the Bland-Altman method, Smeets et al (2006a) demonstrated a limit of agreement for repeated STS of 29% of the mean score. Therefore, CLBP patients would have to improve by more than 29% for that improvement to be considered clinically significant and not due to natural variation of the task. This may therefore question the validity and utility of this test for measuring CLBP patients.

In keeping with the speed and endurance gait measures, repeated STS fails to measure other aspects of STS, such as the movement strategy employed, and it is unknown whether these other aspects may be as or more appropriate to measure than speed or endurance.

Comprehensive Sit to Stand analysis

Comprehensive literature searching resulted in few studies that have measured aspects of STS in CLBP patients other than speed and endurance. Coghlin and McFadyen (1994) compared the STS of five male CLBP subjects to that of five male subjects without LBP. They focused on joint moments and kinematics of the lower limbs and pelvic-trunk junction using EMG, reflective markers and digitised video recordings from three cameras. They based their analysis on a definition of three phases of STS (initiation, seat unloading, ascending), similar to that of Millington et al (1992) described above. They found that in contrast to Simmonds et al (1998), their CLBP patients completed the STS task in slightly less time than those without LBP (1.7s compared to 1.95s). However, the CLBP patients employed a different strategy, with the ascending phase accounting for a larger percentage of the STS task than in the normal subjects. No differences in lower limb or pelvic-trunk kinematics were observed between the two groups. The joint moments however demonstrated that the CLBP subjects employed a modified strategy of distributing moments and power more evenly across joints than the normal subjects who demonstrated either high knee moments or high hip and pelvis-trunk moments.

Clearly this was a small study on a select group of male CLBP subjects. However, is does suggest that there may be alterations in the method of performing STS in the presence of CLBP indicating that further research in this area might be beneficial. Indeed, Gioftos and Grieve (1996) in their work on using artificial neural networks (ANNs) to categorise patients demonstrated that the ANN could reliably categorise subjects as normal, pretending to have or actually having CLBP based on kinetic and kinematic parameters during STS.

In summary, in comparison to gait analysis in CLBP patients, research on STS analysis is still in its infancy. However, it is possible to measure timing and phases of the STS manoeuvre and joint kinematics during the STS manoeuvre. The measurement of spinal joint kinematics is now considered.

3.2.3.3: Spinal kinematics during normal Sit to Stand

As mentioned above, the trunk as a whole has generally been considered as a functional unit in studies of STS. For example Baer and Ashburn (1995) described trunk side flexion in older subjects by placing markers on the scapula and sacroiliac joints, thereby measuring combined lumbar and thoracic motion. Gross et al (1998) reported trunk kinematics in the sagittal plane, also in elderly subjects. They placed markers on the shoulder and hip; thereby again measuring combined lumbar and thoracic motion. Sibella et al (2003) and Bertocco et al (2002), in their studies comparing STS in normal and obese subjects, reported trunk movement between the seventh cervical vertebra and the sacrum thereby measuring a combination of lumbar, thoracic and lower cervical motion. Large amounts of sagittal plane trunk kinematics with almost negligible frontal and transverse plane kinematics have been reported during STS (Sibella et al, 2003; Baer et al, 1995, Krebs et al, 1992). More recently, Gilleard et al (In press) reported ranges of approximately 6º in both frontal and transverse planes for combined thoracic and lumbar spinal kinematics in a small sample of young, healthy female subjects. However, the specific role of the lumbar spine in the STS manoeuvre has received little attention (Tully et al, 2005).

Tully et al (2005) investigated STS in 47 young, healthy subjects using reflective markers and a two-dimensional camera system. They used a novel method of locating L1 by measurement rather than palpation, the reliability of which was not stated in statistical terms, therefore there may have been inclusion of lower thoracic movement in some subjects. They reported a mean lumbar starting angle of 14.5° flexion and an end angle of 16.2° lumbar extension. Therefore, mean lumbar excursion (end angle minus starting angle) was 30.7°, and the range (maximum angle minus minimum) was 37.7°. They also demonstrated that both the lumbar spine and hips flexed prior to lift-off, with maximum flexion achieved prior to lift-off (32% STS duration), and that following lift-off the lumbar spine extended. Tully et al (2005) did not report on pelvic kinematics, which might provide a more complete analysis of STS. However, they have at least provided normal values with which to compare those of future studies.

3.2.3.4: Spinal kinematics during Chronic Low Back Pain Sit to Stand

There is a lack of research on lumbar spinal kinematics during STS in CLBP patients. One study was located however that investigated spinal kinematics in patients with subacute LBP. Shum et al (2005) investigated sagittal plane (flexion/extension) kinematics of the lumbar spine and hips in 20 normal subjects, 20 subjects with subacute LBP (7 to 12 weeks duration) and 20 subjects with subacute LBP combined with a positive straight leg raise test. They used an electromagnetic tracking device (Fastrak) with sensors attached to the sacrum, first lumbar vertebra and both thighs. Therefore, motion of the lumbar spine was measured as a functional unit without the influence of thoracic movement. Only chair height and arm position were controlled in this study, therefore STS was arguably performed in a more natural manner than has been the case in much previous work on this activity. They found that both groups of LBP patients demonstrated reduced lumbar and hip flexion during STS, despite a lack of difference in the starting or finishing positions. Mean lumbar flexion was reduced by 17° ($p<0.05$) and hip flexion by 23° ($p<0.05$). In the normal subjects the total contribution of the lumbar spine to the STS manoeuvre was approximately half that of the hips. In both LBP groups the lumbar spine contributed significantly less to the total STS manoeuvre, the reduction being most pronounced for the positive straight leg raise group. They also found that both groups of LBP patients took longer to reach peak lumbar flexion and to perform STS and that joint co-ordination between the lumbar spine and hips was altered.

Shum et al (2005) demonstrated that it is possible to measure lumbar rather than whole trunk kinematics during STS. They reported altered lumbar spinal kinematics during STS in subacute LBP patients, suggesting that measuring STS may provide clinically significant findings in this patient group. However, they did not report on pelvic kinematics, the inclusion of which may further enhance knowledge of STS in both LBP and asymptomatic subjects. Furthermore, whether subjects with LBP of chronic duration would be similarly affected is unknown and requires further investigation prior to commenting on the usefulness of STS analysis in the CLBP population.

In summary, little is known about lumbar spinal kinematics during STS, since much of the work on STS has involved measurement of the whole spine as one functional unit. However it has been demonstrated that not only is it possible to measure lumbar spinal kinematics during STS, but that it may be useful to the clinician to do so in patients with CLBP due to the differences reported by Shum et al (2005).

3.2.4: Summary of literature review

Although there are many outcome measures available for use with CLBP patients few objectively measure activity limitations and there are questions surrounding the validity of existing measures of range of motion. Complementing existing outcome measures with the inclusion of objective measures and alternative measures of range of motion might enhance outcome measurement of CLBP patients by overcoming the reported limitations of both impairment measures and self-report measures of activity limitation.

Measurement of gait, STS and spinal kinematics during both activities might provide suitable objective measures of activity. However, there is a lack of research in these areas concerning UK subjects undergoing conservative physiotherapy management with a LBP duration of 12 weeks or longer.

In conclusion, there is a need for research that explores the potential of gait, STS and spinal kinematic analysis in CLBP patients attending physiotherapy. There is a need to explore the effect of CLBP on gait, STS and spinal kinematics during both activities in a manner that is suitable for the clinical environment. There is also a need to explore the relationship between these objective measures of activity limitation and CLBP patients' self-report of symptom severity and activity limitation.

3.3: Research questions

Aim

The preceding literature review demonstrated that the analysis of gait and STS could potentially provide suitable objective measures of activity in CLBP patients being managed by the physiotherapist. It also suggested that particular areas requiring further investigation were the effects of altering walking speed, and the relationship between objective measures of gait and STS and patients' self-report of symptom severity and disability.

This component of the research therefore investigated gait and STS parameters. The areas of interest were differences between CLBP patients and people without LBP, the speed effect in gait and the relationship of each measure with commonly used self-report tools. The investigation involved a sample of CLBP patients attending physiotherapy with duration of symptoms of 12 weeks or longer, since the preceding literature review highlighted this population as being under-researched at present. A lack of literature concerning the repeatability of spinal kinematics during gait and STS was identified at the beginning of this study. Therefore, repeatability was investigated first in order to inform the methodology for the remainder of the study.

Research questions

Repeatability of gait and Sit to Stand

1: How repeatable is the gait of CLBP patients compared to normal control subjects, within three gait trials completed on the same day?

2: How repeatable is the STS manoeuvre of CLBP patients compared to normal control subjects, within three STS trials completed on the same day?

Gait and Sit to Stand in Chronic Low Back Pain patients

3: Do CLBP patients display altered spatial and temporal parameters of gait compared to subjects without LBP?

4: Do CLBP patients display altered spinal and pelvic kinematics compared to subjects without LBP?

4a: Is there a difference in the pattern of spinal and pelvic kinematics during gait between CLBP patients and controls?

4b: Is there a difference in the mean spinal and pelvic joint range of motion during gait between CLBP patients and controls?

5: Do CLBP patients display altered temporal parameters of STS compared to subjects without LBP?

6: Do CLBP patients display altered spinal and pelvic kinematics of STS compared to subjects without LBP?

6a: Is there a difference in the pattern of spinal and pelvic kinematics during STS between CLBP patients and controls?

6b: Is there a difference in the mean spinal and pelvic joint range of motion during STS between CLBP patients and controls?

Relationship between gait and Sit to Stand and self-report measures

7: What is the relationship between the spatial and temporal parameters of gait and patients' self-report of symptom severity and disability?

8: What is the relationship between spinal and pelvic kinematics during gait and patients' self-report of symptom severity and disability?

9: What is the relationship between the temporal parameters of STS and patients' self-report of symptom severity and disability?

10: What is the relationship between spinal and pelvic kinematics during STS and patients' self-report of symptom severity and disability?

Suitability of analysis of gait and Sit to Stand

11: Is the analysis of gait and STS a useful measure for CLBP patients?

12: Are the methods of gait and STS analysis used in this study suitable for the routine assessment of CLBP patients?

In order to answer these research questions a comparative and correlational study of gait and STS measurement was undertaken. The choice of methodology and the specific methods employed are described and justified in the following section.

3.4: Methods

3.4.1: Study design

The purpose of this study was to analyse several objective parameters during two activities of daily functioning, gait and STS, in those with and without CLBP, in order to detect differences between the two samples. Therefore, the study design was not experimental, as there was no independent variable to manipulate. Rather, it was one of naturalistic comparison (Polgar and Thomas, 1999) in which the existing situation was observed in order to try to understand it (Bland, 2000). Although this type of design cannot unequivocally determine causation, it is possible to determine important information about differences between groups with this design (Polgar and Thomas, 1999), and therefore it was appropriate for the purpose of this study. There was also a correlational element to this study, where the strength of association between self-report and objective variables was explored in the CLBP subjects. Correlational design again does not allow for causation to be determined (Polgar and Thomas, 1999), but it does allow for understanding of the relationship between variables, which was considered appropriate for this study. The NHS Grampian research ethics committee granted ethical approval for all stages of the study on 17.08.04 (Appendix 1).

3.4.2: Population

The population of interest was people who were receiving physiotherapy for CLBP in an out-patient physiotherapy department in NHS Grampian. This population is justified as follows:

Chronic Low Back Pain

The definition was as for study one (p58), therefore patients with non-specific LBP of more than twelve weeks duration that could be classified as chronic or recurrent were included. The focus was on chronic and not acute or sub acute LBP due to the difficulties surrounding management and the need for objective measures to use with this patient group discussed in section 3.2.

Receiving out-patient physiotherapy in NHS Grampian

Out-patient physiotherapy was defined as any physiotherapy department receiving referrals from GPs and/or Consultants which the patient attended on an appointment basis. Previous research on objective measurement has tended to focus on samples of CLBP patients with high levels of pain and disability, for example those with herniated lumbar intervertebral discs (Morag et al 2000). The results of such research may not therefore be generaliseable to CLBP patients receiving out-patient physiotherapy, who might present with more mild to moderate symptoms. It was the intention of this research to explore the potential of using gait and STS analysis with CLBP patients commonly seen in out-patient physiotherapy departments in NHS Grampian. Therefore, the population of interest was CLBP patients receiving out-patient physiotherapy in any out-patient physiotherapy department in the Grampian region of Scotland.

3.4.3: Sample

The inclusion and exclusion criteria for the CLBP and control sample are now described and justified.

3.4.3.1: Chronic Low Back Pain sample

Inclusion criteria

The inclusion criteria for the CLBP sample were:

- Male or female
- Aged 18 – 65
- GP or Consultant referral
- Diagnosis of chronic or recurrent non-specific CLBP, with or without leg pain
- Able to walk and rise from a chair independently

Gender and age were justified in study one (see 2.5.3, p72 and 2.4.3, p58) and the same criteria applied in this study. Both GP and consultant (orthopaedic and neurological) referrals were included in order to increase the pool of potential subjects. GP referrals accounted for the greatest proportion of CLBP patients in each of the physiotherapy departments involved in the study. However, there are no differences in the patients referred from each source in terms of diagnosis or physiotherapy management, and as long as they fulfilled the other inclusion and exclusion criteria there was no reason to omit patients referred by consultants. Patients with a diagnosis of chronic or recurrent LBP were included as discussed previously. Finally, potential subjects had to be able to walk and rise from a chair independently in order to control for confounding variables that might affect the parameters of interest in the study. Although not an experimental study, it was important nonetheless to control for extraneous variables (Polgar and Thomas, 1999). Use of assistance from another person or a walking aid during gait or STS would affect the data collected in this study (Whittle, 2002), and therefore subjects had to be independent in these activities.

Exclusion criteria

The exclusion criteria for the CLBP sample were:

- "Red flag" indicators requiring urgent surgical opinion
- Worsening nerve root pain
- Previous spinal surgery
- Any medical /orthopaedic condition known to affect walking/STS. For example rheumatoid arthritis, fractures or ligamentous injuries in lower limbs, hemiplegia, use of prosthetic/orthotic devices, pregnancy.

Patients with red flag indicators or worsening nerve root pain no longer fulfil the diagnostic definition of having non-specific CLBP. Moreover, they should be monitored closely, and in the case of red flag indicators will possibly require urgent specialist referral (Waddell et al, 1999), therefore participation in this research would have been unethical. Patients who have had previous spinal surgery comprise a specific sub group of CLBP patients whose walking and STS might conceivably be affected by that surgery. For example a patient who has had fusion of two or more spinal segments would be expected to have reduced intersegmental spinal kinematics during gait and STS and could therefore skew the results if patients without prior surgery did not demonstrate such reductions in intersegmental kinematics. Finally, there are other orthopaedic or medical conditions which are known to affect gait and/or STS. Examples are stroke (Titianova et al, 2003; Chou et al, 2003), rheumatoid arthritis (Sakauchi et al, 2001) and pregnancy (Lou et al, 2001; Wu et al, 2002). In order to control for the presence of confounding variables, patients with these conditions were excluded from this study. The list presented above is not exhaustive; it was used to remind clinicians recruiting patients of the common exclusion criteria in this category. However, each subject was screened by the researcher for medical history and existing complaints that might affect their gait and STS ability prior to inclusion in the study.

3.4.3.2: Control sample

Inclusion criteria

The inclusion criteria for the control sample were:

- Male or female
- Aged 18-65
- Free of LBP
- Able to walk and perform STS independently

In order to be comparable to the CLBP sample, the control sample had the same criteria applied with respect to gender, age and ability to perform gait and STS tasks. Clearly that they were free of LBP was also an important criterion for them to be considered as a control sample, since CLBP was the condition of interest in this study.

Exclusion criteria

The exclusion criteria for the control sample were:

- History of significant LBP in previous year
- Previous spinal surgery
- Any medical/orthopaedic condition known to affect walking/STS

Relatively recent LBP could conceivably have some lasting effect on gait or STS and therefore subjects with a history of LBP in the previous year were excluded. Due to the high incidence of back pain (Cassidy et al, 2005) and the possibility of therefore excluding large numbers of potential control subjects, significant LBP was defined as back pain lasting more than a few days or requiring time off work and/or consultation with a healthcare provider. As discussed above for the CLBP sample, subjects with either previous spinal surgery or other conditions known to affect gait were also excluded from the control sample.

3.4.3.3: Sample size

Power calculations from a pilot study on gait analysis in CLBP patients indicated that 27 subjects would be required in each group to detect statistically significant differences in spatial and temporal parameters with 90% power. Forty subjects per group would be required to detect statistically significant 5° differences in lower limb kinematics with 90% power. Therefore it was intended to recruit 40 CLBP and 40 pain free subjects.

3.4.3.4: Sampling location

Due to the location in Aberdeen City of the human performance laboratory in which the data was collected, subjects were sampled from five physiotherapy departments within Aberdeen City and four physiotherapy departments within reasonable travelling distance of Aberdeen City. The latter were between 15 and 40 miles distance from Aberdeen. The departments were chosen for practical reasons of proximity to Aberdeen and willingness of staff to collaborate in recruitment of subjects.

3.4.3.5: Sampling strategy

Convenience sampling was employed in this study. Although this may result in a sample unrepresentative of the target population (Bowling, 2002) it is common for clinical studies to be performed on the "patients to hand" (Bland, 2000, p 32). The descriptive and exploratory nature of this study meant that using convenience sampling was not a significant limitation. The nature of the present study was likely to result in the need for further research; this further research would need to consider alternative methods of sampling, but the convenience method was considered adequate for this study's purpose.

Sampling method: CLBP sample

Both the researcher and physiotherapists in the nine physiotherapy departments involved in the study took part in recruitment of CLBP subjects during the period from October 2005 to May 2006. An information session took place in each participating department during which the researcher discussed the process and aims of the study with the physiotherapists who had volunteered to participate in recruitment of subjects. A reminder of the inclusion and exclusion criteria was issued to each physiotherapist and study packs were issued to the nine participating physiotherapy departments containing the study information sheet (Appendix 8) and letter of invitation (Appendix 9). Physiotherapists identified potential subjects and issued those who were willing to read them with study information packs. The subjects who were interested in taking part then completed the tear-off slip on the letter of invitation (Appendix 9) and sent it to the researcher in the reply-paid envelope.

Due to low recruitment rates between October and December 2005, an additional strategy was employed for the remainder of the study. The researcher visited the participating physiotherapy departments during CLBP group rehabilitation sessions and approached patients who consented to being approached after discussion with their physiotherapist. The researcher informed them of the study and asked if they would be willing to take home an information pack. The remainder of the process was as described above. Group rehabilitation sessions were chosen due to the potential to target several potential subjects in a short time, in keeping with the convenience method adopted.

Figure 3.4.1 summarises the recruitment process. It can be seen that during the seven month period 29 replies were received from patients interested in taking part in the study.

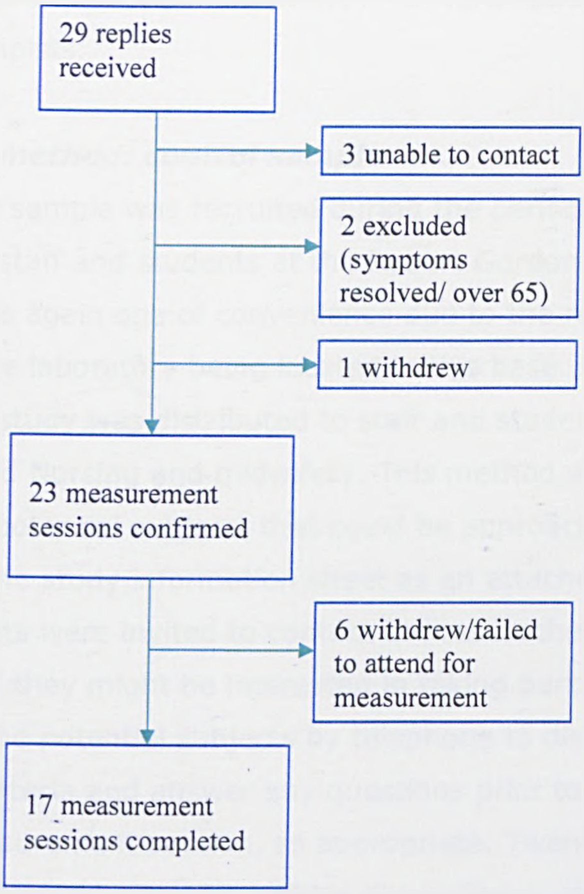


Figure 3.4.1: Recruitment summary for objective measurement study

Despite asking for contact telephone numbers and suitable times for the researcher to telephone subjects on the reply slip, it proved impossible to contact three subjects; either no reply was received at the given telephone number, or the number was not recognised. A further two subjects were excluded at the time of the researcher contacting them by telephone. For one this was due to no longer having symptoms of LBP and for one being outwith the age-range specified in the inclusion criteria. Of the 23 measurement sessions arranged 17 of these took place, with six subjects either withdrawing from the study or failing to attend for the measurement session. The final sample of 17 subjects comprised 12 from physiotherapy departments within Aberdeen City and five from physiotherapy departments within commuting distance of Aberdeen City. Eight were recruited by the researcher from the group rehabilitation sessions whilst nine were recruited by the individual physiotherapists.

Sampling method: control sample

The control sample was recruited during the period from May 2006 to August 2006 from staff and students at the Robert Gordon University, Aberdeen. This location was again one of convenience due to the researcher and the human performance laboratory being located in this base. An e-mail invitation to take part in the study was distributed to staff and students in the schools of Health sciences and Nursing and midwifery. This method was chosen due to the large number of potential subjects that could be approached in this way. The e-mail contained the study information sheet as an attachment (Appendix 10), and the recipients were invited to contact the researcher by return e-mail or telephone if they might be interested in taking part. The researcher then contacted the potential subjects by telephone to discuss inclusion and exclusion criteria and answer any questions prior to arranging a date and time for the measurement session, as appropriate. Twenty subjects were recruited by this method, all of whom fulfilled the inclusion criteria and all of whom took part in the study.

3.4.4: Consent

Each volunteer had the opportunity to read the study information sheet (appendices 8 and 10) prior to deciding whether or not to take part in the study. Having agreed to participate, the measurement session was arranged 48 hours to one week later, thus giving time for the volunteer to change their mind and withdraw if they wished. All volunteers provided written informed consent (appendix 11) on the day of the measurement session, prior to it taking place.

3.4.5: Instrumentation

This section considers the instruments used for the objective measurement of gait and STS and for the collection of self-report information on pain and disability. Pilot work was involved in the selection of the measurement instrument for gait and STS, therefore this is presented first in order to demonstrate the reasons for and justify the choice of the selected instrument. In order to select the most appropriate self-report tools it was necessary to evaluate the available tools and decide on those most suitable for this study. A comprehensive literature review was conducted in order to achieve this aim; this is summarised in this section in order to justify the choice of the tools selected.

3.4.5.1: Measurement instrument for gait and sit to stand

Pilot project 1: Fastrak

The literature review on objective assessment of both gait and STS (section 3.2) highlighted the lack of research using portable measurement tools that could be used in the clinical environment. It was felt that using portable measurement tools would enable any findings from this study to be more easily generalised to the clinical setting and would also increase the pool of potential subjects due to the tools travelling to the subjects rather than the subjects all having to travel to the human performance laboratory in Aberdeen. Two such portable tools were available for this study. GAITRite (CIR systems Inc, Havertown, Philadelphia, USA) is an instrumented walkmat used for the automatic measurement of the spatial and temporal parameters of gait. It has been shown to be accurate (Cutlip et al, 2000) and reliable (van Uden and Besser, 2004; Menz et al, 2004) and has demonstrated concurrent validity against Vicon (Barker et al, 2006; Webster et al, 2005). It has also previously been used for the measurement of gait in subjects with LBP (Al-Obaidi et al, 2003), and was therefore considered an appropriate tool for this study. The second tool, Fastrak (Polhemus, Colchester, Vermont, USA), is an electromagnetic tracking device potentially capable of measuring spinal kinematics during gait and STS. At the time of initiating this study there was no literature reporting the use of Fastrak during gait or STS; therefore it was necessary to conduct pilot work in order to assess the accuracy and reliability of the tool for this purpose. Because this project required the measurement of lumbar spinal movements over a large data capture area (particularly during gait), three different transmitters with varying reported ranges were assessed, and the results for each are summarised below.

Transmitter 1: Standard

The standard, or TX2 transmitter, supplied with the Fastrak measurement system has a reported range of 0.08 to 1.52 metres (Polhemus, 2001). Figure 3.4.2 displays the Fastrak system used for the following experiments, consisting of a source unit (TX2), two sensors, and a systems electronics unit. The TX2 transmitter should be adequate for STS measurements but not for gait, and the TX2 was therefore piloted with respect to measuring spinal kinematics during STS.

Figure 3.4.2: Fastrak systems electronics unit, TX2 transmitter and two receivers
TX2 on the left of picture, receivers on the right

Three separate pilot experiments were conducted in the human performance laboratory at The Robert Gordon University, Aberdeen to assess interference from metal objects, accuracy, and reliability of measuring STS. The researcher conducted all experiments. The results were that there was no interference from metal objects in the testing area, the Fastrak accurately measured known degrees of angular displacements in all three planes, and demonstrated good reliability in measuring lumbar kinematics during STS in one healthy volunteer. Methods of reliably attaching the sensors to the spinous processes and of accurately timing STS were identified as requiring further work, but the TX2 appeared to be suitable for measuring spinal kinematics during STS.

Transmitter 2: Long Ranger® transmitter

The TX2 transmitter did not have sufficient range to capture data from the spinal sensors during gait analysis. It was proposed in this study to collect data with the Fastrak and GAITRite mat simultaneously and synchronise the two measurement systems in order to analyse spinal kinematics in relation to events in the gait cycle. Initial measurements of the experimental set-up confirmed that a range of 3metres in each direction from the transmitter would be required. The Long Ranger® transmitter has a reported range of up to 4.5metres (Polhemus, 2001), which would fulfil the study criteria. It was therefore piloted with respect to measuring spinal kinematics during gait.

Figure 3.4.3 displays the LongRanger® in relation to the systems electronics unit to give an indication of its size. Due to the size of the Long Ranger® transmitter it was not possible to conduct a separate interference test, since this test involved the transmitter and receiver being mounted on a wooden board and moved within the data capture area. The interference test conducted for the TX2 transmitter confirmed that there was no interference; however, it must be remembered that the Long Ranger® emits a stronger electromagnetic field, and as such is more perceptible to interference from metal objects (Day et al, 1998).

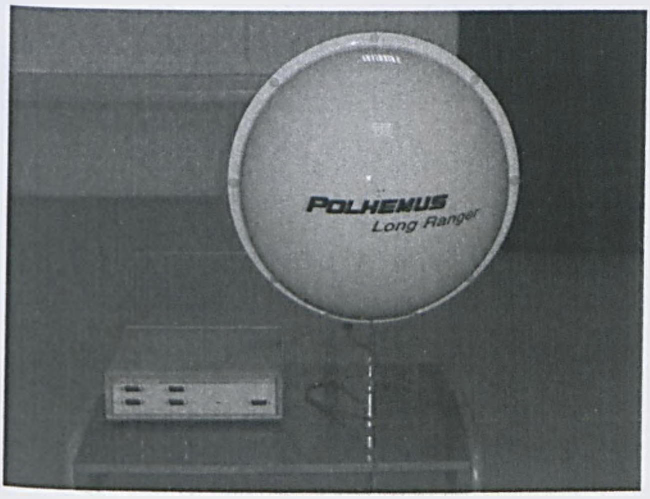


Figure 3.4.3: LongRanger® transmitter and Fastrak systems electronics unit

Accuracy was tested in the following way. The Long Ranger® transmitter was mounted on a wooden table 92cm high in the centre of the laboratory, and a wooden board with the sensors attached placed on a second wooden table 72cm high and 1.5m from the transmitter. The sensors were attached to wooden cubes and the cubes moved through translations and rotations in each of three planes, returning to the start position in between. The translations observed reflected the known translations (measured against a clear plastic ruler on the wooden board). However, the results for the rotations were highly inaccurate as figures 3.4.4 and 3.4.5 illustrate. It can be seen that for the standard transmitter (figure 3.4.4) rotations around the x, y and z axes were recorded in turn; these mimicked the side flexion, flexion/extension and rotation movements that would be measured in the spine during gait and STS. For each of these primary movements, there was little or no secondary movement around the other two axes, although it was not possible to eliminate movement completely due to the experimental design, which involved the manual movement of a wooden cube with the sensor firmly attached to it.

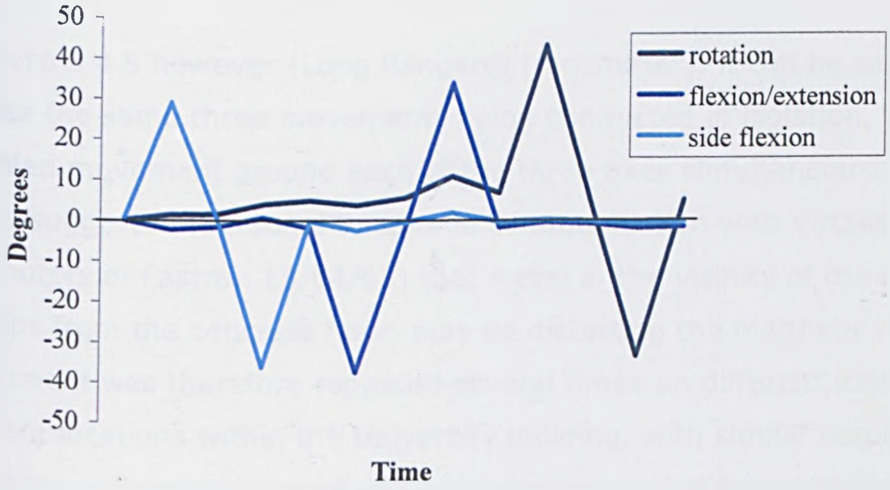


Figure 3.4.4: Accuracy test, standard Fastrak transmitter.

Traces depict side flexion, flexion/extension and rotation movements being performed in turn; each primary movement involving little or no movement in the remaining two directions

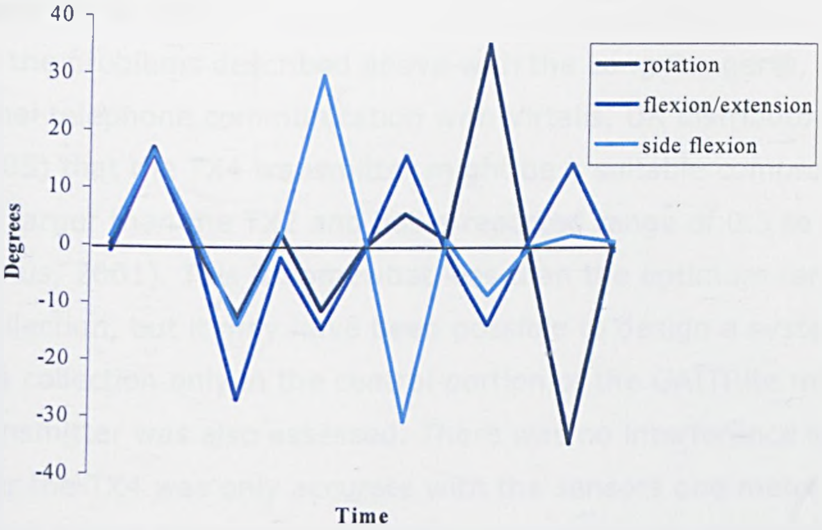


Figure 3.4.5: Accuracy test LongRanger® transmitter

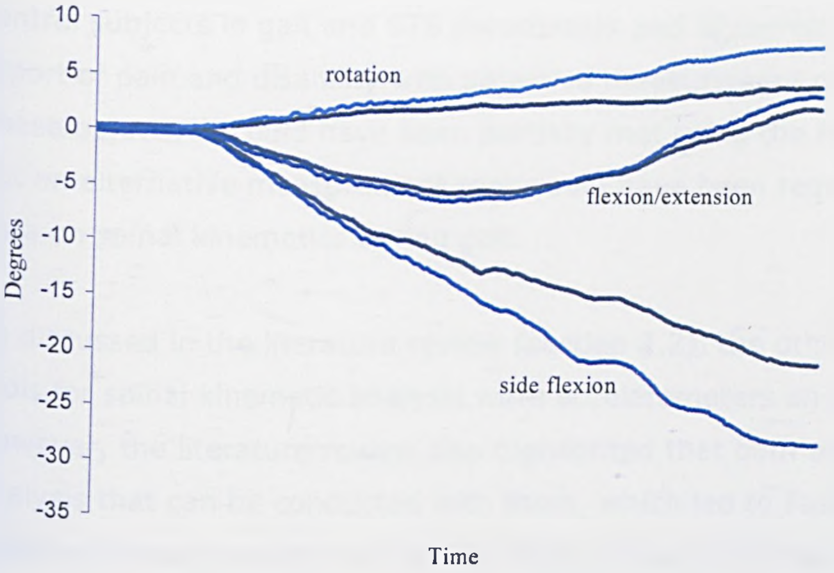
Traces depict side flexion, flexion/extension and rotation movements being performed in turn; each primary movement involving significant movement in the remaining two directions

In figure 3.4.5 however (Long Ranger® transmitter), it can be seen that despite the same three movements being conducted in isolation, the Fastrak recorded movement around each of the three axes simultaneously throughout. It was suggested (personal telephone communication with Virtalis, UK distributors of Fastrak 13/04/05) that metal in the vicinity of the transmitter, perhaps from the concrete floor, may be distorting the magnetic field. This experiment was therefore repeated several times on different days, and in different locations within the University building, with similar results. Several software configurations were piloted, following advice from Virtalis and Polhemus; however, this did not improve the situation. The Fastrak was not piloted in the other proposed study locations. However, these would all have been within institutional buildings, which are similarly likely to have concrete floors. Due to these results, it was decided that the Long Ranger® was not a suitable transmitter for collecting the required data and pilot work with it was terminated.

Transmitter 3: TX4

Due to the problems described above with the Long Ranger®, it was suggested (personal telephone communication with Virtalis, UK distributors of Fastrak, 13/05/05) that the TX4 transmitter might be a suitable compromise. It is only slightly larger than the TX2 and has a reported range of 0.3 to 2.1metres (Polhemus, 2001). This is somewhat less than the optimum range for the gait data collection, but it may have been possible to design a system that allowed for data collection only in the central portion of the GAITRite mat. Therefore, this transmitter was also assessed. There was no interference detected, however the TX4 was only accurate with the sensors one metre or closer to the source; at longer distances the results were similar to those reported for the Long Ranger® above.

To confirm its accuracy, an additional experiment was conducted with the TX4 to represent the protocol required to capture data during gait. Two sensors were attached to the handle of a child's wooden trolley, 45cm high. The trolley was then moved in a straight line past the transmitter, never straying more than 1m from the transmitter. The results of the angular displacements are shown in figure 3.4.6, which confirms that the Fastrak recorded considerable angular displacements during this experiment. However, no angular displacement should have occurred, since the sensors were taped firmly in place to the wooden handle; the only movements observed should have been linear displacements. The results of this experiment further questioned the suitability of the Fastrak for this study.



Key: Dark blue = sensor 1, bright blue = sensor 2

Figure 3.4.6: Accuracy of TX4 Fastrak transmitter

Traces depict considerable angular displacement during experiment in which only linear displacement occurred

Conclusions

The preceding pilot experiments confirmed that of the three transmitters tested only the TX2 was suitable for use in this study. This is presumably why studies which have used the TX2 and whose protocols have involved placing the sensors close to the transmitter have reported positive results (Jordan et al, 2004; Swinkels and Dolan, 2004; Jordan et al, 2000; O'Sullivan et al, 2003; Barrett et al, 1999 Swinkels and Dolan, 1998). In contrast, there is a lack of published studies that have successfully used the TX4 or Long Ranger®. The one study which has evaluated movement over a larger data capture area (fast bowling in cricket) kept the source and sensor close together by mounting both on the subject (Burnett et al, 1998). In conclusion, it would have been possible to use the TX2 to measure spinal kinematics during STS, following a further pilot project to establish reliability of sensor attachment and the establishment of accurate methods of timing STS. However, it was not possible to use Fastrak to measure spinal kinematics during gait.

Recommendations

The aims of this study were to describe differences between CLBP patients and control subjects in gait and STS parameters and to correlate patients self-report of pain and disability with objective measurement of gait and STS. These objectives could have been partially met using the Fastrak and GAITRite, but an alternative measurement tool would have been required for collecting data on spinal kinematics during gait.

As discussed in the literature review (section 2.2), the other potential portable tools for spinal kinematic analysis were accelerometers and digitised video. However, the literature review also highlighted that both are limited in the analysis that can be conducted with them, which led to Fastrak being the preferred measurement tool for this study. Clearly, Fastrak could not fulfil all the study objectives, therefore alternative tools once again had to be considered.

The outcome of the pilot studies described above presented two options: omitting the measurement of spinal kinematics during gait from this study, or employing alternative measurement equipment. It was considered important to include the gait measurements not only to fulfil all the aims of the study, but because of the previous work in this area which this study was to complement (Taylor et al 2004; Taylor et al, 2003; Lamoth et al, 2002). As discussed in the literature review (section 2.2), the other tools capable of measuring spinal kinematics are the two or three-dimensional camera systems. The original intention was not to use these, in order to use equipment that was suitable for use in the clinical environment. However, Fastrak was clearly not suitable for this study for the reasons presented above. A three-dimensional digital optical motion analysis system was however available in the study location; Vicon MX (OMG, Oxford, UK). Vicon is both accurate and reliable (Ehara et al, 1995; Kadaba et al, 1989), therefore it could provide credible data in this study. Three-dimensional motion analysis systems have previously been used to investigate spinal kinematics during gait in both healthy subjects (Callaghan et al, 1999; Syczewska et al, 1999; Taylor et al, 1999; Crosbie et al, 1997a; 1997b) and in those with acute low back pain (Taylor et al, 2004). Three-dimensional motion analysis systems have also been used in studies of STS in subjects without LBP (Sibella et al, 2003; Gross et al, 1998).

The use of Vicon in this study would allow for the measurement of the spatial and temporal parameters of gait and spinal kinematics during gait and STS with one system which has well-documented measurement properties. The compromise with Vicon was that it is not as portable as Fastrak and GAITRite, and the type of analysis it conducts can less easy to conduct in the routine clinical environment. However, bearing in mind the aims of this study, the use of Vicon would allow for the exploration of differences between samples and correlation between subjects' self-report of pain and disability and the objective measurement of gait and STS. This would determine which (if any) movement parameters may be important for the physiotherapist to measure. Further research could then be carried out to investigate methods of measuring them that could be employed clinically.

Justification of Vicon

Validity

Face validity refers to the judgement made about the appropriateness of a measurement tool for its intended use (Durward et al, 1999). Face validity was demonstrated by the reported ability of Vicon to measure all the parameters of interest in this study and by its use in previous studies of spinal kinematics during gait (Saunders et al, 2005) and the use of similar optical systems in STS analysis (Sibella et al, 2003).

Content validity refers to the tool's ability to measure all aspects of the behaviour of interest (Durward et al, 1999). Content validity was demonstrated by the ability of Vicon to measure all gait and STS parameters (spatial and temporal gait parameters, kinematics during gait, temporal STS parameters and kinematics during STS).

A previous model of Vicon (the 370) was shown to be one of the most accurate optical measurement systems in a comparison by Ehara et al (1997), with a reported mean absolute error of 0.94mm. For this reason, Vicon is often considered to be the gold standard in motion analysis and has been used to demonstrate concurrent validity of other tools; for example GAITRite (Barker et al, 2006; Webster et al, 2005).

Reliability

Reliability of a measurement tool incorporates repeatability and precision of its measurements (Durward et al, 1999). Kadaba et al (1989) reported high levels of within and between day reliability of spatial and temporal parameters, with coefficient of variation values 6% or less. Kadaba et al (1989) also reported high levels of within-day reliability for lower limb kinematic parameters with coefficient of multiple correlation values between 0.643 and 0.996. However, between-day reliability was not as high (0.240 to 0.944) which was attributed to variability in marker placement. Therefore intra or inter-rater reliability of marker placement is important to establish in a study using this or similar systems when reliability is in part dependent on placement of markers by the operator. The high levels of reliability of spatial and temporal parameters have been confirmed recently with intraclass correlation coefficients (ICC) of 0.88 and above (Meldrum, 2005), as have the relatively lower levels of between-day reliability of lower limb kinematics with ICC's of 0.11 to 0.83 reported (Gok et al, 2002). Between-day reliability can be affected by marker placement as discussed above, but also by inherent variability in the subject's movement. This study was only measuring kinematics on one occasion per subject; however both intra-rater reliability and intra-subject variability are important to account for in a study using this methodology. Intra-rater reliability of marker placement and intra-subject repeatability of gait and STS parameters were therefore addressed in this study.

Accuracy of marker based systems is affected by errors introduced due to skin movement (Benoit et al, 2006). Therefore, although reliable results are obtained, they might not accurately reflect the motion of the underlying bones. Skin movement was not quantified in the current study. However, any errors due to skin movement would presumably be equally apparent in both samples and would not introduce bias to one sample only. The results however must be interpreted with this limitation in mind.

Marker configuration

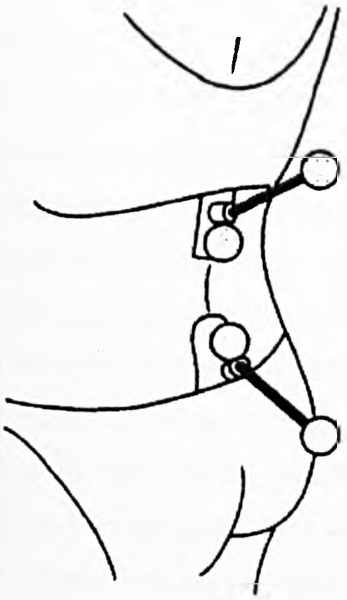
There is a standard marker configuration for measuring lower limb kinematics that is recommended for use with the Vicon system (Vicon Plug-in Gait, Appendix 12). It consists of 14 retro reflective markers plus one or two for the sacrum. It is the same as that developed by Kadaba et al (1990) with the addition of a heel marker and had been employed widely (Gok et al, 2002; Growney et al, 1997). However, no such standard configuration exists for the measurement of spinal kinematics with Vicon or other optical systems. Previous research on gait has used various marker systems. Crosbie et al (1997a; 1997b) and Syczewska et al (1997) favoured placing markers directly over the spinous processes, whilst Saunders et al (2005), Taylor et al (1999) and Whittle and Levine (1997) attached markers to lightweight rigs and attached the rigs to the spine using plastic base plates. No previous research has measured spinal kinematics during STS using optical systems; therefore there was no literature from this area with which to inform the choice for this study. Since no one method had been demonstrated as superior and the configuration employed by Whittle and Levine (1997) had been used successfully in the laboratory in which the current study was conducted, this method was initially employed and the intra-rater reliability of attaching these markers calculated. However, the method involved the alignment of stalks with markers on the end which proved to be somewhat problematic to maintain in position during gait. Therefore, the method validated by Schache et al (2002a, 2002b), which involved the use of one rig on the spine and one individual marker on the pelvis was ultimately deemed to be superior. This latter configuration was developed for the measurement of spinal kinematics during running, and used with the Vicon 370 motion analysis system (Schache et al, 2002a; Schache et al, 2002b), therefore it was considered appropriate for use in this study. The configuration is described in detail below. The pilot study conducted to establish intra-rater reliability of marker placement is first reported.

Pilot project 2: Intra-rater reliability of spinal marker placement

A pilot study was conducted by the researcher between June and August 2005 on a convenience sample of healthy volunteer subjects recruited from The

Robert Gordon University. Subjects were included if they were aged 18 to 64 and free of LBP. Subjects were not considered if they had a history of significant LBP, had previously undergone spinal surgery, or had any other musculoskeletal or neurological condition that impeded movement. Six male and four female subjects volunteered with an age range of 23 to 48 (mean 29.4). The Robert Gordon University's School of Health Sciences ethics committee granted ethical approval. All subjects provided written informed consent after reading the study information sheet (Appendix 13).

The Vicon MX motion analysis system was used. This is a high-resolution three-dimensional optical motion analysis tool, consisting of seven infrared cameras linked to a workstation, which captures the motion of 25mm diameter lightweight retroreflective markers at a rate of 60Hz, and two Kistler™ force-plates. Markers are placed over bony prominences and the movement of the markers is used as an approximation of the movement of the underlying bones. The lower limb marker configuration discussed above was used. This involved placing markers at the following points on each limb: Anterior superior iliac spine (ASIS), thigh, knee joint, tibia, lateral malleolus, space between 2nd and 3rd metatarsal heads and heel. An additional four markers were used to detect lumbar spinal motion (Whittle and Levine, 1997) and can be seen in figure 3.4.7.



Reprinted from Gait and Posture, 5, 2. Whittle M, W and Levine, D. Measurement of lumbar lordosis as a component of clinical gait analysis, pp101-7, copyright (1997), with permission from Elsevier.

Figure 3.4.7: Spinal marker configuration for intrarater reliability pilot. Figure demonstrates markers between right and left PSIS and on spinous process of L1, with wands angled at 45º to horizontal

These consisted of a sacral marker (between posterior superior iliac spines), a marker at the first lumbar spinal process (L1), and markers on the ends of sacral and lumbar wands angled at 45º from the horizontal. Two base plates measuring 45 by 65mm therefore had to be located over L1 and between the right and left PSIS. The sacral marker was placed on the midpoint of an imaginary line joining the right and left posterior superior iliac spines, a method employed by Tully et al (2005) and Swinkels and Dolan (1998). L1 was located in the following manner. The spinous process at the highest level of the iliac crest was identified as L4 (Tully et al, 2005; Burnett et al, 1998); palpating up the spine then allowed L1 to be located (Burnett et al, 1998). Vicon Workstation software collected and processed the data; this takes the raw two-dimensional data from each camera, combines it with calibration data and reconstructs the motion in three dimensions. The three-dimensional data can then be viewed as a virtual motion and also exported to other software for presentation and analysis.

Subjects attended on two occasions, at least four days apart (range 4 to15, mean 8.5), at the same time of day where possible. On each occasion subjects were barefoot and dressed in shorts (males) and shorts and a vest or crop top (females). The researcher recorded the following calibration data on the first occasion only: subjects' height (cm), weight (kg), leg length (cm), and width of knee and ankle joints (cm). On each occasion the researcher attached the markers using hypoallergenic double-sided tape, and one static data capture was performed per subject. The whole procedure took less than an hour on each occasion. One subject was unable to attend on two occasions; therefore after data capture the markers were removed from this subject, the skin was inspected to ensure there were no markings indicating where the markers had been, then they were replaced thirty minutes later and the second data capture took place for this subject.

To determine whether markers were placed in the same locations on each testing occasion, the distance between markers was measured using Vicon Workstation software. Although this did not measure the precise location of each marker, alterations in the distances between markers would indicate that marker placement was not repeatable. All body segments were included, namely spine (sacral marker to L1 marker), pelvis (Right ASIS marker to Left ASIS marker), leg (knee marker to ankle marker) and foot (heel marker to toe marker). Descriptive statistics determined whether statistical assumptions were met. ICC, 3, 1 based on a two- way random effects model for a single measurement was used to calculate intrarater reliability. The ICC 3,1 was chosen, as it is indicated when the reliability of a specific rater is being calculated (Shrout and Fleiss, 1979). The two-way model was chosen to account for the variability in both the rater and the subjects (Nichols, 1998). The ICC estimate for a single measurement was reported, since the measure of interest was the actual distance between markers on each occasion, and this was not averaged in any way. This method has been reported by other authors interested in intrarater reliability of measurement tools (Amiri et al, 2003; Jordan et al, 2000). SPSS version 11 was used for these calculations. The Standard error of the mean (SEM) was also calculated to express the magnitude of the measurement error. This was calculated from the following formula: SEM=sx√1-rxx, where sx is the standard deviation (SD) of the segment measurements for the group, and rxx is the reliability coefficient, ICC (Bruton et al, 2000). The statistical methods employed are in keeping with recommendations on reliability measurement, which suggest that no single statistic provides a complete measure of reliability (Bruton et al, 2000).

The results of this pilot study are presented in table 3.4.1, which displays the mean and standard deviation (SD) for each segment's measurement on each of the two days. Table 3.4.1 also reports the ICC for each measurement, the 95% confidence interval (CI) of the ICC and the SEM in mm for the distances between markers. These results indicate that spinal markers demonstrated poor intrarater reliability whilst the other markers demonstrated good intrarater reliability, with ICC's of 0.8 or above.

Table 3.4.1: Intrarater reliability results

	Mean (SD) Day 1	Mean (SD) Day 2	ICC (3,1)	95% C I for ICC		SEM (mm)
				Lower	Upper	
Spine	78.9 (7.0)	76.9 (9.2)	0.2341	-0.4723	0.2341	7.0
Pelvis	287.8 (24.8)	289.5 (24.4)	0.8494	0.5041	0.9604	9.3
Left Knee	430.1 (25.3)	428.0 (20.2)	0.8638	0.5505	0.9642	8.2
Right Knee	428.7 (20.7)	426.2 (17.9)	0.8592	0.5475	0.9627	7.1
Left Foot	191.5 (14.7)	189.7 (14.2)	0.7959	0.3763	0.9447	6.4
Right Foot	191.6 (14.7)	191.7 (8.0)	0.8773	0.5771	0.9682	2.8

Mean (SD) distance between two markers in mm, intraclass correlation coefficient (ICC 3,1) with upper and lower confidence intervals and standard error of the mean (SEM) in mm

Due to the poor results for the spinal markers, the absolute errors were also reported for each subject (measurement one minus measurement two). These are displayed in table 3.4.2. It can be seen that most errors were around 10mm or less, with the exception of subject five, which was almost double that value.

Table 3.4.2: Absolute errors for distance between two spinal markers for each subject in intrarater reliability study

Subject	Session 1 (mm)	Session 2 (mm)	Difference (mm)
01	63.9	73.0	9.1
02	74.2	80.6	6.4
03	81.6	87.0	5.4
04	76.1	66.7	9.4
05	84.3	67.1	17.2
06	80.4	73.6	6.8
07	88.8	78.8	10.0
08	74.2	75.8	1.6
09	81.8	70.3	11.5
10	83.6	96.0	12.4

Measurements for each session (1 and 2) and difference between sessions reported. All measurements in mm

The results for the pelvis, knee and foot segments suggested that these markers were reliably placed. The results for the spinal markers were poor. However, the spinal markers consisted of a marker at the end of a wand attached to a clear plastic base-plate, with a second marker attached to this base plate. It was these second markers which were required to be placed over the sacrum and L1, and which were used to calculate the spinal distance used in this analysis. This methodology does make it potentially more difficult to place the marker precisely over the spinal segment, and previous researchers have also reported that these wand markers are more difficult to position accurately (Kadaba et al, 1989; Growney et al, 1997). In addition, the spinal segment was not marked in any way between palpating and attaching the markers, which may have contributed to the errors. On inspection of the results the ICC was poor, but the SEM less than 1cm. Table 3.4.2 confirms this, with the exception of subject five. Considering the size of the base-plates and the fact that this study is considering the lumbar spine as one rigid segment between the sacral and lumbar markers, errors of this magnitude are not as problematic as they would be if the motion between individual vertebrae were being considered. The researcher is an experienced manual therapist and used recognised palpation techniques to identify the bony landmarks for marker placement. However, spinal palpation has been shown to have variable reliability (O'Haire and Gibbons, 2000). Furthermore, in a recent study (Harlick et al, 2007) the accuracy of experienced manipulative physiotherapists in palpating spinal levels was investigated. Harlick et al (2007) demonstrated that the mean inaccuracy for palpating L1 was 19.7mm; the physiotherapists on average marked L1 as being either 19.7mm above or below the spinous process detected on radiographs, considerably larger then the SEM (7mm) in this study. Therefore, the difficulties in accurately and reliably palpating spinal segments combined with the size of the base plates contributed to the results in this pilot study.

Second intrarater reliability pilot study

Due to the results obtained above, a second smaller study was conducted in November 2005. In this study the skin was marked with a dark pencil between palpating the spinal segments and attaching the markers. Three of the volunteers from the first intrarater study attended on one occasion each. The spinal markers were removed and replaced five times within a one-hour session, care being taken to remove the pencil mark with a cleansing wipe on removal of the markers. The results are presented in table 3.4.3.

Table 3.4.3: Results of second pilot study on intrarater reliability of marker placement.

Variable	Value
Mean difference, mm (SD) T1	99.8 (6.9)
Mean difference, mm (SD) T2	103.8 (14.8)
Mean difference, mm (SD) T3	111.3 (22.3)
Mean difference, mm (SD) T4	108.3 (6.4)
Mean difference, mm (SD) T5	115.1 (11.8)
ICC	0.5405
95% CI for ICC Lower	0.0790
Upper	0.9816
SEM	8.7

Mean difference between markers (n=5) in mm (SD) on each of five occasions of marker placement, intraclass correlation coefficient (ICC) with upper and lower confidence intervals and standard error of the mean (SEM)

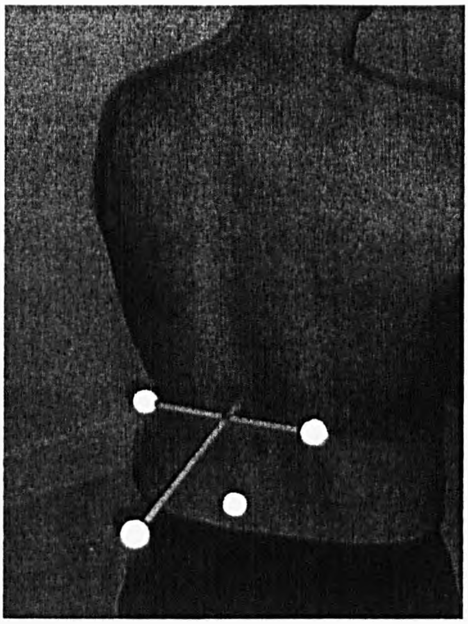
It can be seen that the ICC was improved in this study compared to the first (table 3.4.1), confirming that the markers were more reliably placed. An ICC value of 0.5405 can be considered to demonstrate a moderate level of reliability (Batterham and George, 2000). Considering the variable accuracy and reliability of spinal palpation (Harlick et al, 2007; O'Haire and Gibbons, 2000), this was considered adequate for this study.

Conclusion

These pilot studies have demonstrated that the researcher could reliably place the Vicon markers on the pelvis, lower limbs and feet. The within-day reliability of placing the spinal markers was better than the between-day reliability, however the magnitude of the between-day errors was not considered problematic for this study since markers were being placed only once on each subject. In the subsequent study on spinal motion analysis in CLBP patients, every effort was made to ensure accurate placement of the spinal markers, including marking the skin with a dark pencil between palpating the spinal segment and attaching the marker.

Final selection of marker configuration

As discussed above, partly due to the difficulties in maintaining the placement of the wands in the configuration piloted (Whittle and Levine, 1997) the configuration adopted in this study was that used by Schache et al (2002a; 2002b). This involved the placement of a single 25mm marker between the right and left posterior superior iliac spines and a lightweight rig with a cluster of three markers attached to it over the first lumbar spinous process, illustrated in figure 3.4.8.



Marker configuration of Schache et al (2002a; 2002b) consisting of single marker midway between posterior superior iliac spines and cluster of three markers attached to lightweight rig at level of first lumbar spinous process

Figure 3.4.8: Final marker configuration used in quantitative study

Schache et al (2002a; 2002b) used this configuration to record pelvic and lumbar kinematics during treadmill running, with the exception that they placed the cluster over the 12th thoracic spinous process. For reasons discussed in chapter 3.2 it was decided in this study to eliminate thoracic spinal measurement and therefore the cluster was placed over L1, similar to the protocol of Taylor et al (2004). Schache et al (2002a) attached the spinal rig with a "tight elastic thoracic strap" (p143) due to the rig reportedly being markedly drawn across the back with maximal axial twisting. In piloting the rig for the current study this was not demonstrated; however axial twisting will be greater in running than walking (Saunders et al, 2005) which could account for this finding. Therefore, a strap was not used in the current study, since the rig did not appear to be drawn across the back and previous authors have suggested that a strap might affect the measured kinematics (Pearcy et al, 1987). Joint angular kinematic data were computed by measuring relative movement of one body segment to another; therefore lumbar spinal movement was measured relative to the pelvis.

A further intrarater reliability study was not conducted, partly due to time constraints. However, the spinal cluster had the same size and shape of base plate as that in the previous intrarater studies, therefore reliability of placing it would not be affected by its size or shape. The use of a single marker on the pelvis instead of a second rig however should be more reliably placed since it was easier to place the centre of the marker on the pencil mark than it was to place the centre of the larger base plate.

3.4.5.2: Measurement instruments for self-report information

One aim of this study was to investigate correlations of objective measurement with self-report of disability and pain severity. Therefore, it was necessary to evaluate the available questionnaires for measuring the latter two domains. Although the measurement of additional domains has been recommended for subjects with spinal pain, these are considered outwith the scope of this study. These domains are generic health status, work disability and patient satisfaction (Bombardier, 2000; Ehrlich 2003). Patient satisfaction was clearly not relevant to this study, since an intervention was not taking place. It could be argued that correlation of objective measurement with generic health status and/or work disability might be interesting. However, in this study there was a need to gather enough relevant information on subjects' self-reported symptoms, without subjecting them to a lengthy battery of questionnaires in addition to the objective measures they would undergo. For this reason, it was decided to focus on CLBP patients' main reported symptoms; those of pain and disability. In addition, there are several self-report questionnaires which address specific domains such as self-efficacy (Anderson et al, 1995; Williams and Myers, 1998) and fear of movement (Waddell et al, 1993; Vlaeyen et al, 1995). These were also considered outwith the scope of this study, for the reason presented above. A comprehensive literature review was conducted in order to choose the most appropriate measurement tools. The findings of that literature review are summarised below.

Back specific instruments

The properties of the main self-report tools identified and reviewed for back specific functioning are summarised in tables 3.4.4a and b. Whilst there is no one measure accepted as being superior to the others, largely due to the lack of direct comparisons in the literature (Kopec 2000), two measures are widely recommended and most commonly used. These are the Oswestry Disability Index (ODI; Fairbank et al, 1980) and the Roland Morris Low Back Pain Disability Questionnaire (RDQ; Roland and Morris, 1983). Employing a frequently used tool would certainly allow for comparisons between the study group and other populations (Muller et al, 2004). However, it was several years since the expert panels recommended these two measures (Deyo et al, 1998; Bombardier, 2000); therefore, this review considered all the measures listed in tables 3.4.4a and b.

Table 3.4.4a: *Measures of back specific functioning in chronological order of original publication; 1980 to 1994*

Measure	Author	Year	Self-administered	Time to complete	Time to score	Validity	Reliability	Floor effect	Ceiling effect
Oswestry Disability Index	Fairbank et al	1980	Yes	5	1	Very good	Good	In non-surgical patients	Unknown
Million Visual Analogue Scale (Million VAS)	Million et al	1982	If omit lumbar spine movements	5-10	2 - 3	Good	Good	Unknown	Unknown
Roland-Morris Disability Questionnaire	Roland & Morris	1983	Yes	5	1	Very good	Good	Unknown	Yes
Waddell Disability Index	Waddell & Main	1984	Yes	5	1	Good	Moderate	Yes	Yes
Dallas Pain Questionnaire	Lawliss et al	1989	Yes	3 - 5	1	Good	Good in original study	Unknown	Unknown
Low Back Outcome Score	Greenough & Fraser	1992	Yes	5	1	Very good	Very good	No	Yes (small)
Low Back Pain Rating Scale	Manniche et al	1994	If omit tests of endurance & flexibility	15	3 - 5	Good	Unknown	Unknown	Unknown
Clinical Back Pain Questionnaire	Ruta et al	1994	Yes	5 - 10	3	Good	Good	Unknown	Unknown

Table 3.4.4b: *Measures of back specific functioning in chronological order of original publication; 1995 to 2000*

Measure	Author	Year	Self-administered	Time to complete	Time to score	Validity	Reliability	Floor effect	Ceiling effect
Quebec Back Pain Disability Scale	Kopec et al	1995	Yes	5	2	Very good	Good	Unknown	Unknown
Lumbar Spine Questionnaire (North American Spine Society)	Daltroy et al	1996	Yes	20	Unknown	Unknown	Good	Unknown	Unknown
Resumption of Activities of Daily Living Scale	Williams & Myers	1998	Yes	5	Not reported	Unknown	Good	Unknown	Unknown
Back Pain Functional Scale	Stratford et al	2000	Yes	<5	<30	Very good	Good in initial tests	No	No

Davidson and Keating (2002) suggested several criteria that a questionnaire must meet in order to be suitable for use with LBP patients attending physiotherapy. These criteria were considered here; that the questionnaire must be brief, easy to complete, easy to score, valid, reliable, suitable for self-administration, and have no serious floor or ceiling effects in a general ambulatory population. The literature review identified four instruments that were potentially useful in this study: the ODI, RDQ, Low Back Outcome Score (LBOS; Greenough and Fraser, 1992) and Quebec Back Pain Disability Scale (Quebec; Kopec et al, 1995). The LBOS would first have had to be validated on a population of CLBP patients referred to physiotherapy, which was outwith the timescale of this study, and the Quebec had the unknown factor of whether serious floor or ceiling effects existed in an ambulatory population of CLBP patients. Therefore, in keeping with previous authors, the choice was between the two most popular instruments, the ODI and the RDQ (Bombardier, 2000; Deyo et al, 1998). Both were equal in terms of brevity, ease of completion and scoring, validity and reliability. The ODI had demonstrated a floor effect in non-surgical patients, whilst the RDQ had demonstrated a ceiling effect (in acute LBP patients); this perhaps tipped the balance in favour of the RDQ in this study. In addition, several researchers investigating physical performance had used the RDQ; this would allow for comparison of this study with this previous research. It was for this reason that the RDQ was chosen as the back specific disability outcome measure in this study. The properties of the RDQ are described below and the questionnaire used in this study is presented in Appendix 14.

Properties of Roland Morris Disability Questionnaire

Roland and Morris (1983) developed this 24 item self-administered questionnaire, derived from selected questions from the Sickness Impact Profile (Bergner et al, 1981) with the added phrase "because of my back". Questions relate to body functions (pain, sleeping, appetite) and activities (self-care, walking, sitting, standing, lifting, work, dressing, stairs, housework, resting). It has gained popularity, and is one of the few back specific questionnaires reportedly in routine use by some physiotherapists (Kirkness and Korner-Bitensky, 2002). It takes about five minutes to complete and one to score (CSP, 2004). There are several modified versions (Chansirinukor et al, 2004; Stroud et al, 2004; Stratford and Binkley, 1997; Patrick et al, 1995), however the original has been most frequently cited and more is known about its measurement properties. Ostelo et al (2004) found the original version to be superior in terms of reproducibility and responsiveness when compared to the two earlier modifications. The most recent modifications by Chansirinukor et al (2004) and Stroud et al (2004) were developed on subjects with mixed LBP (proportion with CLBP not reported) and chronic pain (only 36% CLBP) respectively, and so their validity for CLBP patients is not known. Test-retest reliability has been reported between 0.81 and 0.91 (Stratford et al, 1996; Deyo and Centor, 1986; Roland and Morris, 1983), and it has been found to be slightly more responsive than the ODI (Leclaire et al, 1997). Davidson and Keating (2002) reported results contradictory to all previous studies, demonstrating low reliability and poor scale width, leading them to recommend that the RDQ is not suitable for clinical use. Riddle and Stratford (2002) suggested that this might be due to the statistical methods employed, variations within the sample, or the small sample size (16 for one calculation of reliability). It may also have been due to the relatively long retest period (Brouwer et al, 2004). Certainly, the confidence intervals (upper bounds) were similar to previous studies, but Davidson and Keating (2002) based their conclusions solely on the (poorer) ICC coefficient. This also caused them to calculate a much larger Minimal Detectable Change than previous studies, with over 50% of their patients scoring less than this on initial testing. Since Davidson and Keating's (2002) findings have not been replicated, and the RDQ has subsequently shown good test-retest reliability and responsiveness (Brouwer et al, 2004; Ostelo et al, 2004), it was decided that there was insufficient evidence from this one study to refute the reliability of this measure. A ceiling effect was reported by Stratford et al (1996), which has led to the suggestion that the questionnaire is best suited to populations with lower disability levels (Bombardier, 2000), such as non-surgical candidates. It has been used in several studies of both CLBP (Cherkin et al, 2001; Von Korff et al, 1998) and out patient physiotherapy (Burton et al, 2004; Stratford et al, 1996). The RDQ has also been used in studies investigating objective tests of physical performance (Magnussen et al, 2004; Al-Obaidi et al, 2003; Walsh et al, 2003; Cunha et al, 2002; Novy et al, 2002; Al-Obaidi et al, 2000; Simmonds et al, 1998; Simmonds and Claveau, 1997).

Measures of pain severity

The RDQ measures the effect of LBP on activities, but does not measure the severity of the pain itself, and therefore was used in conjunction with a pain measure in this study. This is in keeping with the recommendations on outcome measures for LBP research, which encourage the use of pain measurement in addition to measurement of disease-specific functioning/disability (Ehrlich, 2003; Bombardier, 2000; Deyo et al, 1998).

Pain intensity

Pain has come to be regarded as a multidimensional construct with two dimensions, intensity and affect, receiving much research attention in recent years (Elliott et al, 2003; Von Korff et al, 2000). The measurement of pain intensity is reasonably straightforward (Bombardier, 2000; Holroyd et al, 1996), whilst measurement of pain affect is less well understood (Bombardier, 2000). Pain intensity has frequently been measured in CLBP patients in previous research and by physiotherapists in clinical practice; Kirkness and Korner-Bitensky (2002) found pain intensity scales to be the most prevalent standardised outcome measure in use in their study of 60 physiotherapists in Canada.

There are three common methods of measuring pain intensity; verbal rating scales, visual analogue scales, and numerical rating scales. A verbal rating scale (VRS) consists of a series of verbal descriptors of pain (usually four or five) such as none, slight, moderate, severe, intense (White, 1998), with the subject marking the descriptor that best describes their pain (Burckhardt and Jones, 2003). A visual analogue scale (VAS) consists of a straight line of predetermined length, with the ends defined by descriptors of the extremes of the pain experience such as "no pain" and "pain as bad as it could be" (Jensen et al, 1986). The subject places a mark on the line at the point that best indicates their pain (Burckhardt and Jones, 2003). A numerical rating scale (NRS) is a VAS that is divided into (usually 11) scale points, with the subject choosing the point that represents their pain (Sim and Waterfield, 1997). The VAS has been used extensively in CLBP research (for example, Lang et al, 2003; Storheim et al, 2003) and is regarded as a valid and reliable method of pain measurement (Burckhardt and Jones, 2003; Roach et al, 1997; Ogon et al, 1996). However, it can pose problems for subjects with cognitive or perceptual difficulties, and it can be difficult for some subjects to conceptualise their pain experience to a point on a line, particularly when there is such wide choice as to where to place the point (Von Korff et al, 2000; Sim and Waterfield, 1997). For this reason, numerical scales may be easier for subjects to complete (Burckhardt and Jones, 2003; Sim and Waterfield, 1997). Verbal scales are seen less often in the CLBP literature (Von Korff et al, 2000). There can be problems with the interpretation of all three scales by both the subject and rater, and it must be clear to both parties whether present pain is being measured, or an average, worst or least pain over a recall period (Sim and Waterfield, 1997).

Global pain severity

As shown above, verbal, visual and numerical rating scales are relatively straightforward to use and have sound measurement properties. They have seen extensive use in CLBP research, particularly the VAS which is recommended for LBP patients by the WHO (Ehrlich et al, 2003). However, there are drawbacks, as discussed above. In addition, their unidimensional nature poses a problem in that pain experience is considered to be multidimensional, as previously discussed. Furthermore, it has been suggested that pain intensity and interference with activities can contribute to an underlying construct of pain, that of global pain severity (Von Korff et al 2000), and several questionnaires have been developed which relate to this construct (table 3.4.5). It was considered that the use of such a questionnaire would be more relevant in this study of CLBP subjects, since there are other dimensions of the chronic pain experience which may be as, or more, important to measure as intensity. The global pain severity instruments were therefore reviewed using the same criteria as for the back-specific instruments, in order to determine which was suitable for use in this study. Only measures that could be self-administered were reviewed, as this was a prerequisite for this study. For the same reason, only measures that could be completed at one point in time were reviewed. Therefore, Pain Diaries and the Pain Perception Profile (Tursky et al, 1982), which incorporates a pain diary, were outwith the scope of this review. The six measures identified and reviewed are presented in table (3.4.5).

Table 3.4.5: *Measures of pain severity in chronological order of original publication*

Measure	Author	Year	Self-administered	Time to complete (minutes)	Time to score	Validity	Reliability
McGill Pain Questionnaire	Melzack	1975	Yes	15-20 Short form 2-5	1-2 Short form 1	Good	Good
Brief Pain Inventory (BPI)	Daut et al	1983	Yes	15 Short form 5	Not stated in literature. Probably approx. 5	Good	Very good
Multidimensional Pain Inventory (MDPI)	Kerns et al	1985	Yes	5-10	5	Good	Good
SF-36 Bodily Pain Subscale	Ware and Sherbourne	1992	Yes	2	Not stated in literature. Probably 1-2	Good	Good
Graded Chronic Pain Scale	Von Korff et al	1992	Yes	Not stated in literature. Probably approx. 5	Not stated in literature. Probably 1-2	Good	Good
Glasgow Pain Questionnaire	Thomas et al	1996	Yes	Not stated in literature. Probably approx. 5	Not stated in literature. Probably 1-2	Good	Good

The review identified two possible measures that were of potential use in this study; the McGill Pain questionnaire and the BPI short form. The BPI however had been specifically validated on CLBP patients, and its twenty-four hour recall was considered advantageous in this study. The purpose was to investigate correlations of objective measurement with self-report of disability and pain severity. Clearly, to fulfil this aim, pain measurement had to reflect the patients' status at the time of testing. Due to the variable nature of chronic pain (Von Korff et al, 2000), pain "now" may not accurately reflect that status, and pain recall of a week or longer may also be inaccurate, since patients' status may have changed in that time period. Pain over the last twenty-four hours therefore seemed appropriate for this study. The BPI short form was therefore the chosen pain severity instrument for this study. Permission to use the BPI was granted by its developer (Appendix 15) and the form used is presented in Appendix 16. The properties of the BPI are presented below.

The BPI was designed to measure pain severity and interference with activities in cancer patients, and was originally called the Wisconsin Brief Pain Questionnaire (Daut et al, 1983). It measures severity with numeric scales relating to "pain now" and at its "worst", "least" and "average" over either the last week or twenty-four hours. The pain worst can be used as the primary variable or the ratings can be averaged to give a "composite index of pain severity" (Cleeland, 1991, p298). Numeric scales also measure how much pain interferes with mood, walking and other physical activities, work, social activities, relations with others, sleep and enjoyment of life. The average of these scales is used as a score of pain interference. In addition, the BPI incorporates a pain location diagram, fourteen questions relating to medication and other forms of pain-relief, perception of the cause of pain, and a group of adjectives describing the quality of pain. High levels of reliability were demonstrated in its development (McDowell and Newell, 1996). It reportedly takes fifteen minutes to complete (Cleeland, 1991a). However, there is a short-form available (Cleeland, 2004) which omits most of the pain-relief questions, the perception of cause question and the pain quality adjectives. Although originally developed for use with cancer patients, it has been used as an outcome measure in CLBP studies (Lang et al, 2003; Pharem et al, 2003;

Sculco et al, 2001). It's short-form version has been specifically validated on patients with non-malignant chronic pain by Keller et al (2004) and Tan et al (2004), both studies including a substantial number of CLBP subjects. Both studies reported high scale score reliabilities, with alpha coefficients similar to those reported for cancer patients by McDowell and Newell (1996). BPI scores correlated moderately to strongly with RDQ scores. Correlation coefficients for the severity and interference BPI scales were 0.40 and 0.57 (Tan et al, 2004) and 0.57 and 0.81 (Keller et al, 2004). Keller et al also reported correlation with the bodily pain subscale of the SF-36 generic health status questionnaire, with coefficients of 0.61 and 0.64 for the two respective BPI scales. Keller et al (2004) recruited subjects from primary care facilities, whilst Tan et al (2004) recruited from a chronic pain centre, which may explain the different results with respect to the RDQ, which is perhaps most suited to the less disabled subject, as previously discussed. The BPI therefore appears to be a useful tool for CLBP research. The brevity, ease of use, reliability and validity of the short-form in particular suggested that consideration of its use in this study was warranted. There is some overlap between the pain interference section of the BPI and the RDQ. However, there are also questions relating to relations with others and enjoyment of life, not specifically addressed by the RDQ, and thereby measuring different dimensions of interference with functioning. Together, the BPI and RDQ took approximately ten minutes to complete, thereby not unreasonably adding to the duration of the measurement session. In addition, both were completed without assistance, allowing the researcher to remain blind to their results until the objective measurement has taken place.

3.4.6: Location

All data collection took place in the human performance laboratory, The Robert Gordon University, Aberdeen. Subjects were reimbursed for travel expenses to attend this location.

3.4.7: Experimental procedure

Figure 3.4.9 displays the process of data collection. Each stage is described and justified.

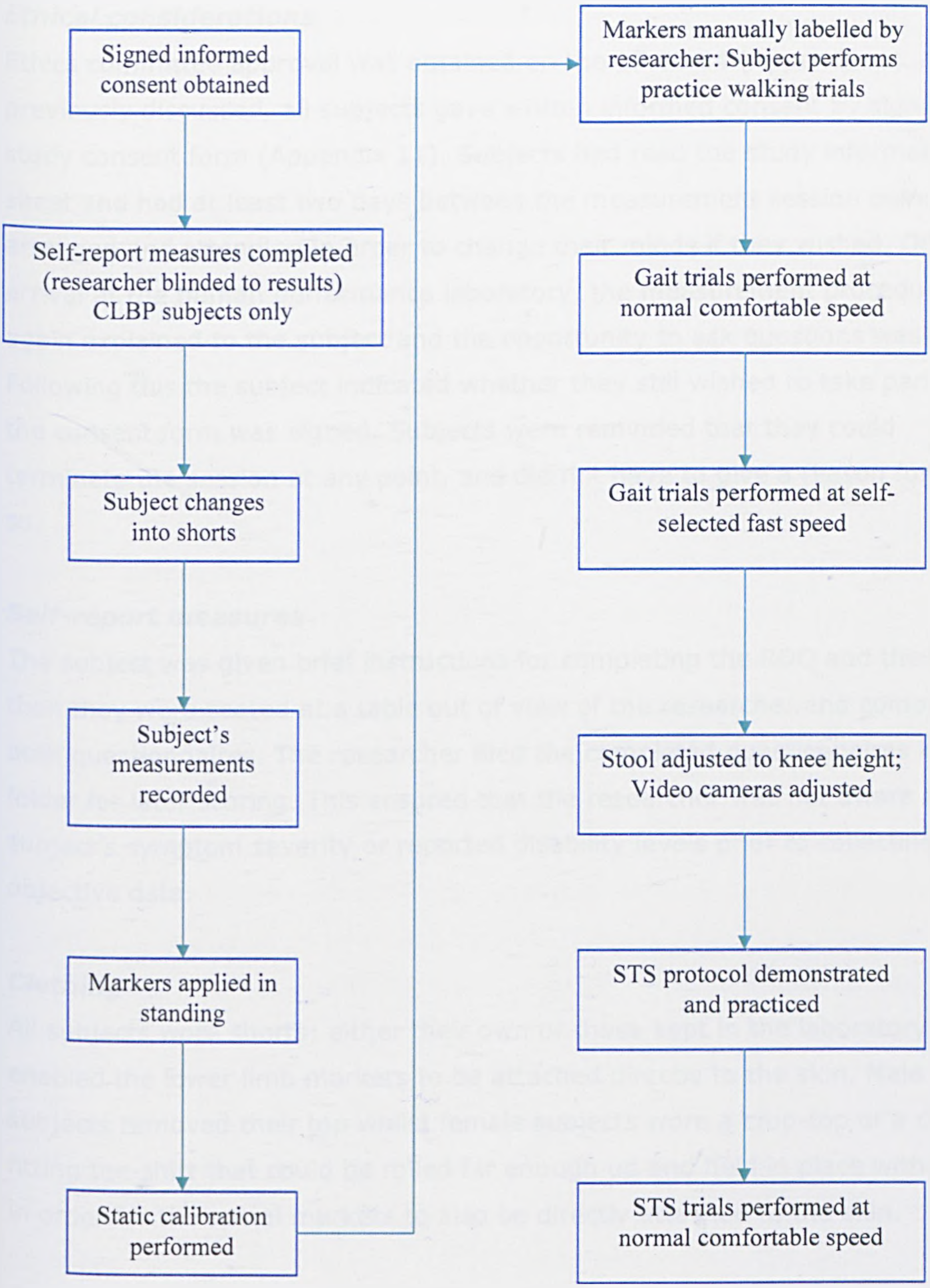


Figure 3.4.9: Flowchart of data collection protocol objective measurement study

Ethical considerations

Ethics committee approval was obtained on the 17.08.04 (Appendix 1). As previously discussed, all subjects gave written informed consent by signing the study consent form (Appendix 11). Subjects had read the study information sheet and had at least two days between the measurement session being arranged and attending in order to change their minds if they wished. On arrival at the human performance laboratory, the measurement procedure was again explained to the subject and the opportunity to ask questions was given. Following this the subject indicated whether they still wished to take part and the consent form was signed. Subjects were reminded that they could terminate the session at any point, and did not have to give a reason for doing so.

Self-report measures

The subject was given brief instructions for completing the RDQ and the BPI, then they were seated at a table out of view of the researcher and completed both questionnaires. The researcher filed the completed questionnaires in a folder for later scoring. This ensured that the researcher was not aware of the subject's symptom severity or reported disability levels prior to collecting the objective data.

Clothing

All subjects wore shorts; either their own or those kept in the laboratory. This enabled the lower limb markers to be attached directly to the skin. Male subjects removed their top whilst female subjects wore a crop-top or a close fitting tee-shirt that could be rolled far enough up and held in place with tape in order for the spinal markers to also be directly attached to the skin.

Subject measurements

The following measurements were recorded: Height (cm) using a stadiometer, weight (kg) using electronic scales, leg length (cm) measured from ASIS to medial malleolus performed in lying and measured with a standard tape-measure, and width of knee and ankle joints (cm) performed in lying using callipers. These were necessary for data analysis, since the Vicon software uses anthropometrics, ground reaction forces and segment-linked equations based on Euler transformation matrices to calculate torques and kinematics (Ramakrishnan and Kadaba, 1991).

Marker application

The lower limb markers were as described in pilot project 2 above (p245), and the spinal markers as described on page 243. All markers were attached with the subject in standing using hypoallergenic double-sided tape (Oxford motion systems, UK). The location of the spinous process of the first lumbar vertebra and the point midway between right and left PSIS were marked with a hypoallergenic black kohl pencil as discussed in the pilot study (p251).

Subject calibration

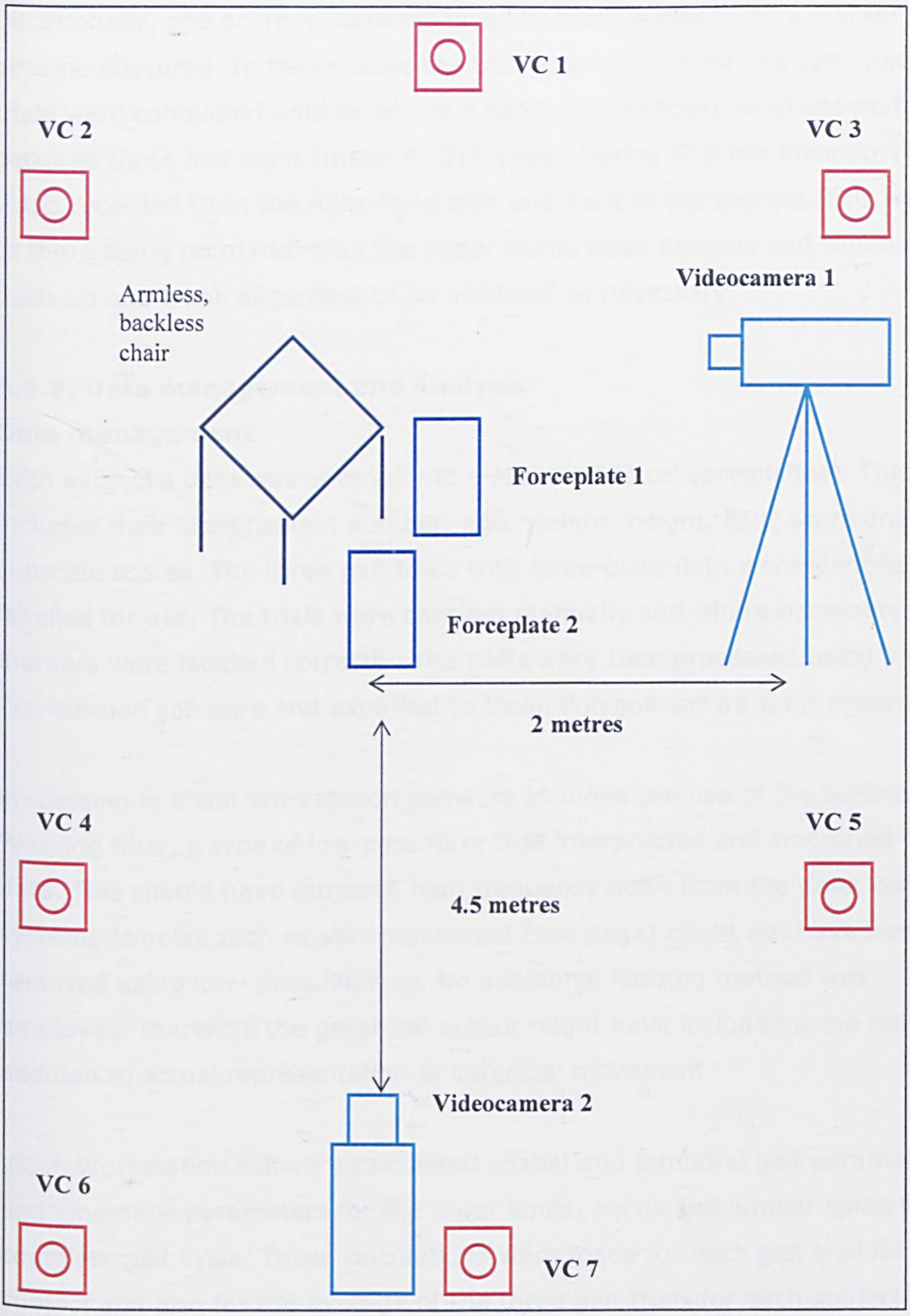
Static and dynamic calibration of the Vicon MX was performed using a standardised protocol (Vicon preparation manual) prior to each measurement session, approximately one hour before the subject arrived. Subject calibration involved the subject standing in the measurement volume, at a standardised location and direction, and capturing a static trial with the Vicon Workstation software. This took approximately one minute. Following this, the researcher manually labelled the markers using the Vicon Workstation software; this took approximately five minutes during which time the subjects accustomed themselves to walking at their normal speed with the markers attached.

Gait trials

The subject was asked to walk at their "normal, comfortable speed" from one end of the 12-metre walkway to the other. The subject's starting position was altered by the researcher to try to achieve "clean" foot strikes on the two force-plates (Kirtley, 2006, p88) in which the foot landed clearly within the force plate. This was in order for the force plate data to be used for the automatic calculation of the temporal and spatial parameters. However, the presence of the force-plates was not highlighted to the subjects. In each gait trial, data capture was commenced after the subject had completed three steps, in order for steady-state gait to be achieved (Miller and Verstraete, 1996). This ensured that the subject was not accelerating whilst their gait trial was being recorded. The process was repeated until three trials had been performed in which there was a clean foot strike on at least one force-plate, or until the subject tired or complained of pain. Fast gait followed the same procedure with the instruction "walk as fast as you can without beginning to run". Subjects performed between nine and 37 (mean 13) gait trials.

Sit to stand trials

Figure 3.4.10 illustrates the laboratory set-up for the STS trials. An armless, backless chair of the type used in several previous studies was used for the measurement of STS (Shum et al, 2005; Sibella et al, 2003). The chair was adjusted to knee height as done by Tully et al (2005), Coghlin and McFadyen (1994) and Roebroeck et al (1994). The chair was first placed in a standardised position, but slight adjustments were made to ensure that the subjects' feet were placed on the force-plates at the start of the STS manoeuvre. Subjects were instructed to sit in a comfortable position with the buttocks and upper half of the thighs supported (Shum et al, 2005). They placed one foot on each force-plate, but the feet did not have to be a certain distance apart or parallel, since the objective was to analyse as natural a STS manoeuvre as possible in this study. Due to pilot work detecting the possibility that the arms might obscure the ASIS markers, subjects were instructed to keep their arms by their sides or to push up from the chair but not to place their hands on their thighs when rising. Subjects were instructed to rise at their normal, comfortable speed then to stand still for five seconds before stepping off the force-plates. Due to previous work on STS in this laboratory detecting problems with data capture beginning with the feet on the force plates, data capture commenced with the subject standing next to the force-plates. Therefore on the instruction to commence, the subject sat down, found their comfortable starting position, maintained that position for a few seconds, stood at their normal speed, remained standing for five seconds then stepped off the force-plates at which point data capture was terminated. This was repeated three times.



Armless, backless chair was moved for each subject in order for one foot to be placed on each force-plate in subject's normal, comfortable sitting position. Videocamera one recorded movement in the frontal plane, videocamera two recorded movement in the sagittal plane. VC = Vicon Camera, mounted at a height of 2.1 metres, except VC 6 at a height of 1.5 metres.

Figure 3.4.10: Laboratory set-up for Sit-to-Stand analysis

Occasionally, one or more cameras failed to track marker/s or a marker became obscured. In these cases the trial was not kept for analysis; further trials were conducted until three trials had been collected. Subjects performed between three and eight (mean 4) STS trials. During STS the manoeuvre was video recorded from the right-hand side and front of the subject. This was due to there being no markers on the upper trunk, head or arms and would enable push-up and trunk alignment to be analysed as necessary.

3.4.8: Data management and analysis

Data management

Each subject's data was entered into a Microsoft Excel spreadsheet. This included their identification number, age, weight, height, RDQ score and BPI subscale scores. The three gait trials with force-plate data were identified and labelled for use. The trials were checked manually and where necessary markers were labelled correctly. The trials were then processed using Vicon Workstation software and exported to Vicon Polygon software for presentation.

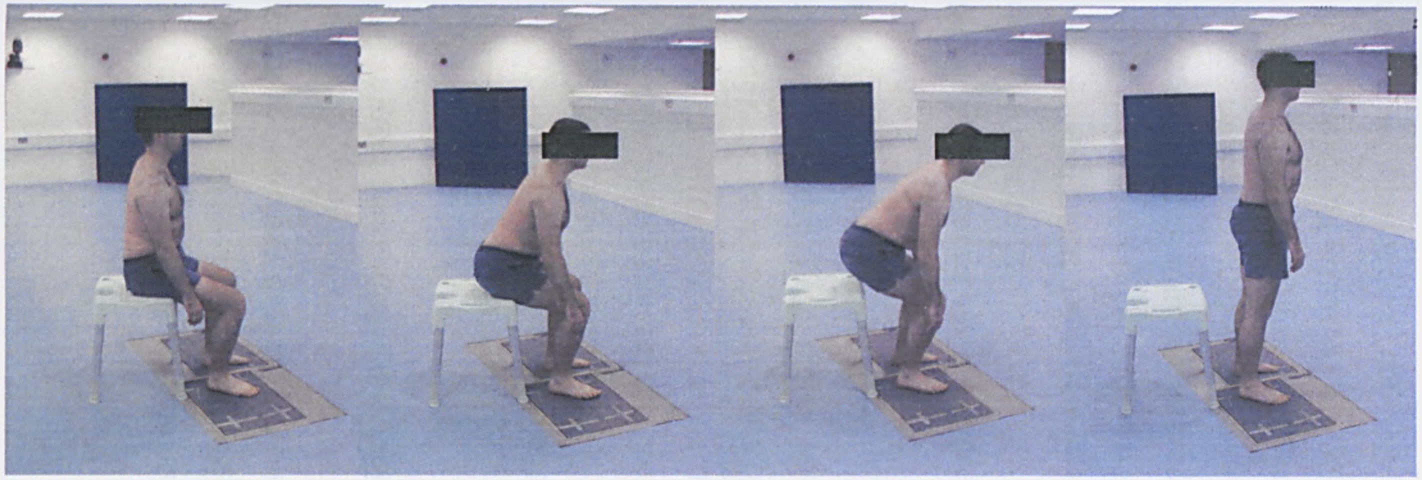
Processing in Vicon Workstation software included the use of the built-in Woltring filter, a type of low-pass filter that interpolated and smoothed the data. This should have removed high frequency noise from the data; however systematic noise such as skin movement (see page) might not have been removed using low- pass filtering. No additional filtering method was employed; therefore the graphical output might have included some noise in addition to actual representation of subjects' movement.

Vicon Workstation software calculated spatial and temporal gait parameters and kinematic parameters for the lower limbs, pelvis and lumbar spine for one complete gait cycle. These calculations were made for each gait trial for each subject and also for the average of the three gait trials for each subject. Each subject's average trial was then used to calculate the sample average (CLBP and control) for each parameter. All data was normalised to include 51 data points equally distributed throughout the gait cycle. All data was saved in a format that could be read into Microsoft Excel and SPSS for analysis and presentation in graphical format.

The STS trials were similarly checked for markers that required manual labelling and then processed using Vicon Workstation software. The beginning of STS was identified manually as the point at which movement (of any body part) began. Observing the Vicon Workstation and video data simultaneously identified this point and it was manually labelled in Vicon Workstation. The end of the STS trial was identified as an arbitrary point just prior to stepping off the force-plates; the true end-point was identified in Vicon Polygon software and is described below. Once the beginning and end of STS had been identified and the trials processed they were read into Vicon Polygon software as for the gait trials. Vicon Workstation software calculated lower limb, pelvic and lumbar kinematics normalised to 51 data points equally distributed throughout the STS cycle. The data was again saved in a format that could be read into Microsoft Excel and SPSS. This was performed for each STS trial for each subject, and as for gait each subject's average was calculated and used to calculate the sample average data. STS was analysed with reference to the phases identified by Schenkman et al (1990) and discussed in the literature review (section 3.2.3.1), therefore the phases required identification and Vicon Polygon software was used to do this. The end of phase I of STS, lift-off, was identified as the point at which the force vector first began to increase in a weight-bearing direction (Schenkman et al, 1990). The end of phase II was identified from the ankle dorsi/plantarflexion data; the point of maximum ankle dorsiflexion (Schenkman et al, 1990). The end of phase III was identified from the hip flexion/extension data as the point at which the hip ceased to extend (Schenkman et al, 1990). Phase IV was not analysed in this study in keeping with previous work on LBP (Coghlin and McFadyen,1994) due to the previously reported difficulties in identifying the end of this stabilisation phase (Schenkman et al 1990). Figure 3.4.11 illustrates the STS phases and their identification.

Vicon Workstation software did not automatically calculate the duration of the temporal parameters of STS, therefore these were manually calculated in the following way. Using the frame counter in Vicon Workstation and the knowledge that data was captured at a rate of 60Hz it was possible to calculate the time in seconds from the start of STS identified as described above and the arbitrary end point. This resulted in a time for the whole data capture. Using the graphs in Vicon Polygon and the procedure for identifying the phases described above it was possible to identify the percentage of the whole data capture period that each of the three phases accounted for. Therefore, the time in seconds was calculated for each phase and the total of these three phases was the "new" total STS time, since phase IV was redundant in this study. This information was entered into a Microsoft Excel spreadsheet and the percentage (of the "new" total time) that each of the three phases accounted for was calculated. Microsoft Excel was then used to display graphs of the STS data.

Figure 3.4.11: *Sit to Stand phases and points used to identify them*



Start phase I Point at which movement begins	End phase I "Lift-off" Force vector first increases in weight-bearing direction	End phase II Maximum ankle dorsiflexion	End phase III Hips cease to extend

Data analysis

Sample: Descriptive statistics

Age, weight and height data for each sample (CLBP and control) were tested for normality using Shapiro Wilks test with an α level of 0.05. This tests the null hypothesis that the sample is from a population with a normal distribution and therefore provides an objective test of normality (Petrie and Sabin, 2005). The results of the Shapiro Wilks tests were used to determine which statistics were reported for the central tendency of the data. Shapiro Wilks tests were similarly performed on all variables in this study prior to deciding on the appropriate measures of central tendency and statistical tests to use. For those from a normal distribution (non-significant Shapiro Wilks) the mean and standard deviation (SD) was reported; for those from a non-normal distribution (significant Shapiro Wilks) the median and interquartile range (IQR) was reported. RDQ and BPI subscale scores were from nominal scales (Bland, 2000) and therefore the median and IQR were the appropriate measures of central tendency for these variables. All statistical tests were performed using SPSS 14, as for all the remaining tests to be described in this section. The distribution of RDQ and BPI subscale scores within the CLBP sample were illustrated using bar graphs constructed using Microsoft Excel.

Sample: Inferential statistics

Differences between the samples were tested for statistical significance with either independent samples t-tests (data from normal distribution) or Mann-Whitney U tests (data from non-normal distribution). This was appropriate since the difference between two means/medians was being tested and data from a non-normal distribution should be tested with a non-parametric test (Bland, 2000). All tests were performed with an α level of 0.05, as for all other tests described.

Repeatability: Spatial and temporal parameters

The Coefficient of variation (CV) statistic was used as a calculation of repeatability, and was defined as the standard deviation (SD) divided by the mean, expressed as a percentage (Bland, 2000). This statistic was chosen since it has been used in previous studies on repeatability of gait using three-dimensional measurement systems (Kadaba et al, 1989; Growney et al, 1997), and would therefore allow for comparisons to previous work to be made. The CV was calculated for each parameter for each subject and a sample average CV was subsequently calculated for each sample (CLBP and control). Between sample differences in CV were tested for statistical significance using t-tests or Mann-Whitney U tests.

Repeatability: spinal kinematics gait

Previous authors have analysed the similarity between two or more waveforms using the coefficient of multiple correlation (CMC, Kadaba et al, 1989; Growney et al, 1997). However, this statistic indicates whether the waveforms as a whole are different and does not indicate at which point in the waveform any differences lie. Therefore, the first step in this study was to visually inspect graphs for each subject with kinematic traces of the three gait trials plotted together. These were created using Microsoft Excel. The CV statistic was also calculated for the joint range (maximum angle minus minimum angle) for each subject and subsequently each sample's average CV was calculated for pelvic and spinal flexion/extension, side flexion and rotation. Between group differences were tested as described for spatial and temporal parameters.

Repeatability: Temporal parameters STS

The CV statistic was calculated for the overall timing of STS for each subject and for each sample, and differences tested for statistical significance as described above.

Repeatability: Spinal kinematics STS

As for gait, graphs were plotted displaying the STS traces for each subject. The CV statistic for each joint range was also calculated for each subject and sample.

Between-sample differences: spatial and temporal parameters gait

Changes in each parameter between normal and fast walking speed for each sample were tested for statistical significance using either paired t-tests (normally distributed data) or Wilcoxon matched pairs tests (non-normally distributed data). The data in this case was related since the same subjects were tested under two different conditions; normal and fast walking speed. Between-sample differences were tested for statistical significance using either independent samples t-tests (normally distributed data) or Mann-Whitney U tests (non-normally distributed data). This was relevant since the data was from two unrelated samples. Tests were carried out for differences between the samples at slow speed and at fast walking speed. Clearly a number of statistical tests were being performed on the data. It has been suggested that this increases the likelihood of a type I error (deciding against a true null hypothesis, Bland, 2000), and that the α level should be adjusted accordingly, for example using a Bonferroni correction (Bland and Altman, 1995). However, this can increase the likelihood of a type II error, failing to reject a false null hypothesis, and it has been suggested that the possible interpretations of each statistical test should be individually considered without applying adjustments (Perneger, 1998). Therefore, in this study all tests were treated as individual experiments and carried out at $\alpha=0.05$.

Between-sample differences: spinal kinematics gait

Graphs of kinematics were plotted using Microsoft Excel displaying sample mean and SD traces. Graphs displaying both samples were then visually inspected for differences in kinematic traces. Graphs displaying mean traces for one sample at normal and fast speed were also plotted to illustrate the effect of speed on kinematics. Joint ranges were calculated for pelvic and lumbar kinematics. As for the spatial and temporal parameters, the same paired tests were used to detect statistically significant differences within samples between the two speeds of walking, and the same unpaired tests were used to detect statistically significant differences between the samples for each pelvic and lumbar kinematic parameter.

Between sample differences: Temporal parameters STS

Statistically significant differences in overall timing and the timing of each STS phase were tested for using either independent samples t-tests (normally distributed data) or Mann-Whitney U tests (non-normally distributed data).

Between sample differences: Pelvic and lumbar kinematics STS

Mean kinematic traces were plotted using Microsoft Excel. In addition, mean starting position, end position, peak flexion and joint range was calculated in the sagittal plane (flexion/extension) for the lumbar spine, pelvis and hips. This allowed for comparison to previous research on normal subjects (Tully et al, 2005) and those with acute LBP (Shum et al, 2005). Frontal plane (side flexion) and transverse plane (rotation) kinematic ranges were also calculated for the pelvis and lumbar spine, as described for gait above. Differences in these variables were tested for statistical significance using either unpaired t-tests or Mann-Whitney U tests, as described for all other variables. Finally for STS the video data was visually analysed to detect the number of subjects who used their arms for push-up and for any variation in STS strategies used by the subjects.

Relationship between objective parameters and self-report

Any of the parameters described above that demonstrated statistically significant between-group differences were tested for their strength of association with RDQ and BPI subscale scores. Because the RDQ and BPI produced ordinal data a non-parametric correlation coefficient was the appropriate test to use (Bland, 2000); therefore Spearman's rank correlation coefficients were calculated for the relevant variables, the alpha level as for all other tests was set at 0.05.

Section 3.5 presents the results obtained using the methods outlined above. The results for repeatability are presented first, followed by the results for between-sample differences and finally correlations between the objective parameters and CLBP patients' self-report.

3.5 Results

3.5.1. Sample descriptives

Twenty controls (2 males, 18 females) and seventeen CLBP patients (7 males, 10 females) provided informed consent and took part in the study. Their characteristics are displayed in tables 3.5.1 and 3.5.2. For the CLBP sample, table 3.5.2 also displays the scores for the Roland Morris Disability Questionnaire (RDQ) and each of the four subscales of the Brief Pain Inventory (BPI): BPI "worst", BPI "mean", BPI "interference" and BPI "now". The CLBP sample was older than the control sample, with mean ages of 48 and 33 respectively. The age range was 29 to 64 for the CLBP sample and 19 to 54 for the control sample. The CLBP sample was also an average of 9.82 kg heavier and 1.83cm taller than the control sample. These differences were tested for statistical significance using two-tailed independent samples t-tests Table 3.5.3 demonstrates that there was a statistically significant difference in the mean age ($p<0.001$) between the two groups of subjects, but not in the weight or height.

Table 3.5.1: Control sample characteristics, objective measurement study

Subject	Gender	Age (years)	Weight (kg)	Height (cm)
1	Male	26	75.3	181.5
2	Female	21	73	164
3	Female	36	56.4	169
4	Female	19	59.5	155
5	Female	20	57.8	168.5
6	Female	21	61.7	176
7**	Female	28	63.9	175
8**	Female	34	75	169
9	Female	38	60.6	165
10	Female	24	71.8	175.5
11*	Female	49	53.1	151.5
12**	Female	26	71.4	163.5
13*	Female	45	67.4	169
14	Female	36	60	165.5
15**	Female	54	57.3	155
16	Female	43	94	174
17	Male	27	76.6	165.5
18	Female	26	63	155.5
19	Female	43	106.2	158.5
20	Female	40	61.3	177
Mean		**33**	**68.3**	**166.7**
SD		**10**	**13.1**	**8.4**

Key: SD = Standard Deviation, * = excluded from STS analysis, ** = excluded from STS kinematics analysis

Table 3.5.2: *Chronic Low Back Pain sample characteristics objective measurement study, Roland Morris Disability Questionnaire scores and Brief Pain Inventory subscale scores*

Subject	**Gender**	**Age (years)**	**Weight (kg)**	**Height (cm)**	**Symptoms**	**RDQ**	**BPI "Worst"**	**BPI "Mean"**	**BPI "Interference"**	**BPI "Now"**
1	Male	60	80.6	169	L LBP+L Calf pain	6	4	2	3	2
2	Female	50	83	170	R LBP	15	6	4	3	5
3	Male	42	134.4	182	Central LBP	5	5	3	1	2
4	Male	57	107.4	179	Central LBP+L Calf pain	10	4	3	4	2
5	Male	38	93.6	188	Central LBP +R&L Thigh pain	3	2	1	1	1
6	Female	63	56.2	162.0	R LBP	0	2	1	0	1
7	Female	41	56.9	164.5	L LBP+L Leg pain	5	6	4	2	4
8	Female	29	78.6	164	Central LBP	7	6	3	2	2
9**	Female	41	55.3	162.5	R LBP	5	3	2	1	1
10	Female	59	50.6	148.5	R LBP+R Leg pain	5	0	0	0	0
11	Female	61	69.7	155	Bilateral LBP +R&L Calf pain	11	4	3	2	3
12	Female	55	60.3	164	Bilateral LBP	1	3	2	0	1
13**	Male	39	85.4	177.5	Central LBP	9	7	3	5	0
14*	Male	46	110.6	177	R LBP	5	5	4	3	3
15	Male	31	68.9	182.5	Bilateral LBP	4	5	5	2	5
16	Female	45	66.1	164	R LBP	5	2	1	1	1
17	Female	64	69.8	155	Bilateral LBP	13	6	4	3	3
Mean		**48**	**78.1**	**168.5**	**Median**	**5**	**4**	**3**	**2**	**2**
SD		**11**	**22.8**	**11.0**	**Interquartile Range**	**5 to 10**	**3 to 6**	**2 to 4**	**1 to 3**	**1 to 3**

Key: RDQ = Roland Morris Low Back Pain Disability Questionnaire score, BPI=Brief Pain Inventory subscale score, L=left, R=right, LBP=Low Back Pain, Central=pain located over vertebrae, Bilateral pain=pain that radiates from vertebrae to both left and right paraspinal muscles or beyond,
SD = Standard Deviation, * = excluded from STS analysis, ** = excluded from STS kinematic analysis

Table 3.5.3: Results of t-tests for mean age, weight and height, n=37

Characteristic	Mean difference (control-CLBP)	SE difference	t-statistic (df)	p-value
Age (years)	-15.5	3.6	-4.339 (35)	<0.001
Weight (kg)	-9.82	6.3	-1.571 (35)	0.129
Height (cm)	-1.83	3.2	-0.570 (35)	0.572

Key: SE = Standard Error, df =degrees of freedom

The CLBP sample reported mild to moderate disability and symptom severity (table 3.5.2). The median score for the RDQ was five out of a possible 24 (IQR 5 to10). The median BPI scores for the "worst", "mean", "interference" and "now" subscales were four (IQR 3 to 6), three (IQR 2 to 4), two (IQR 1 to3), and two (IQR 1 to 3) out of a possible ten respectively. The distribution of scores is illustrated in figures 3.5.1 and 3.5.2.

Eleven of the seventeen CLBP subjects reported LBP only; the remaining six reported LBP with leg pain. Both legs were affected in two cases, the left leg only was affected in a further three cases, and the right leg only in one.

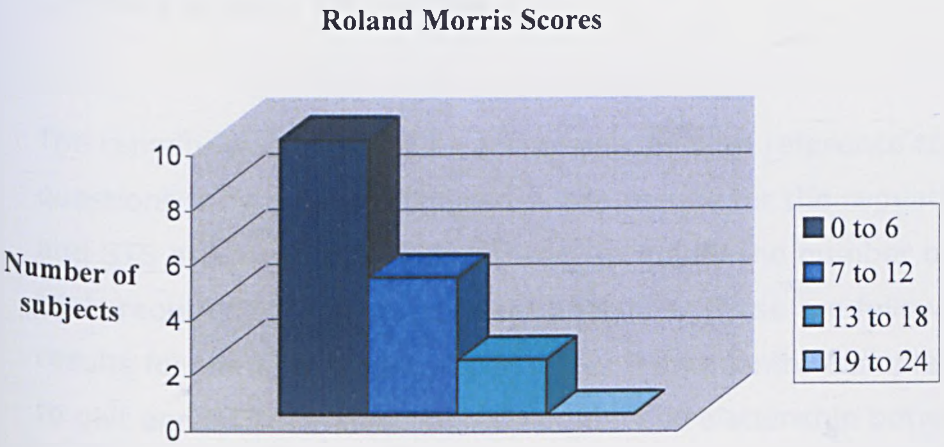
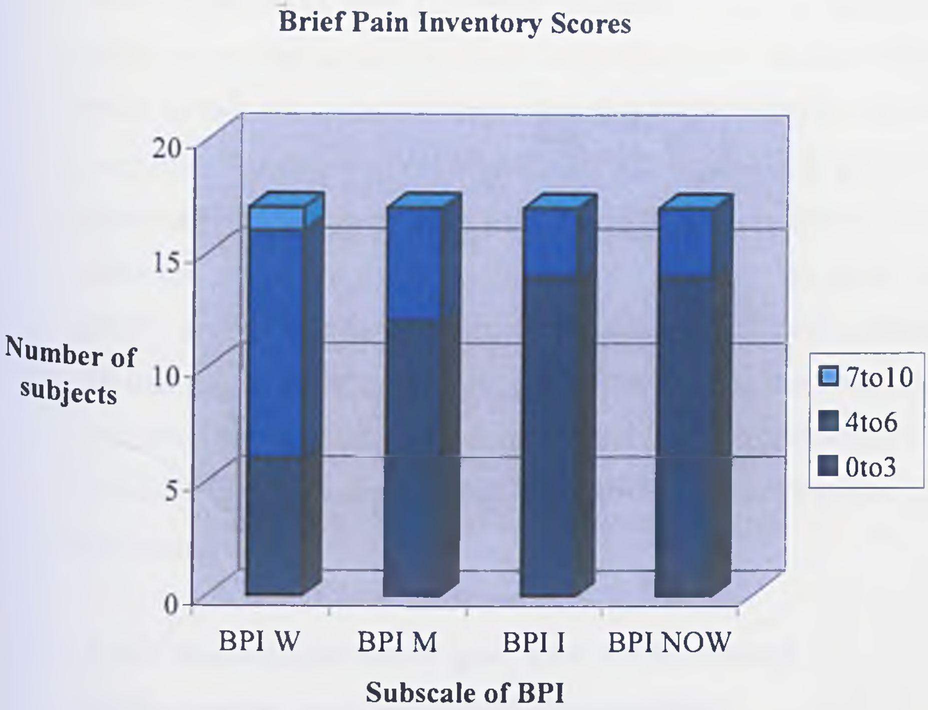


Figure 3.5.1: Roland Morris Disability Questionnaire: Score distribution in Chronic Low Back Pain sample



Key: BPI W= BPI "worst" subscale, BPI M= BPI "mean" subscale, BPI I= BPI "interference" subscale, BPI NOW= BPI "now" subscale.

Figure 3.5.2: Brief Pain Inventory: Distribution of subscale scores in Chronic Low Back Pain sample

The remainder of the results are presented with reference to the research questions they refer to. Therefore, the results for the repeatability of gait and STS are presented first, in order to justify the number of gait and STS trials required for the subsequent analyses. These are followed by the results for the differences between CLBP and control samples with respect to gait and STS. Finally, the results for the relationship between gait and STS and the self-report measures are presented. The research questions relating to the suitability of analysis of gait and STS with CLBP patients are addressed in section 3.6.

The data for all subjects in tables 3.5.1 and 3.5.2 were used in the analysis of gait. However, some subjects had incomplete data or insufficient trials of acceptable quality for inclusion in the analysis of STS. This was due to the failure of one or more makers, usually the right or left ASIS on the pelvis, to be tracked during the entire STS manoeuvre, and may have been related to the position of the cameras on the laboratory walls. The reasons for and limitations of this are discussed in full in section 3.6. For the control group, two subjects (11 and 13) were excluded from temporal and kinematic analysis, whilst a further four subjects (7, 8, 12 and 15) were excluded from kinematic analysis only. For the CLBP sample, one subject (14) was excluded from temporal and kinematic analysis and two (9 and13) from kinematic analysis only. A further two CLBP subjects (3 and 11) had missing data for pelvic rotation during STS but otherwise good quality data for other pelvic and spinal kinematics; they were therefore included in the analysis of all but pelvic rotation during STS. Therefore, the data from all 37 subjects is reported for spatial, temporal and kinematic gait analysis. For STS, the data from 34 subjects is reported for temporal analysis and 28 for kinematic analysis.

3.5.2 Repeatability of gait and Sit to Stand

Gait: Spatial and temporal parameters

Tables 3.5.4 and 3.5.5 display the sample average coefficient of variation (CV) found for each spatial and temporal parameter for the CLBP and control samples at normal and fast speeds respectively. The individual CV values for each subject are available in appendix 17.

Tables 3.5.4 and 3.5.5 display that all sample average CV values were below 15% with most being below 5%. Double support appeared consistently less repeatable than the other gait parameters across both groups of subjects. At self-selected normal walking speed the CLBP sample displayed CV values up to 2.9% greater than the control sample for eleven of the fifteen parameters. However, there was only a statistically significant difference for left single support (median difference 2%, $p<0.05$). Conversely, at self-selected fast walking speed the CLBP sample displayed CV values up to 2.8% lower than the control sample for thirteen of the fifteen parameters. Statistically significant between-group differences were detected for left single support (median difference 2.7%, $p<0.05$) and cadence (median difference 0.6, $p<0.05$).

Table 3.5.4: Repeatability of the spatial and temporal parameters of gait displayed as sample average Coefficient of Variation (%) for control and CLBP samples walking at self-selected normal speed.

Parameter	Control		CLBP		Test used	p-value
	Mean/ median	SD/IQR	Mean/ median	SD/IQR		
Cadence	1.4	0.8 to 3.7	2.1	1.6 to 3.3	M-W U	0.474
Left stride time	1.8	1.2 to 3.5	2.4	1.5 to 2.8	M-W U	0.532
Right stride time	2.3	1.3 to 3.3	2.1	1.0 to 3.2	M-W U	0.655
Left step time	3.0	2.0 to 4.7	5.1	2.7 to 6.7	M-W U	0.113
Right step time	2.6	1.7 to 3 8	3.6	2.2 to 6.8	M-W U	0.166
Left Single Support	**2.7**	**2.2 to 4.6**	**4.7**	**3.3 to 8.7**	**M-W U**	**0.024**
Right Single Support	3.9	2.1 to 7.5	3.5	2.9 to 5.5	M-W U	0.831
Double Support	5.4	4.1 to 12.9	8.3	5.6 to 12 9	M-W U	0.273
Left stance (foot off)	3.0	1.5	2.7	1.1	t-test	0.508
Right stance (foot off)	1.5	1.0 to 2.8	3.1	1.8 to 5.7	M-W U	0.070
Left stride length	2.2	1.7 to 3.5	2.4	1.9 to 4.1	M-W U	0.532
Right stride length	2.2	1.3 to 3.8	2.2	1.6 to 4.3	M-W U	0.522
Left step length	2.4	1.8 to 3.1	3.5	2.3 to 5.6	M-W U	0.082
Right step length	2.9	1.6	3.8	2.5	t-test	0.166
Speed	3.4	2.1 to 5.4	3.8	2.5 to 7.2	M-W U	0.377

Key: SD = Standard Deviation, IQR = Interquartile Range, M-W U = Mann-Whitney U test
Mean and Standard deviation (SD) and t-test results reported for normally distributed data.
Median and interquartile range (IQR) and results of Mann-Whitney U tests (MW-U) reported for non-normally distributed data.

Table 3.5.5: Repeatability of the spatial and temporal parameters of gait displayed as sample average Coefficient of Variation (%) for control and CLBP samples walking at self-selected fast speed.

Parameter	Control		CLBP		Test used	p-value
	Mean/ median	SD/IQR	Mean/ median	SD/IQR		
Cadence	**2.1**	**1.9 to 3.0**	**1.5**	**0.8 to 2.4**	**M-W U**	**0.028**
Left stride time	2.6	1.7 to 3.5	1.5	1.0 to 2.4	M-W U	0.085
Right stride time	2.5	1.9 to 3.2	2.1	1.1 to 2.7	M-W U	0.059
Left step time	5.1	3.5 to 8.2	3.2	2.1 to 5.5	M-W U	0.117
Right step time	5.4	2.3 to 7.6	3.7	1.9 to 4.6	M-W U	0.293
Left SS	**5.1**	**2.6 to 7.6**	**2.4**	**2.0 to 5.1**	**M-W U**	**0.020**
Right SS	4.8	3.1 to 7.8	3.1	1.5 to 4.3	M-W U	0.110
Double Support	14.5	9.2	11.7	7.8	t-test	0.331
Left stance (foot off)	2.3	1.4 to 4.2	2.1	1.5 to 2.7	M-W U	0.557
Right stance (foot off)	2.7	1.6 to 4.8	2.0	1.2 to 3.5	M-W U	0.211
Left stride length	2.2	1.2 to 3.0	1.5	1.2 to 3.4	M-W U	0.851
Right stride length	2.3	1.3 to 4.0	1.5	1.2 to 3.3	M-W U	0.593
Left step length	2.6	1.4 to 4.2	2.8	1.6 to 3.7	M-W U	0.845
Right step length	2.7	1.4 to 3.7	2.5	1.7 to 4.2	M-W U	0.988
Speed	2.9	1.6 to 4.9	2.9	1.8 to 4.4	M-W U	0.792

Key: SD = Standard Deviation, IQR = Interquartile Range, M-W U = Mann-Whitney U test
Mean and Standard deviation (SD) and t-test results reported for normally distributed data.
Median and interquartile range (IQR) and results of Mann-Whitney U tests MW-U) reported for non-normally distributed data

The effect of increased speed on the repeatability of spatial and temporal parameters was as follows. The control sample demonstrated statistically significant 9 to 14% increases in average CV values for left and right step times and double support (p=0.023, 0.029, 0.032 respectively). However, the CLBP sample demonstrated a statistically significant 2.3% reduction in average CV value for left single support (p=0.031).

Gait: spinal kinematics

Figures 3.5.3 to 3.5.8 on pages 276 to 281 illustrate for CLBP subject one to CLBP subject 17 the repeatability of spinal and pelvic kinematics during the three gait trials at both normal and fast speeds. For simplicity, only the CLBP sample's graphs are presented here, since visual inspection of the kinematic graphs for the control sample did not reveal significant between group differences. The control sample's graphs are available in Appendix 18.

The graphs demonstrate typical traces for pelvic kinematics, and several oscillations per gait cycle for lumbar spinal kinematics, with lumbar flexion/extension demonstrating the greatest number of (small) oscillations.

The sample average CV values for pelvic and spinal joint range of motion (ROM; maximum angle minus minimum angle) for normal and fast speeds are displayed in tables 3.5.6 and 3.5.7. The individual CV values, which ranged from 0 to 60.9% (control) and 0 to 35.3% (CLBP), are available in appendix 19. The CV values for joint ROM were mostly over 10%, in contrast to those for the spatial and temporal parameters which were mostly less than 5%, suggesting that spinal kinematics are less reproducible between three trials on the same day than the spatial and temporal parameters. The CLBP sample displayed a statistically significantly increased CV value for spine side flexion compared to the control sample at slow speed (median difference 4.5%, p<0.05). At fast speed the CLBP sample displayed a statistically significantly decreased CV value for pelvic rotation (median difference 6.5%, p<0.05) compared with the control sample. There were no statistically significant differences in the CV values of the control sample for normal compared to fast walking speed (p>0.05). However, the CLBP sample demonstrated a statistically significant 8.8% reduction in the CV value for spine side flexion at fast speed (p=0.003). Due to the reduced repeatability of spinal kinematics compared to the spatial and temporal parameters, the average of all three trials for each subject was used in the subsequent comparative analyses, since it would have been difficult to select one "typical" trial.

Table 3.5.6: Repeatability of spinal and pelvic range of motion during gait at normal speed displayed as sample average Coefficient of Variation (%), control and chronic low back pain samples

Range	**Control**		**CLBP**		**Test used**	**p-value**
	Mean/ median	**SD/IQR**	**Mean/ median**	**SD/IQR**		
Spine F/E	14.8	8.2	13.2	9.9	t-test	0.393
Spine Side flexion	**10.7**	**7.0 to 14.8**	**15.2**	**11.4 to 17.7**	**M-W U**	**0.024**
Spine Rotation	7.2	5.2 to 11.2	11.7	3.9 to 15.3	M-W U	0.573
Pelvis F/E	16.5	8.8	14.6	8.4	t-test	0.507
Pelvis Side flexion	7.6	5.3 to 13 6	12.8	11 to 16.4	M-W U	0.088
Pelvis Rotation	16.3	11.6 to 21.5	11.5	9.5 to 19.4	M-W U	0.235

Key: F/E = Flexion/Extension, SD = Standard Deviation, IQR = Interquartile Range, M-W U = Mann-Whitney U test

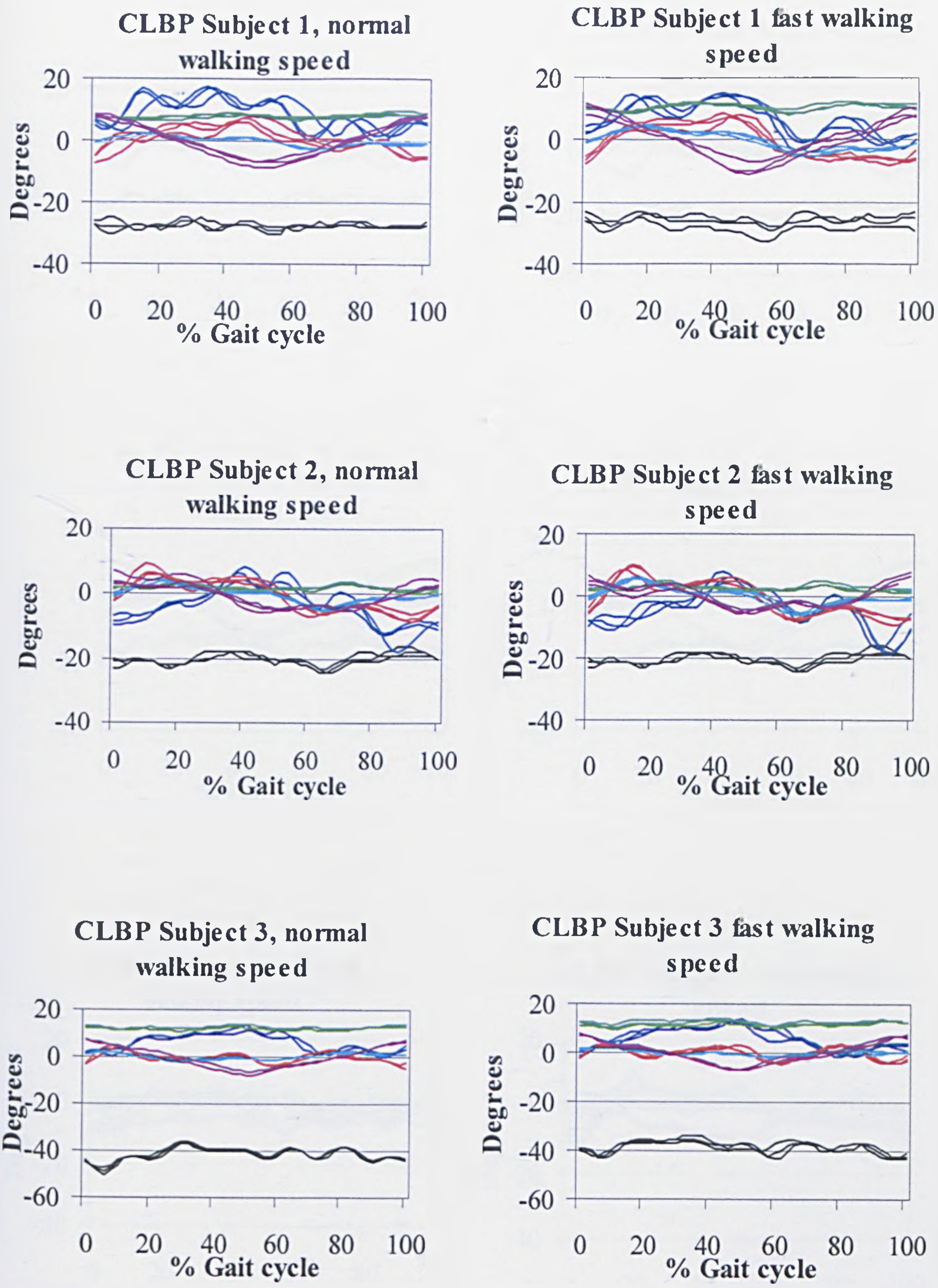
Repeatability displayed as Coefficient of variation (%), n=37. Mean and Standard deviation (SD) and t-test results reported for normally distributed data. Median and interquartile range (IQR) and results of Mann-Whitney U tests (MW-U) reported for non-normally distributed data.

Table 3.5.7: Repeatability of spinal and pelvic range of motion during gait at fast speed displayed as sample average Coefficient of Variation (%), control and chronic low back pain samples

Range	**Control**		**CLBP**		**Test used**	**p-value**
	Mean/ median	**SD/IQR**	**Mean/ median**	**SD/IQR**		
Spine F/E	14.6	8.7	15.2	8.6	t-test	0.835
Spine Side flexion	13.9	10.9 to 15.9	8.8	6.1 to 12.0	M-W U	0.411
Spine Rotation	11.8	5.9	9.1	5.1	t-test	0.145
Pelvis F/E	16.0	8 to 26.6	12.9	7.8 to 20.6	M-W U	0.373
Pelvis Side flexion	7.6	5.0	10.3	7.7	t-test	0.210
Pelvis Rotation	**13.6**	**7.7 to 17.2**	**7.1**	**4.8 to 12.8**	**M-W U**	**0.041**

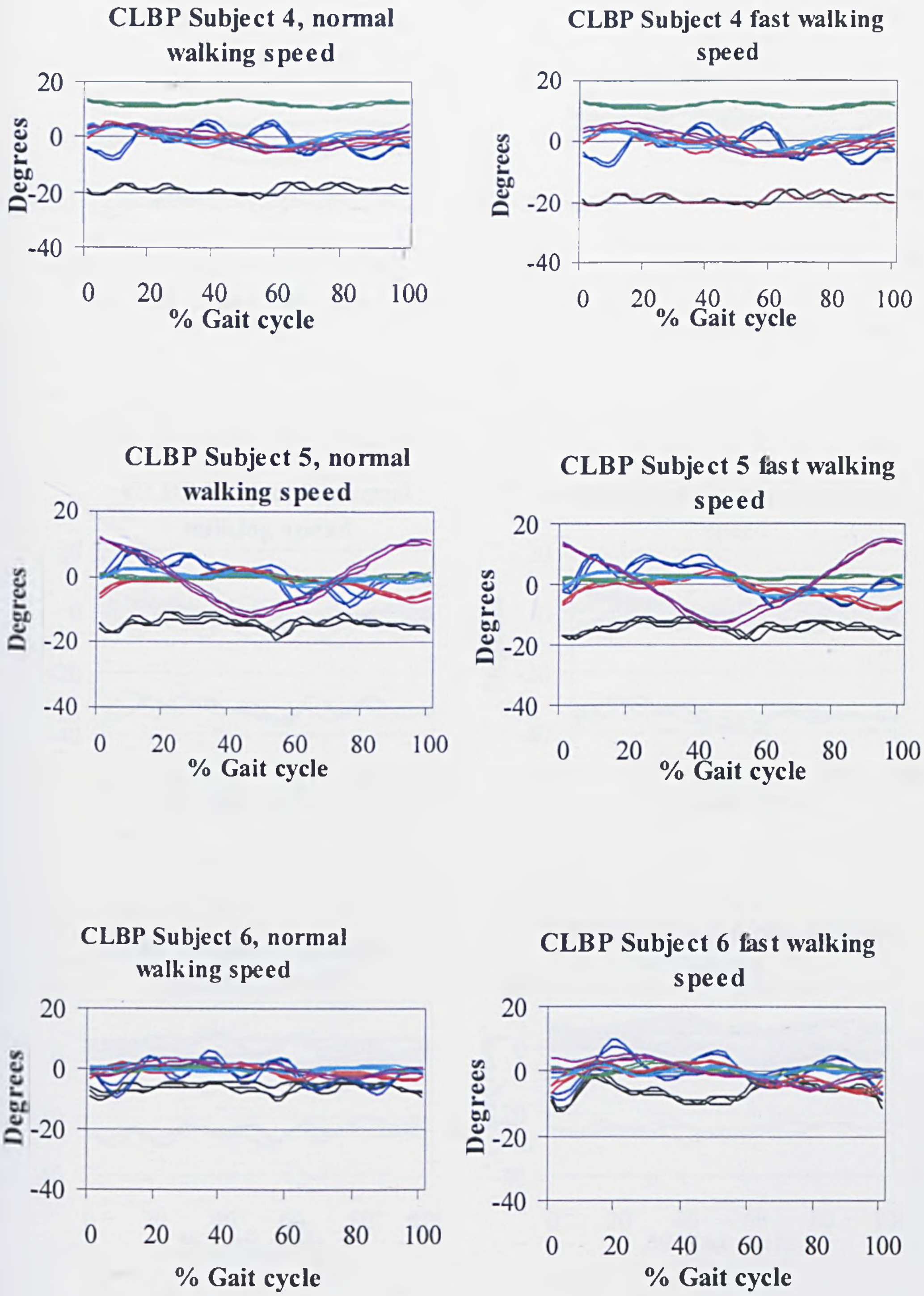
Key: F/E = Flexion/Extension, SD = Standard Deviation, IQR = Interquartile Range, M-W U = Mann-Whitney U test

Repeatability displayed as Coefficient of variation (%), n=37. Mean and Standard deviation (SD) and t-test results reported for normally distributed data. Median and interquartile range (IQR) and results of Mann-Whitney U tests (MW-U) reported for non-normally distributed data.



Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension, Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.3: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 1 to 3


CLBP Subject 4, normal walking speed

CLBP Subject 4 fast walking speed

CLBP Subject 5, normal walking speed

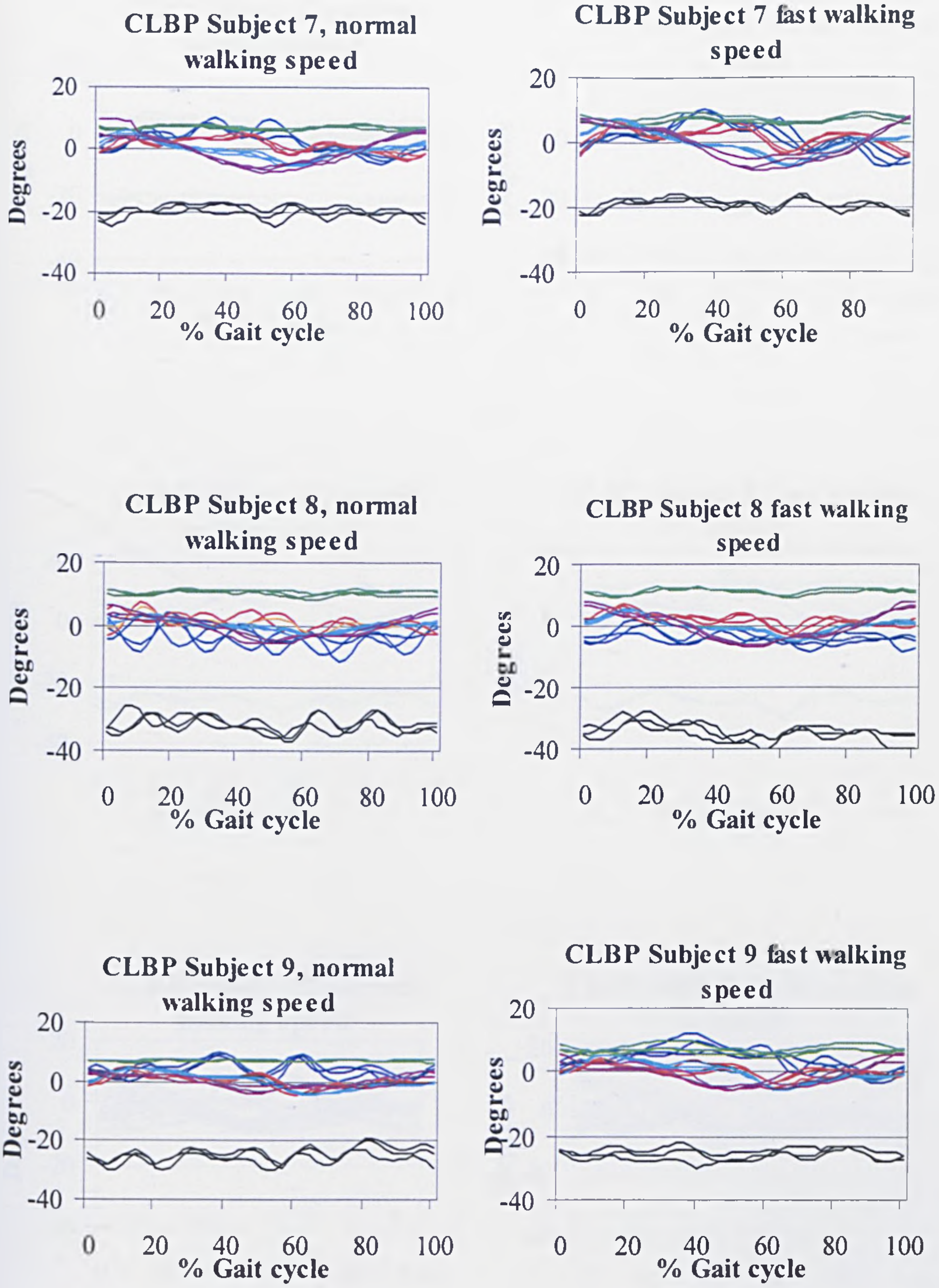
CLBP Subject 5 fast walking speed

CLBP Subject 6, normal walking speed

CLBP Subject 6 fast walking speed

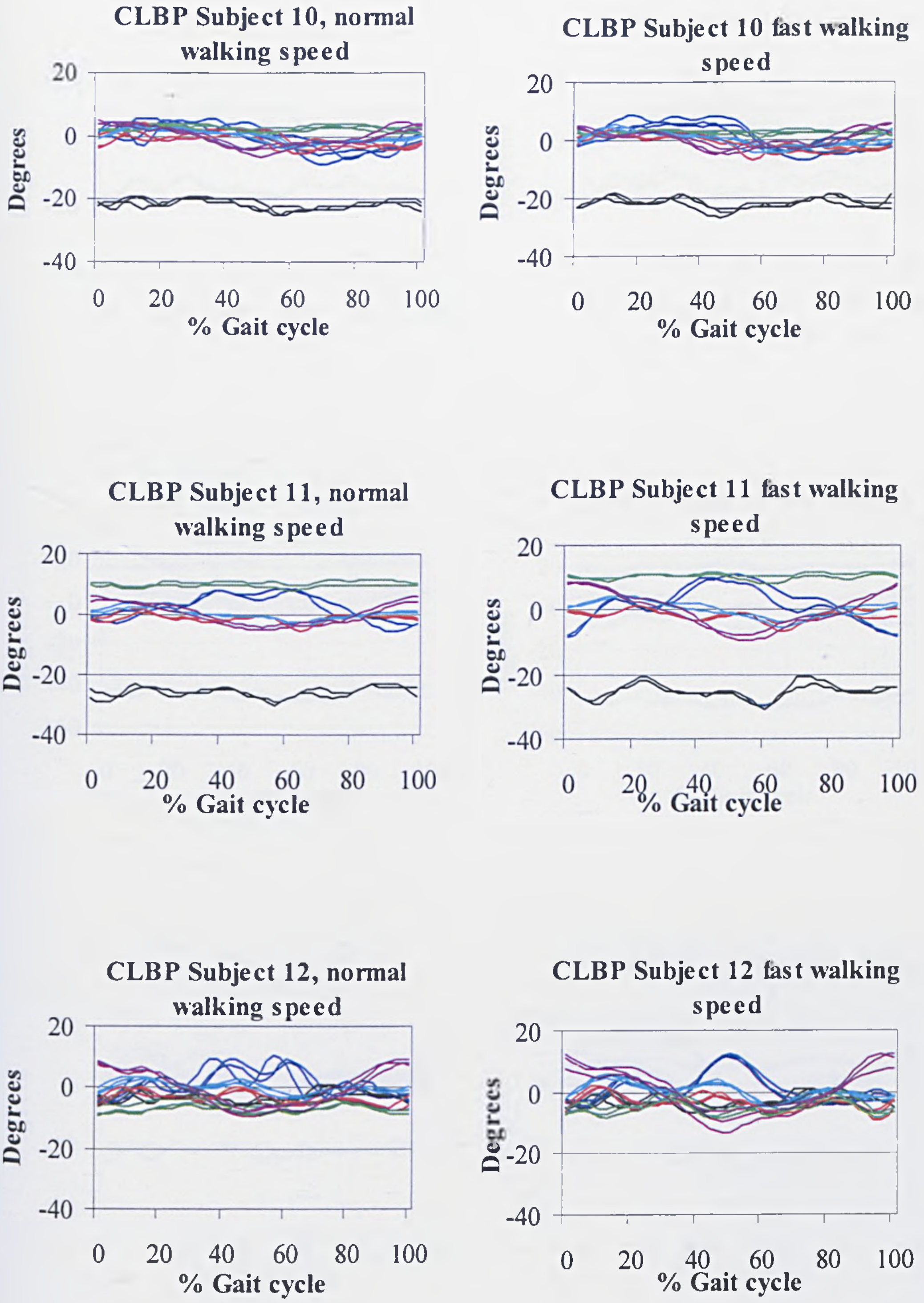
Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.4: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 4 to 6



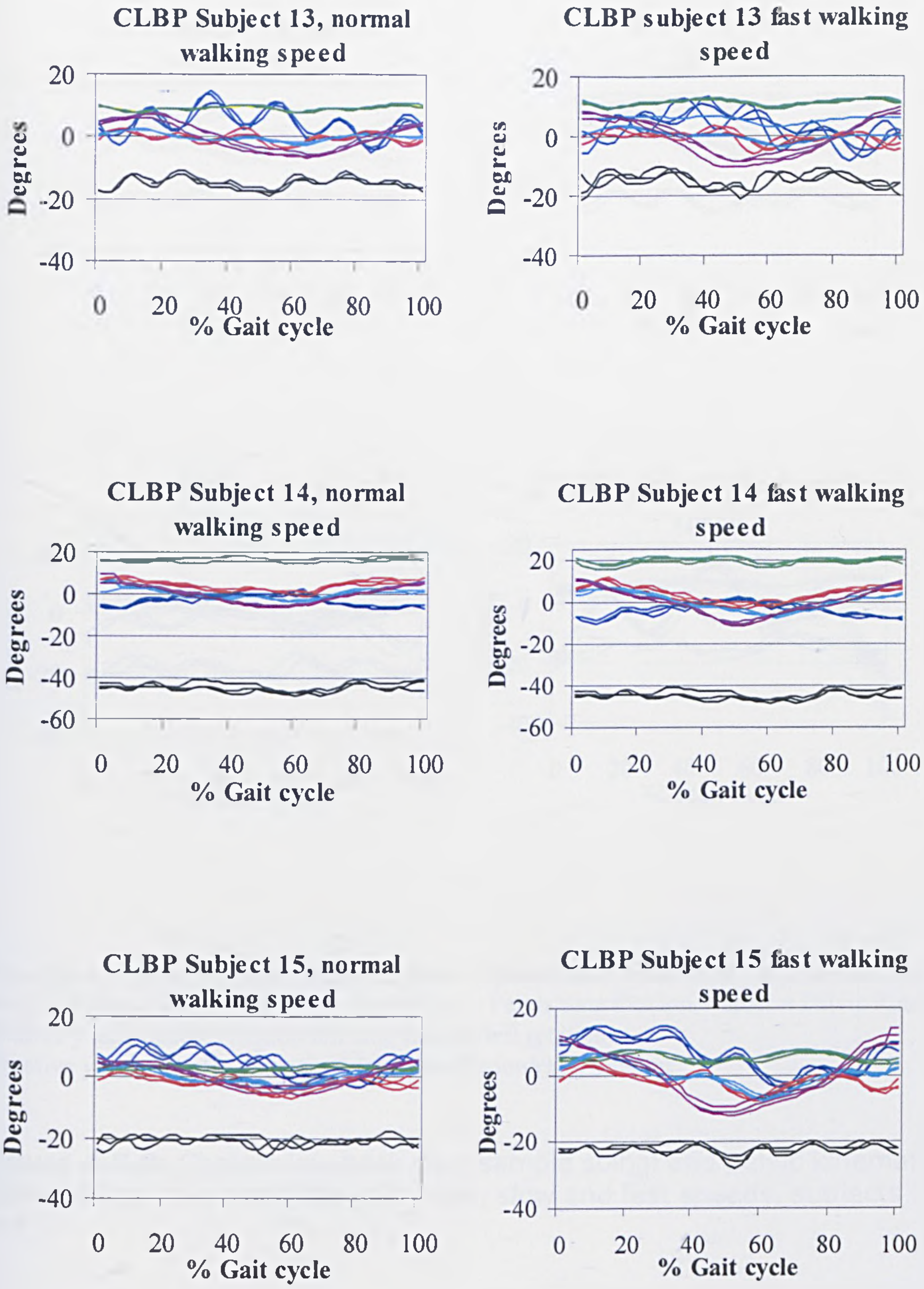
Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension, Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.5: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 7 to 9



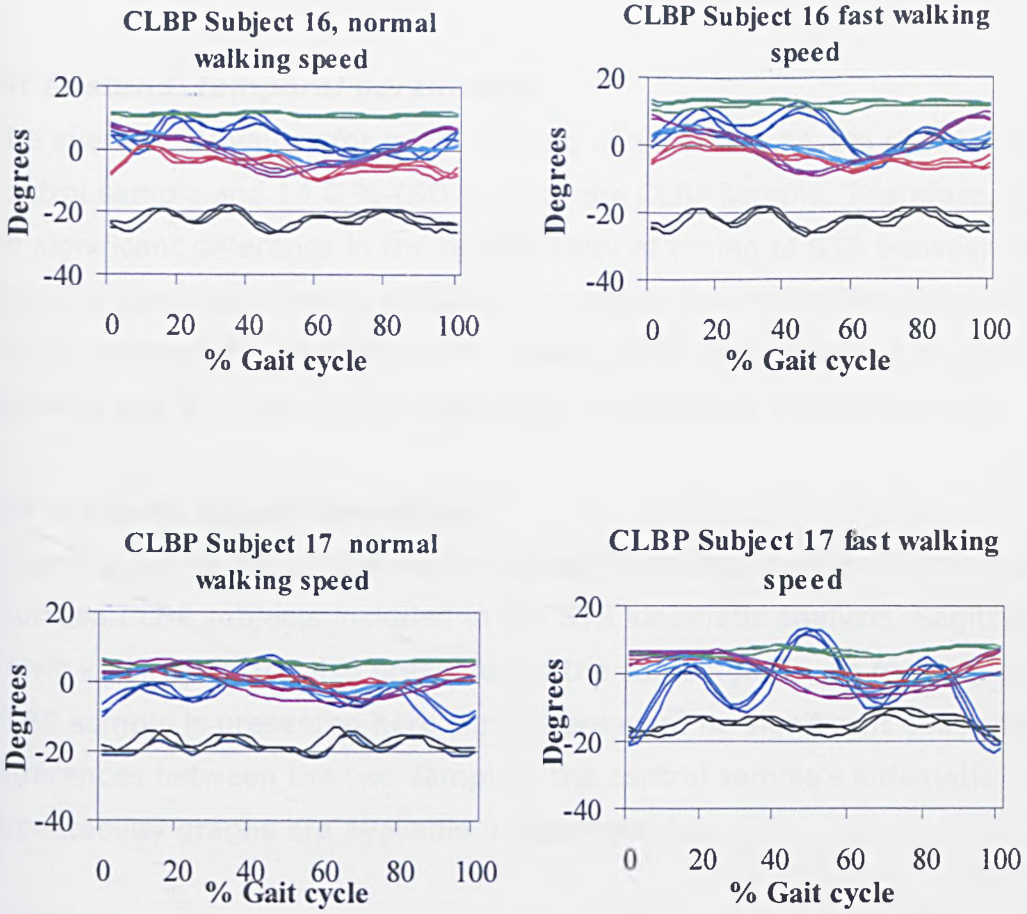
Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.6: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 10 to 12



Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.7: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 13 to 15



Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension Light blue = Pelvis Side Flexion, Violet = Pelvis Rotation
Positive y axis denotes flexion/left side flexion/left rotation
Negative y axis denotes extension/right side flexion/right rotation

Figure 4.5.8: Chronic low back pain sample spinal and pelvic kinematic repeatability, one complete gait cycle, slow and fast speeds, subjects 16 and 17

Sit to stand: temporal parameters

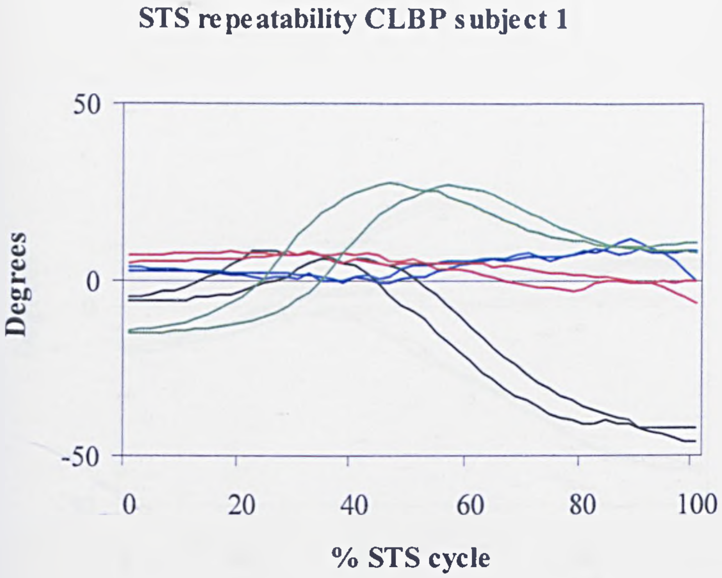
The average CV values for overall timing of STS were 14.1% (SD 9.4) for the control sample and 14.0 % (SD 9.1) for the CLBP sample. Therefore, there was no significant difference in the repeatability of timing of STS between the two samples (p>0.05). Timing of STS is somewhat less repeatable than the timing of gait parameters. The individual values, which ranged from 1 to 38% (CLBP sample) and 3 to39% (control sample), are available in appendix 20.

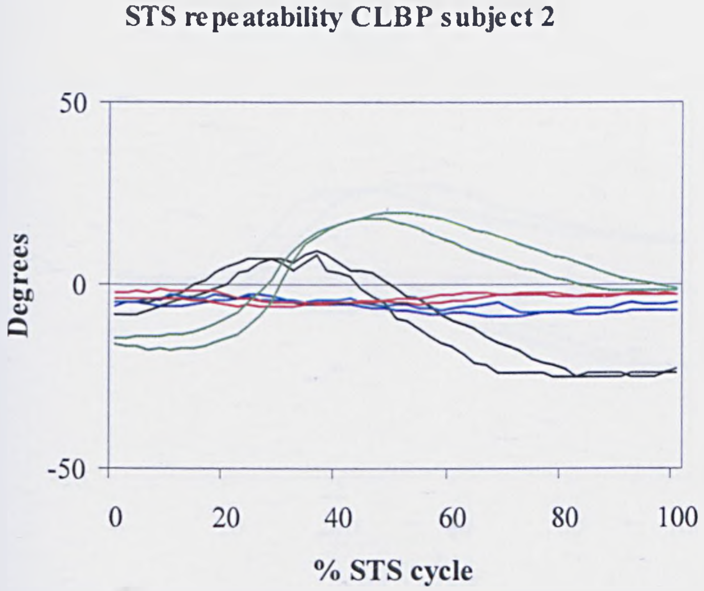
Sit to stand: spinal kinematics

Figures 3.5.9 to 3.5.15 display the spinal kinematics during STS for each of the fourteen CLBP subjects included in the STS kinematic analysis. Sagittal plane pelvic kinematics are also presented in the same figures. As for gait, only the CLBP sample is presented here since there were no significant observable differences between the two samples; the control sample's kinematic repeatability graphs are available in Appendix 21.

The graphs demonstrate small excursions for lumbar spinal side flexion and rotation, and a phase of lumbar spinal flexion followed by extension for all except one subject (10) who does not demonstrate a spinal flexion phase. The graphs demonstrate a longer phase of pelvic flexion, similarly followed by an extension phase.

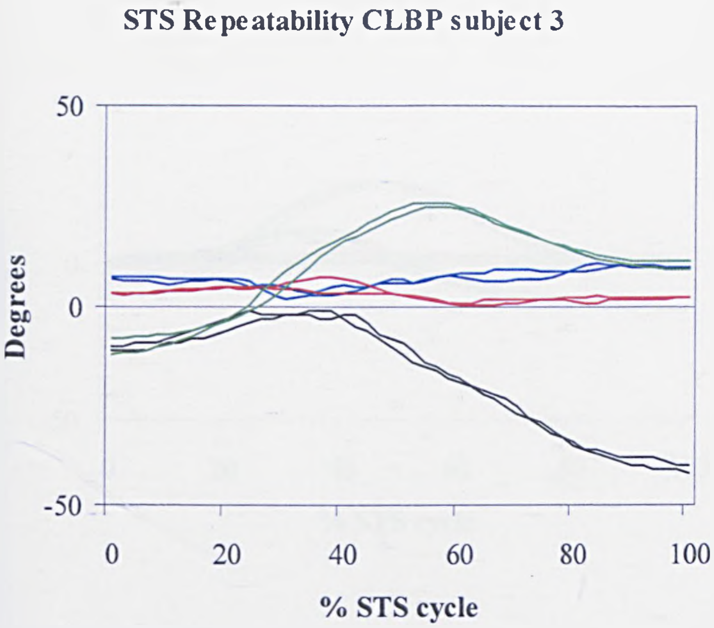
The graphs appeared to demonstrate relatively small intrasubject variability for the two or three available STS trials. The sample average CV values for joint ROM are displayed in table 3.5.8 which illustrates that sagittal plane kinematics (flexion/extension) were the most repeatable for both samples, with the smaller joint ranges in the frontal (side flexion) and transverse (rotation) planes demonstrating greater variability. The individual values, ranging from 1.4 to 54.4% (control) and 0 to 47.8% (CLBP) are available in appendix 20. Due to the level of repeatability for both the temporal and kinematic parameters the average of two or three STS trials (depending on available data of suitable quality) for each subject was used in the subsequent analyses, since it would have been difficult to select one "typical" trial.

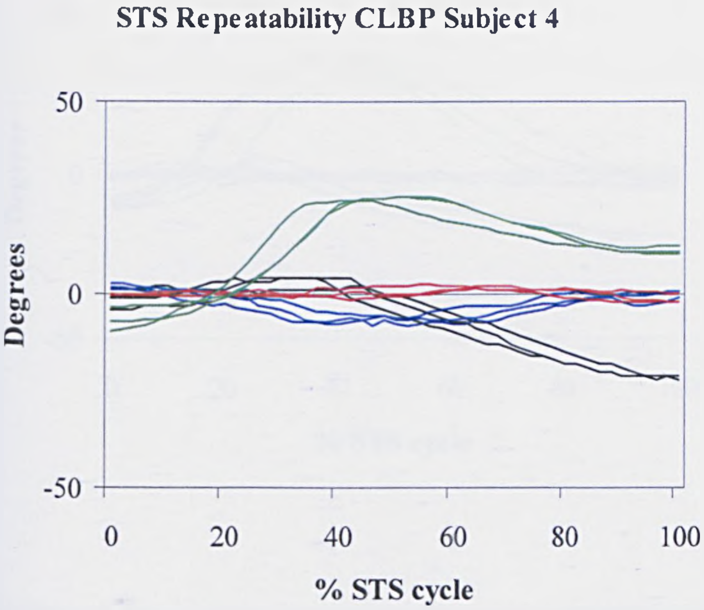




Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

Figure 3.5.9: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 1 and 2

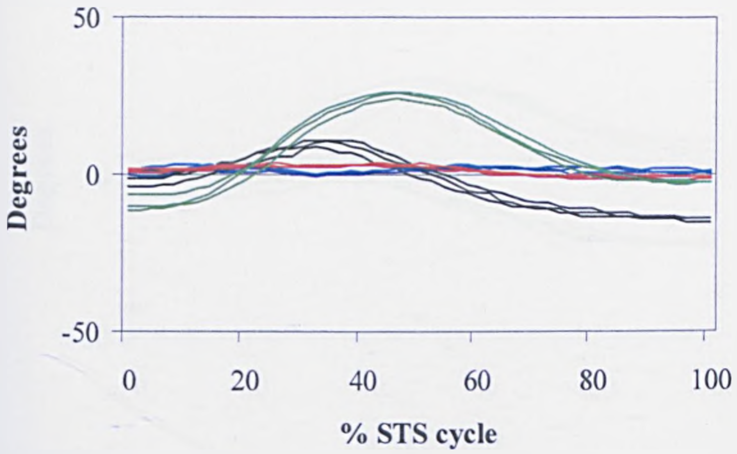




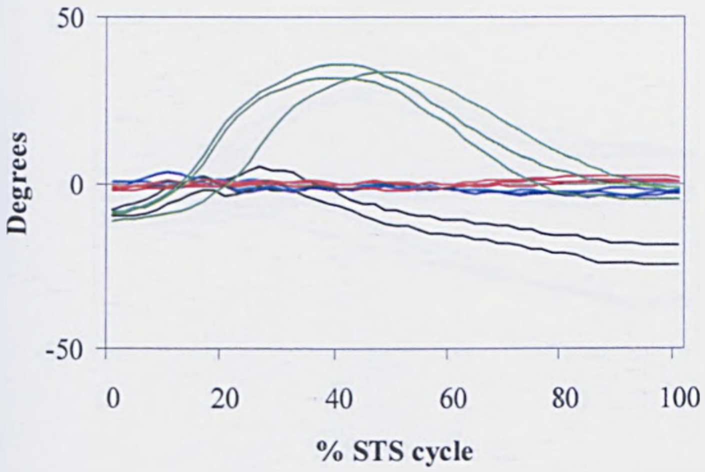
Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

Figure 3.5.10: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 3 and 4

STS Repeatability CLBP Subject 5

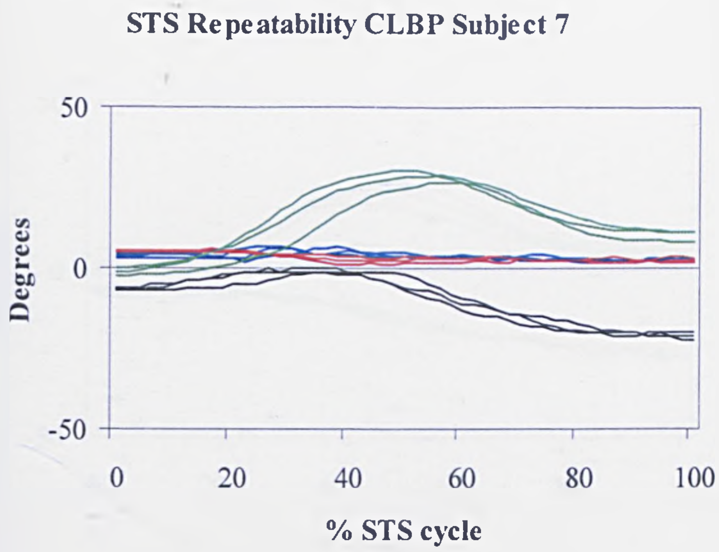


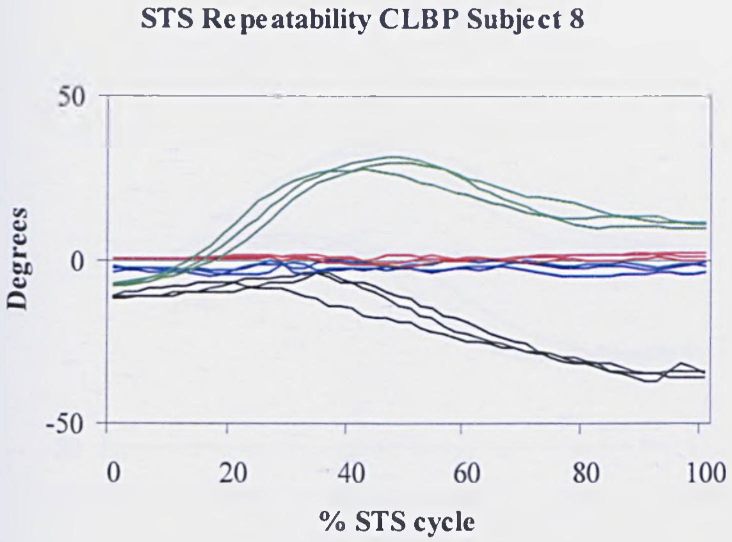
STS Repeatability CLBP Subject 6



Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

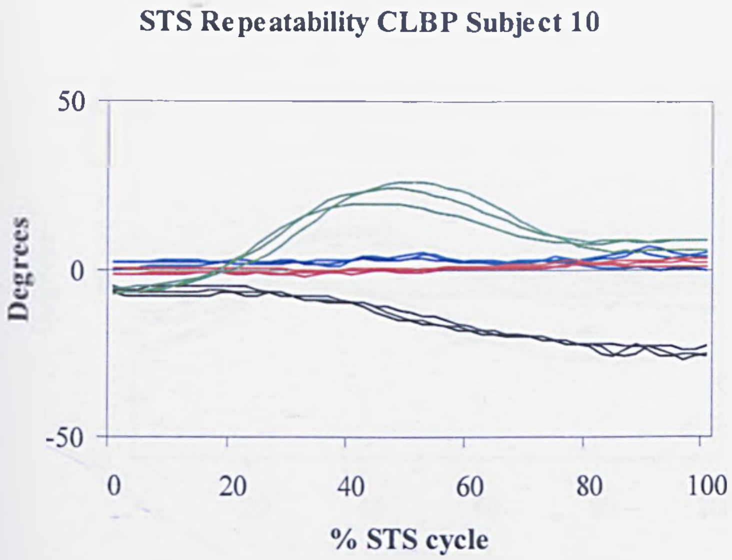
Figure 3.5.11: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 5 and 6

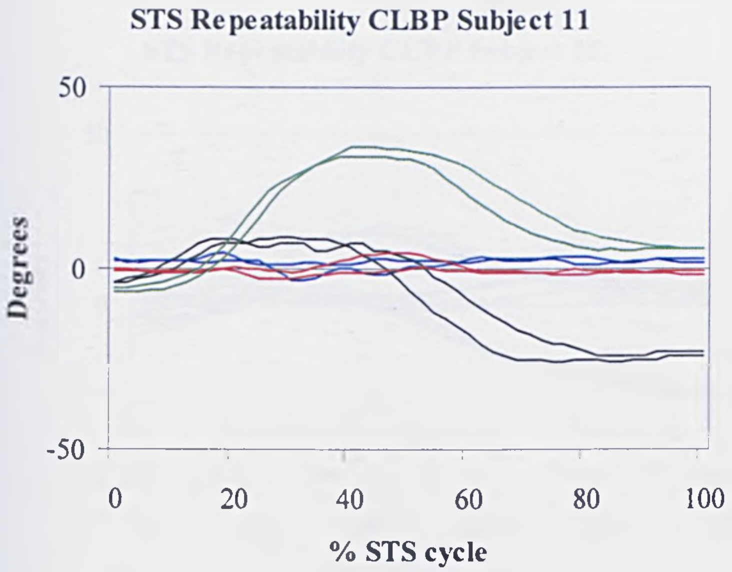




Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

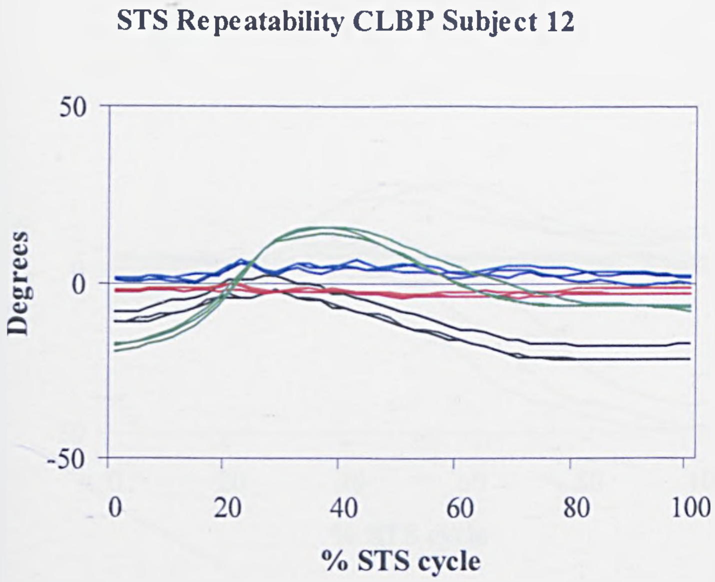
Figure 3.5.12: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 7 and 8

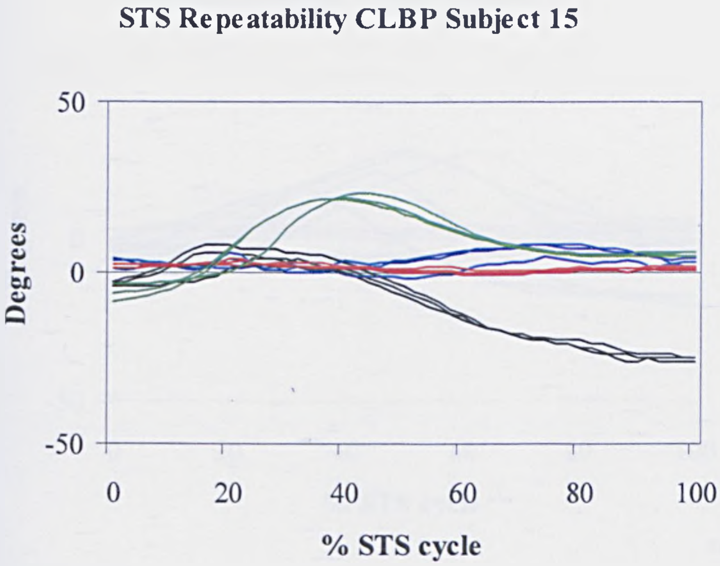




Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

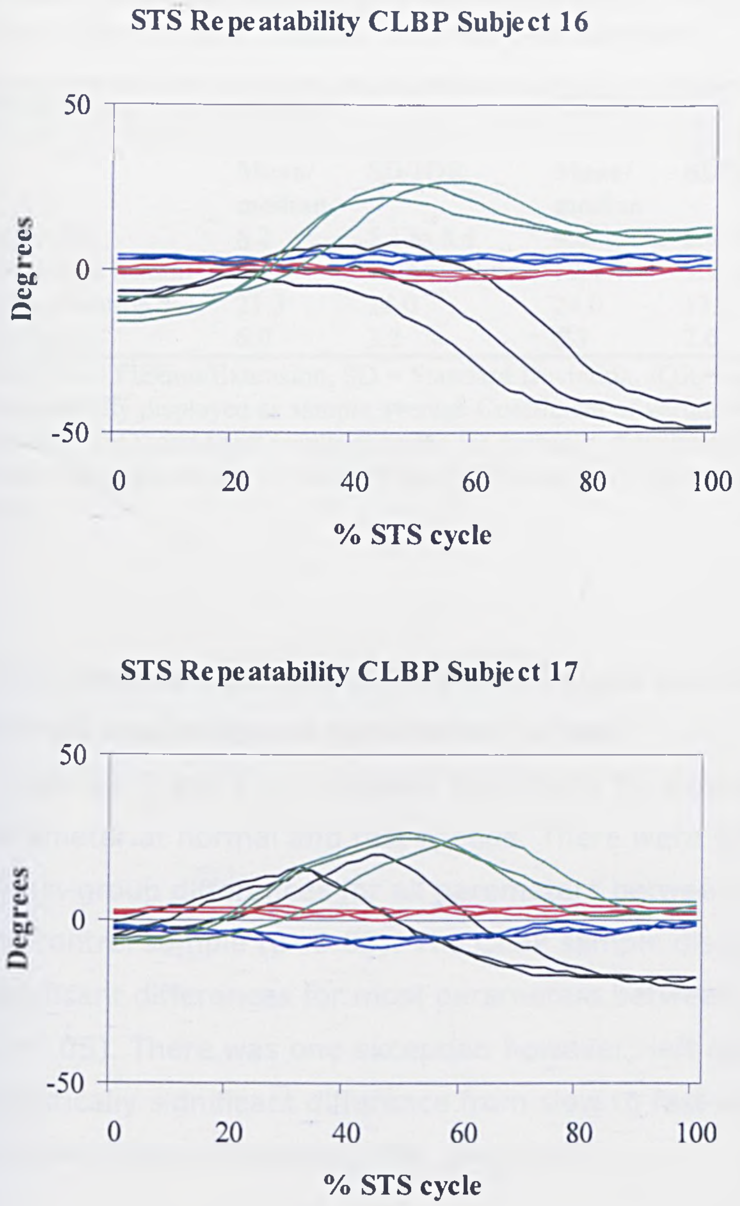
Figure 3.5.13: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 10 and 11


STS Repeatability CLBP Subject 12


STS Repeatability CLBP Subject 15

Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Green = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

Figure 3.5.14: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 12 and 15



Key: Black = Spine Flexion/Extension, Blue = Spine Side Flexion, Red = Spine Rotation, Yellow = Pelvis Flexion/Extension
Positive y-axis denotes flexion/ left side flexion/ left rotation
Negative y-axis denotes extension/ right side flexion/ right rotation

Figure 3.5.15: Chronic low back pain sample spinal and pelvic kinematic repeatability sit to stand, subjects 16 and 17

Table 3.5.8: Repeatability of spinal kinematic range of motion during sit to stand, control and chronic low back pain samples

Movement	Control		CLBP		Test used	p-value
	Mean/ median	SD/IQR	Mean/ median	SD/IQR		
Spine F/E	6.2	5.1 to 8.4	4.6	2.9 to 6.6	M-W U	0.164
Spine Side flexion	16.7	10.2 to 22.9	12.4	9.7 to 21.1	M-W U	0.829
Spine Rotation	21.3	14.0	24.0	13.2	t-test	0.617
Pelvis F/E	6.0	3.2	6.3	2.6	t-test	0.800

Key: F/E = Flexion/Extension, SD = Standard Deviation, IQR = Interquartile Range
Repeatability displayed as sample average Coefficient of variation (%), n=28. Mean and Standard deviation (SD) and t-test results reported for normally distributed data. Median and interquartile range (IQR) and results of Mann-Whitney U tests (MW-U) reported for non-normally distributed data.

3.5.3 Between sample differences in gait and Sit to Stand

Spatial and temporal parameters of gait

Tables 3.5.9 and 3.5.10 display the results for each spatial and temporal parameter at normal and fast speeds. There were statistically significant within-group differences for all parameters between normal and fast speeds for the control sample ($p<0.05$). The CLBP sample displayed statistically significant differences for most parameters between normal and fast speeds ($p<0.05$). There was one exception however; left stance showed no statistically significant difference from slow to fast walking speed for the CLBP sample (mean difference 1.4%, $p=0.055$)

Table 3.5.9: Spatial and temporal parameters, chronic low back pain and control samples, self-selected normal walking speed, n=37

Parameter	Units	CLBP Mean/ median	SD/IQR	Control Mean/ median	SD/IQR
Cadence	steps/min	117.35	12.28	116.60	6.70
Left stride time*	seconds	1.04	0.95 to 1.10	1.02	0.99 to 1.06
Right stride time*	seconds	1.03	0.93 to 1.11	1.02	1.00 to 1.06
Left step time	seconds	0.52	0.06	0.51	0.04
Right step time*	seconds	0.52	0.45 to 0 55	0.52	0.50 to 0.54
Left Single support	percent	39.12	1.89	39.91	1.55
Right single support	percent	39.94	1.78	39.28	2.67
Double support*	percent	21.16	19.09 to 22.99	20.68	19.44 to 23 35
Left stance	percent	60.37	1.58	60.66	1.69
Right stance	percent	61.25	1.81	60.61	1.53
Left stride length	metres	1.27	0.15	1.37	0.13
Right stride length	metres	1.26	0.15	1.38	0.13
Left step length	metres	0.62	0.08	0.68	0.06
Right step length	metres	0.64	0.07	0.69	0.07
Speed	m/s	1.24	0.18	1.33	0.15

Key: SD = Standard Deviation, IQR = Interquartile Range
Mean and Standard deviation (SD) reported for normally distributed data. Median and interquartile range (IQR) reported for non-normally distributed data *

Table 3.5.10: Spatial and temporal parameters, chronic low back pain and control samples, self-selected fast walking speed, n=37

Parameter	Units	CLBP Mean/ median	SD/IQR	Control Mean/ median	SD/IQR
Cadence	steps/min	143.92	15.67	138.52	13.61
Left stride time	seconds	0.84	0.09	0.88	0.09
Right stride time	seconds	0.85	0.09	0.87	0.08
Left step time	seconds	0.42	0.04	0.44	0.05
Right step time	seconds	0.42	0.05	0.43	0.04
Left Single support	percent	41.33	2.11	41.74	1.61
Right single support*	percent	41.49	39.55 to 42.99	42.81	41.91 to 43.84
Double support*	percent	17.79	14.89 to 20.47	15.39	14.55 to 16.87
Left stance	percent	59.02	2.83	58.18	1.32
Right stance	percent	59.06	2.20	58.82	1.72
Left stride length	metres	1.48	0.20	1.58	0.14
Right stride length	metres	1.48	0.21	1.58	0.14
Left step length	metres	0.72	0.12	0.78	0.07
Right step length*	metres	0.72	0.68 to 0.81	0.79	0.73 to 0.86
Speed	m/s	1.74	0.24	1.81	0.20

Key: SD = Standard Deviation, IQR = Interquartile Range
Mean and Standard deviation (SD) reported for normally distributed data. Median and interquartile range (IQR) reported for non-normally distributed data *

Both samples increased walking speed by similar amounts from normal to fast speeds; control subjects by 40% and CLBP subjects by 36%. However, different strategies were used to increase speed, illustrated in table 3.5.11. As table 3.5.11 illustrates, left step time was reduced significantly more in CLBP subjects than controls in response to increased speed, and double support phases demonstrated significantly less alteration in CLBP subjects than controls. Both samples demonstrated small increases in single support time in response to increased speed; the CLBP sample demonstrated a significantly greater increase in left single support but a smaller increase in right single support compared to the control sample.

Table 3.5.11: Differences in parameters with speed increase (fast minus slow)

Parameter	**Units**	**CLBP Average**	**Control Average**	**Test used**	**p-value**
Cadence	steps/min	26.57	21.92	t-test	0.215
Left stride time	seconds	-0.20	-0.14	Mann-Whitney U	0.123
Right stride time	seconds	-0.18	-0.15	Mann-Whitney U	0.195
Left step time	**seconds**	**-0.10**	**-0.07**	**t-test**	**0.023**
Right step time	seconds	-0.10	-0.09	t-test	0.958
Left Single support	**percent**	**2.21**	**1.83**	**Mann-Whitney U**	**<0.001**
Right single support	**percent**	**1.50**	**3.53**	**Mann-Whitney U**	**<0.001**
Double support	**percent**	**-3.37**	**-5.29**	**Mann-Whitney U**	**<0.001**
Left stance	percent	-1.36	-2.48	t-test	0.122
Right stance	percent	-2.20	-1.79	t-test	0.653
Left stride length	metres	0.21	0.21	Mann-Whitney U	0.551
Right stride length	metres	0.21	0.21	Mann-Whitney U	0.729
Left step length	metres	0.10	0.10	t-test	0.626
Right step length	metres	0.08	0.10	t-test	0.977
Speed	m/s	0.50	0.48	t-test	0.985

Statistically significant differences between the samples for each parameter were tested for using two-tailed independent samples t-tests or Mann-Whitney U tests. The results of these tests are presented in tables 3.5.12 to 3.5.15. The results indicated that CLBP was associated with reduced stride and step lengths in this sample of patients. However, this only occurred at self-selected normal walking speed; CLBP was not associated with statistically significant alterations in gait parameters at self-selected fast walking speed.

Table 3.5.12: Results of t-tests for spatial and temporal parameters, self-selected normal walking speed, n=37

Parameter	**Mean difference (control-CLBP)**	**SE difference**	**t-statistic (df)**	**p-statistic**
Cadence	-0.75	3.33	-0.226 (24)	0.823
Left step time	-0.01	0.02	-0.491 (35)	0.626
Left single support	0.78	0.57	1.380 (35)	0.176
Right single support	-0.66	0.76	-0.870 (35)	0.390
Left stance	0.29	0.54	0.532 (35)	0.598
Right stance	-0.64	0.55	-1.169 (35)	0.250
Left stride length	**0.10**	**0.05**	**2.279 (35)**	**0.029**
Right stride length	**0.11**	**0.05**	**2.404 (35)**	**0.022**
Left step length	**0.06**	**0.02**	**2.456 (35)**	**0.019**
Right step length	**0.05**	**0.02**	**2.174 (35)**	**0.037**
Speed	0.09	0.01	1.740 (35)	0.091

Key: SE = Standard Error, df = degrees of freedom

Table 3.5.13: Results of Mann-Whitney U tests, spatial and temporal parameters, self-selected normal walking speed, n=37

Parameter	**Median difference**	**U statistic**	**P exact, two-tailed**
Right step time	0.01	156	0.677
Double support	0.96	169.5	0.0994
Right stride time	-0.01	156.5	0.689
Left stride time	-0.02	161.5	0.804

Table 3.5.14: Results of t-tests for spatial and temporal parameters, self-selected fast walking speed, n=37

Parameter	**Mean difference (control-CLBP)**	**SE difference**	**t-statistic**	**p-statistic**
Cadence	-5.40	4.8	-1.122 (35)	0.269
Left stride time	0.03	0.03	1.185 (35)	0.244
Right stride time	0.03	0.03	0.993 (35)	0.327
Left step time	0.02	0.01	1.573 (35)	0.124
Right step time	0.00	0.02	0.428 (35)	0.671
Left Single support	0.41	0.61	0.665(35)	0.511
Left stance	-0.83	0.75	-1.117 (22)	0.276
Right stance	-0.24	0.65	-0.364 (35)	0.718
Left stride length	0.10	0.06	1.83 (35)	0.076
Right stride length	0.10	0.06	1.846 (35)	0.073
Left step length	0.06	0.03	1.920 (35)	0.063
Speed	0.08	0.07	1.041 (35)	0.305

Key: SE = Standard Error, df = degrees of freedom

Table 3.5.15: Results of Mann-Whitney U tests, spatial and temporal parameters, self-selected fast walking speed, n=37

Parameter	Median difference	U statistic	P exact, two-tailed
Right single support	1.32	118	0.117
Double support	-2.4	128	0.209
Right step length	0.07	108	0.059

Spinal kinematics during gait

Figures 3.5.16 and 3.5.17 display the mean kinematic data for both samples at self-selected normal and fast walking speeds. All graphs are normalised such that the x-axis represents one complete gait cycle (right heel strike to following right heel strike). The figures suggested that at both speeds the two samples displayed similar results for pelvic kinematics, with the exception of a small difference in starting flexion/extension (pelvic tilt). The larger standard deviations obtained for spinal kinematics can in part be explained by the variability in starting position, and do not appear to be a reflection of inter-subject variability in the pattern of the curve. Figure 3.5.18 illustrates this for normal walking speed, indicating the range in starting positions, most marked for spine flexion/extension, but also apparent for spine side flexion and rotation. The mean sagittal plane starting positions for each sample were −19.9° (control) and −23.3° (CLBP) at slow speed, and −21.6° (control) and −22.8° (CLBP) at fast speed. These small differences were not statistically significant, indicating that both samples demonstrated a mean starting posture of approximately 20 ° lumbar extension.

The effect of speed is illustrated in figures 3.5.19 and 3.5.20, which display the mean kinematics for each sample at both normal and fast walking speeds. These figures suggested that there was little variability in the shape of the spinal or pelvic kinematic traces associated with speed increase, but that differences in joint ROM may be present. These differences were in fact detected in both samples and are now described

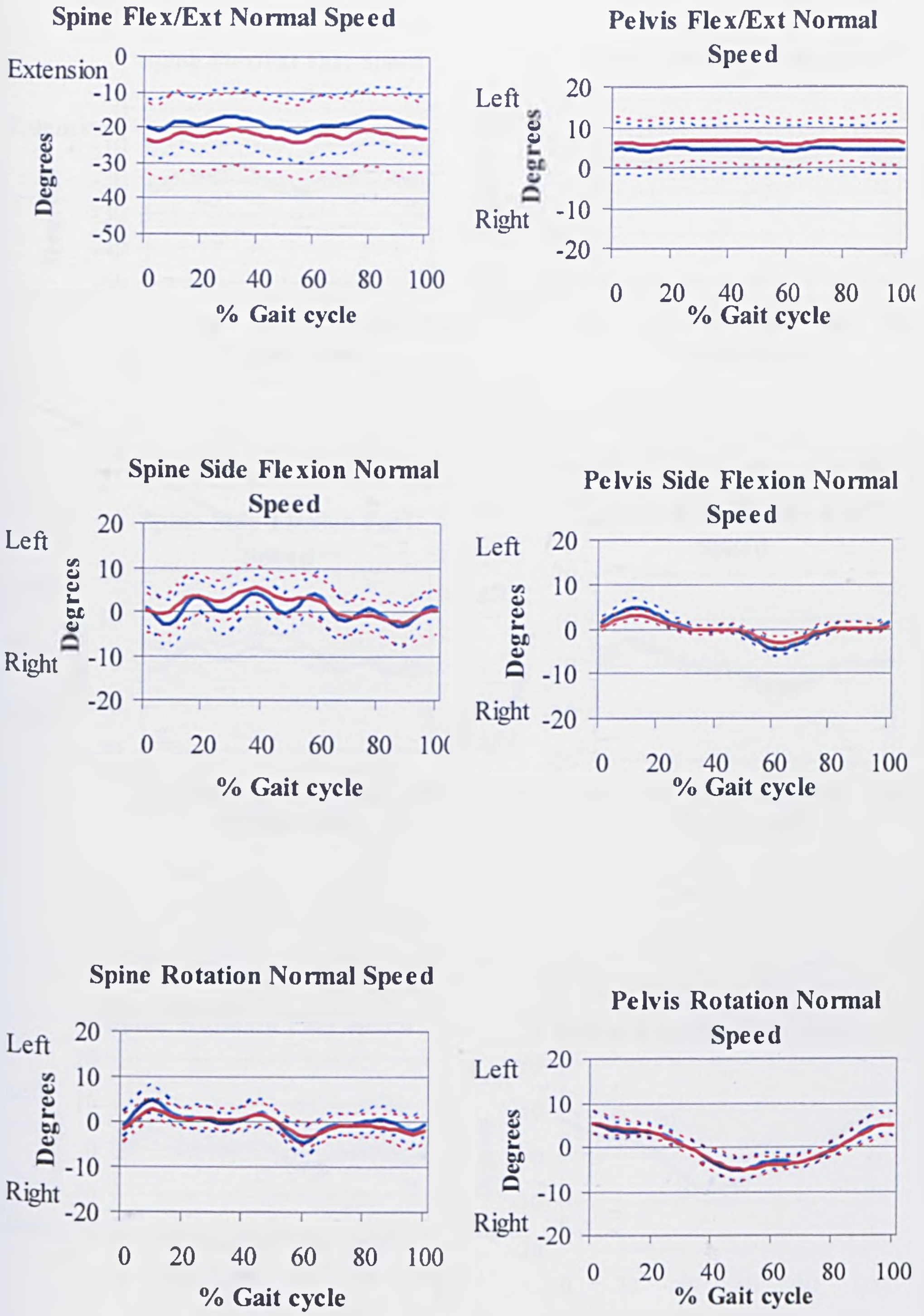


Figure 3.5.16: Mean joint kinematics for one complete gait cycle (right heel strike to following right heelstrike) at self-selected normal walking speed Control sample (blue) and chronic low back pain sample (red). Dotted lines represent standard deviation

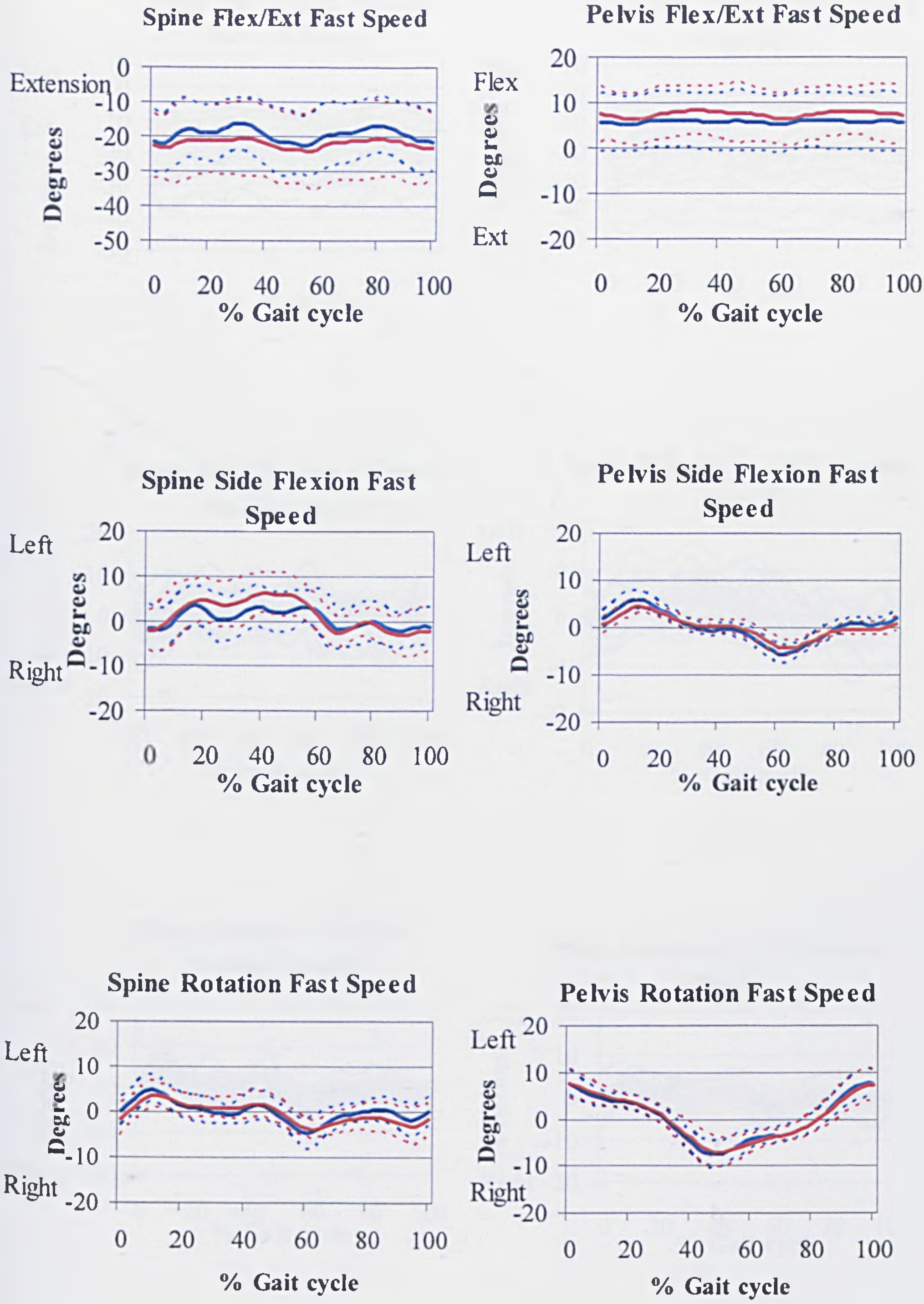


Figure 3.5.17: Mean joint kinematics for one complete gait cycle (right heel strike to following right heelstrike) at self-selected fast walking speed Control sample (blue) and chronic low back pain sample (red). Dotted lines represent standard deviation

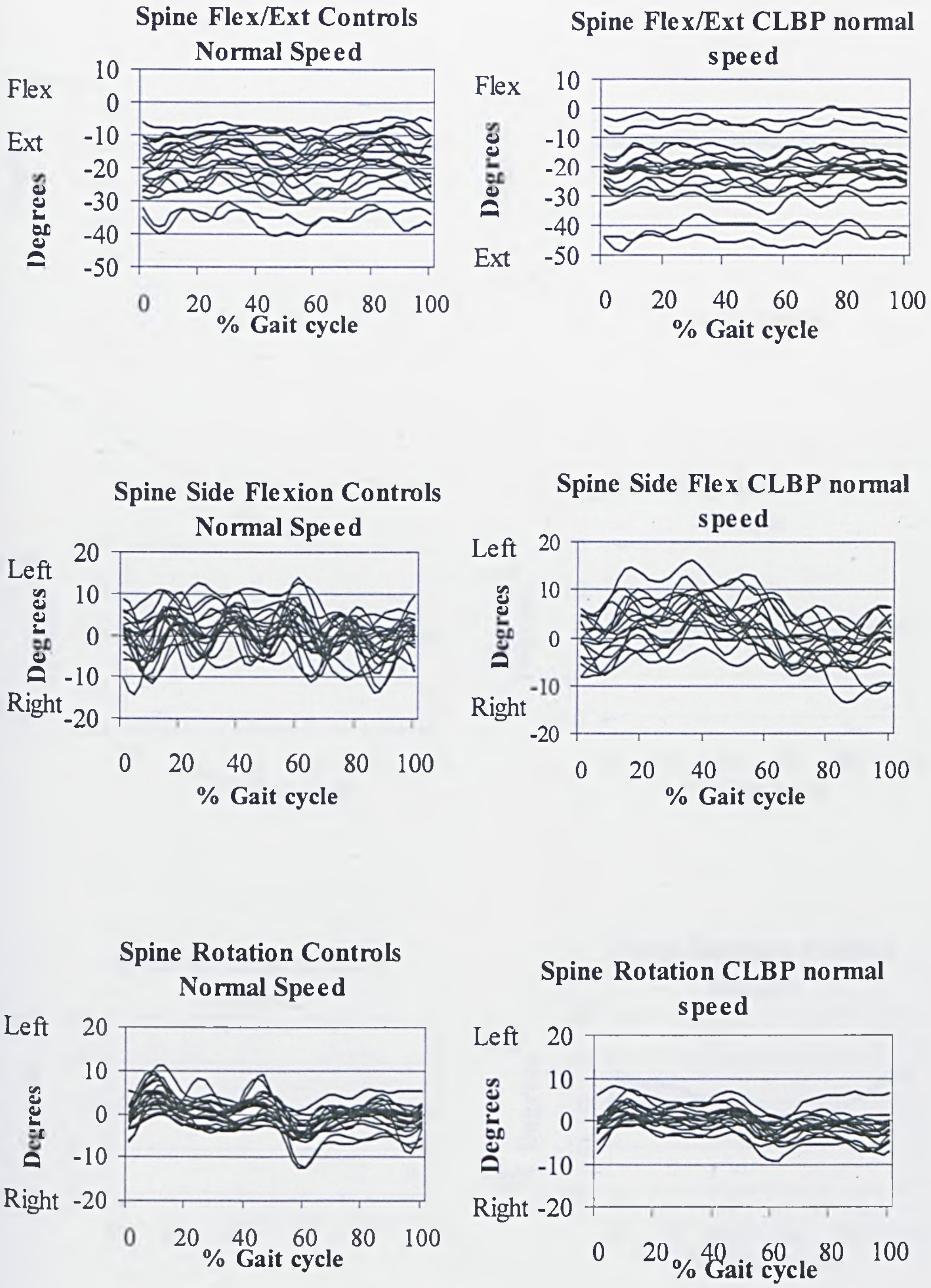


Figure 3.5.18: Control and chronic low back pain sample, lumbar spinal kinematic inter-subject variability at self-selected normal walking speed. Each trace represents mean spinal kinematics for one subject

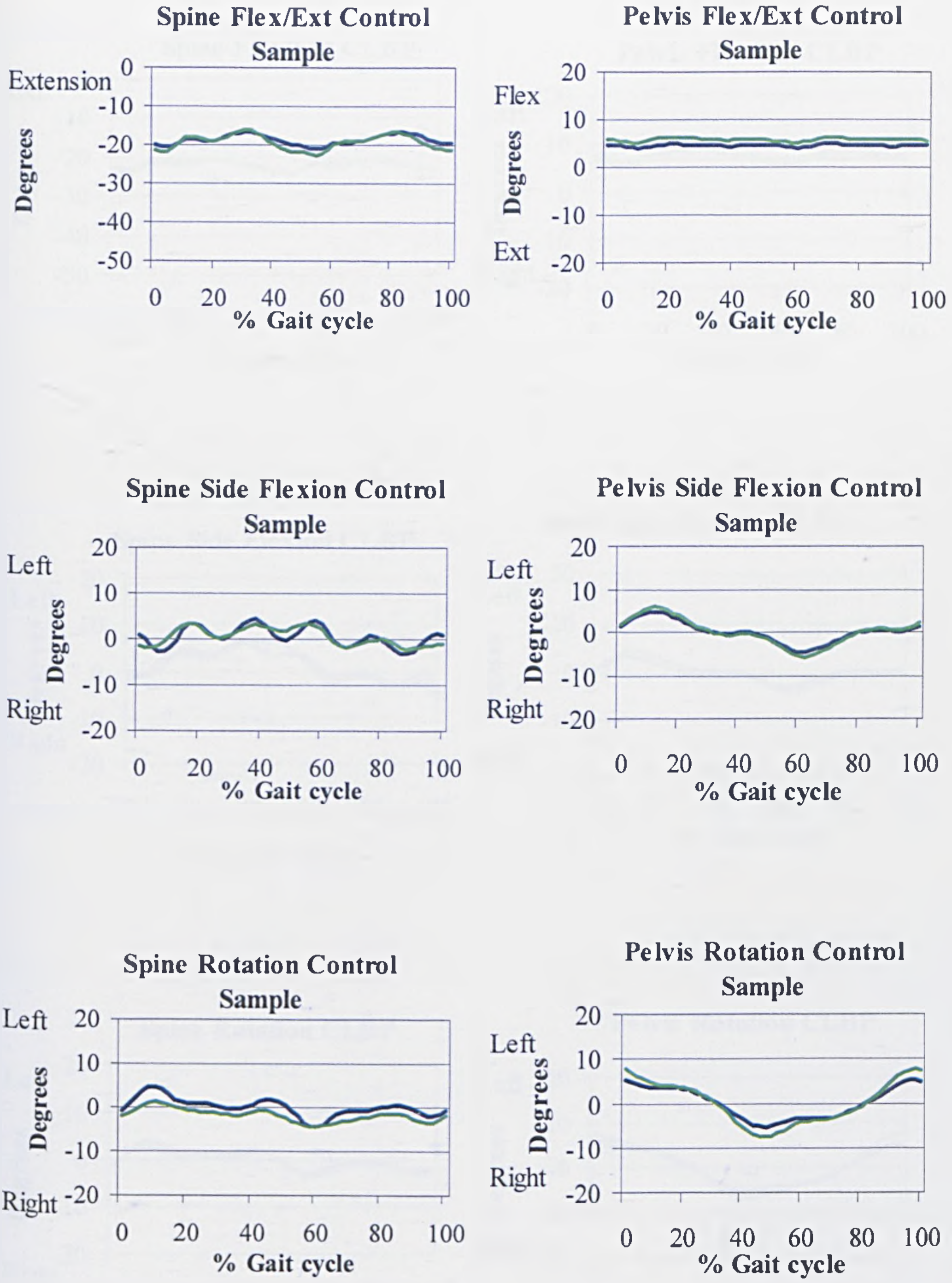


Figure 3.5.19: Mean control sample spinal and pelvic kinematics for one complete gait cycle (right heel strike to following right heelstrike)
Blue = normal speed, green = fast speed

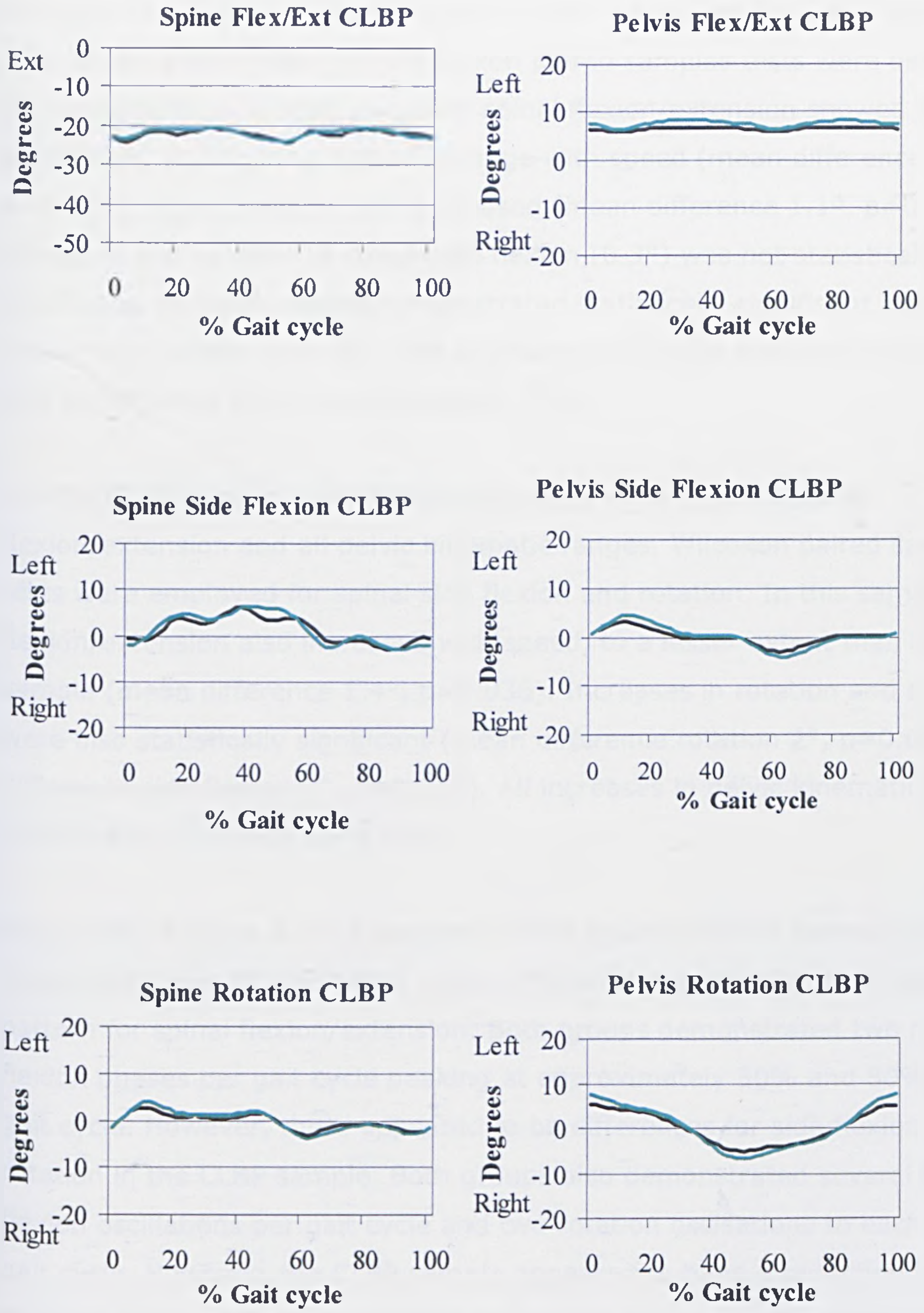


Figure 3.5.20: Mean chronic low back pain sample spinal and pelvic kinematics for one complete gait cycle (right heel strike to following right heelstrike)
Blue = normal speed, green = fast speed

Joint ROM was tested for within group statistically significant differences between slow and fast speeds. Paired t-tests were used for spinal and pelvic side flexion and rotation, and Wilcoxon paired samples tests were used for flexion/extension. Control subjects' spinal flexion/extension showed a small but statistically significant increase in range with speed (mean difference 3°, $p<0.001$). Spinal rotation also increased (mean difference 1.1°, $p=0.021$). However, the increase in spinal side flexion (0.3°) was not statistically significant. All pelvic ranges demonstrated statistically significant increases in response to speed ($p<0.01$). The largest increase was seen for rotation (4.7°) and the smallest for flexion/extension (1.1°).

For the CLBP sample, paired samples t-tests were used for spinal flexion/extension and all pelvic kinematic ranges. Wilcoxon paired samples tests were employed for spinal side flexion and rotation. In this sample spinal flexion/extension also increased with speed, to a lesser extent than the control sample (mean difference 1.4°, $p=0.036$). Increases in rotation and side flexion were also statistically significant (mean difference rotation 2°, $p=0.001$; mean difference side flexion 3°, $p=0.015$). All increases in pelvic kinematics were statistically significant ($p<0.005$).

Inspection of figure 3. 5.16 suggested that at self-selected normal walking speed there was little between group difference in joint ROM or kinematic pattern for spinal flexion/extension. Both groups demonstrated two main flexion phases per gait cycle peaking at approximately 30% and 80% of the gait cycle. However, there appeared to be differences for side flexion and rotation in the CLBP sample. Both groups also demonstrated several side flexion oscillations per gait cycle and two rotation oscillations to each side per gait cycle. However, the CLBP sample appeared to have a reduction in the range of some of these oscillations for both side flexion and rotation in comparison to the control sample. At self-selected fast walking speed (figure 3.5.17) there appeared to be a reduction in joint ROM for spinal flexion/extension and rotation in the CLBP sample demonstrated by the flattening of the kinematic trace, and an increase in the ROM of spinal side flexion. Pelvic kinematics appeared to demonstrate small differences between and within groups at different speeds as figures 3.5.16, 3.5.17, 3.5.19 and 3.5.20 illustrate.

The average joint ROM for spinal and pelvic kinematics is displayed in tables 3.5.16 and 3.5.17. It can be seen that there were small differences in joint ROM (up to 3°) between the samples. The results of the independent t-tests for differences between samples at normal speed are displayed in table 3.5.18. It can be seen that the largest of the differences, pelvic side flexion, was statistically significant. Therefore, at normal walking speed CLBP patients displayed an average 3° reduction in pelvic side flexion compared to controls. All other pelvic and spinal kinematics were within normal ranges.

Table 3.5.16: Lumbar joint range of motion in degrees during gait, control and chronic low back pain samples

	Normal				**Fast**			
	Control		**CLBP**		**Control**		**CLBP**	
	Mean	**SD**	**Mean**	**SD**	**Median**	**IQR**	**Median**	**IQR**
Flex/Ext	8.26	2.50	6.90	1.90	10.67	9 to 12.33	8.33	6.67 to 9.67
Side Flexion	13.56	4.84	13.75	3.11	13.92	10.94 to 15.87	16.68	12.57 to 17.54
Rotation	10.84	4.42	8.45	2.69	11.00	8.98 to 14.27	9.64	8.80 to 11.42

Key: SD = Standard Deviation, IQR = Interquartile Range
ROM (degrees), n=37. Mean and Standard Deviation (SD) reported for normally distributed data.
Median and Interquartile range (IQR) reported for non normally distributed data

Table 3.5.17: Pelvic joint range of motion in degrees during gait, control and chronic low back pain samples

	Normal				**Fast**			
	Control		**CLBP**		**Control**		**CLBP**	
	Mean	**SD**	**Mean**	**SD**	**Mean/ median**	**SD/IQR**	**Mean/ median**	**SD/IQR**
Flex/Ext	2.34	0.95	1.86	0.58	2.95*	2.16 to 3.88	2.90*	2.19 to 3.15
Side Flexion	9.59	3.27	6.59	2.14	12.03	3.83	9.31	3.10
Rotation	11.65	4.42	11.62	4.28	16.33	5.54	15.58	5.50

Key: SD = Standard Deviation, IQR = Interquartile Range
ROM (degrees), n=37. Mean and Standard Deviation (SD) reported for normally distributed data.
Median and Interquartile range (IQR) reported for non normally distributed data*

Table 3.5.18: Results of t-tests lumbar and pelvic kinematics during normal gait, n=37

Parameter	Mean difference (Control-CLBP)	SE Diff	t-statistic (df)	p-statistic
Spine Flex/Ext,	1.32	0.73	-1.807 (35)	0.079
Spine Side Flex	-0.19	1.32	0.147 (33)	0.884
Spine Rotation	2.38	1.18	-2.013 (32)	0.53
Pelvic Flex/Ext	0.48	0.26	1.83 (35)	0.076
Pelvic Side Flex	**3.0**	**0.93**	**3.247 (35)**	**0.003**
Pelvic Rotation	0.03	1.44	0.024 (35)	0.981

Key: SE = Standard Error, df = degrees of freedom

The results of the t-tests and Mann Whitney U tests for spinal and pelvic ROM at fast speed are displayed in table 3.5.19 and 3.5.20 which demonstrate that there were statistically significant between group differences for pelvic side flexion and spine flexion/extension at this speed. It can therefore be stated that at self-selected fast walking speed, CLBP patients displayed an average 2.7° reduction in pelvic side flexion and 2.4° reduction in lumbar flexion.

Table 3.5.19: Results of Mann Whitney U tests spinal and pelvic kinematics during fast gait, n=37

Parameter	U statistic	P exact, two-tailed
Spine Flex/Ext,	**78.5**	**0.004**
Spine Side Flex	119	0.125
Spine Rotation	133	0.133
Pelvic Flex/Ext	151	0.572

Table 3.5.20: Results of t-tests pelvic kinematics during fast gait, n=37

Parameter	Mean difference (Control-CLBP)	SE Diff	t-statistic (df)	p-statistic
Pelvic Side Flex	**2.71**	**1.16**	**2.340 (35)**	**0.025**
Pelvic Rotation	0.75	1.82	0.412 (35)	0.683

Key: SE = Standard Error, df = degrees of freedom

Temporal parameters of Sit to Stand

The temporal parameters of STS for each group are displayed in table 3.5.21. For both groups, phases I (flexion-momentum) and II (momentum transfer) were almost equal, with a longer phase III (extension).

Table 3.5.21: Temporal parameters Sit to Stand (STS) control and chronic low back pain samples

Phase	Control Median time, seconds (IQR)	Median % STS cycle (IQR)	CLBP Median time, seconds (IQR)	Median % STS cycle (IQR)
I	0.54 (0.47 to 0.56)	25.2 (23.5 to 28.7)	0.53 (0.45 to 0.60)	26.08 (22.83 to 27.13)
II	0.50 (0.43 to 0.66)	25.7 (22.5 to 29.1)	0.53 (0.45 to 0.67)	22.83 (23.75 to 30.33)
III	0.91 (0.79 to 1.00)	46.3 (42.9 to 49.8)	1.09 (0.81 to 1.22)	27.13 (44.50 to 50.33)
Mean total time I to III	**1.98 (SD 0.39)**		**2.12 (SD 0.45)**	

n=34. Median and interquartile range (IQR) reported for non-normally distributed data; mean and standard deviation (SD) reported for normally distributed data.

The independent t-test (two tailed) was used to test the small difference in mean overall timing for statistical significance. No statistically significant difference was detected (p=0.482). The small differences in timing of each of the three phases of STS were also tested for between-group statistically significant differences with Mann-Whitney U tests. None were statistically significant (phase I p=0.885, phase II p=0.652, phase III p=0.301).

Spinal kinematics Sit to Stand

Figures 3.5.21 to 3.5.23 display the mean joint kinematic traces for the pelvis and spine during the STS manoeuvre. Table 3.5.22 displays the mean joint positions for the lumbar spine, pelvis and hips in the sagittal plane for both sitting and standing. Table 3.5.22 also displays the peak flexion attained for each joint as well as the total ROM. For the sagittal plane it can be seen that the control sample began in an average of 5° of spinal flexion whilst the CLBP sample began in an average of 6.3° of extension. A Mann-Whitney U test was performed on the data to compare the spinal starting positions. The results were statistically significant as table 3.5.22 demonstrates (U=27.5, p=0.001).

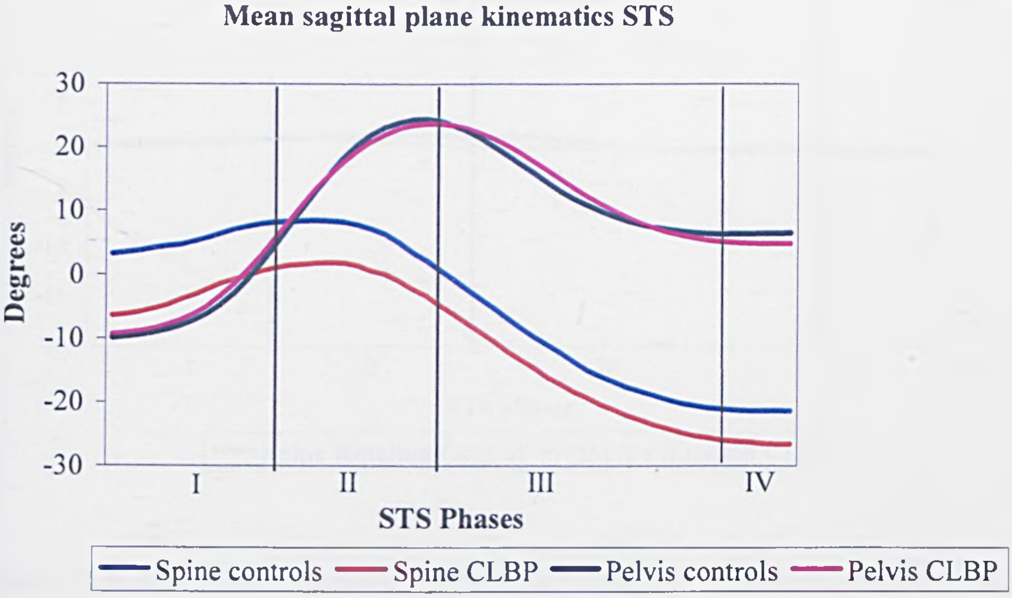


Figure 3.5.21: Mean pelvic and spinal kinematics during Sit to Stand, sagittal plane, n=28

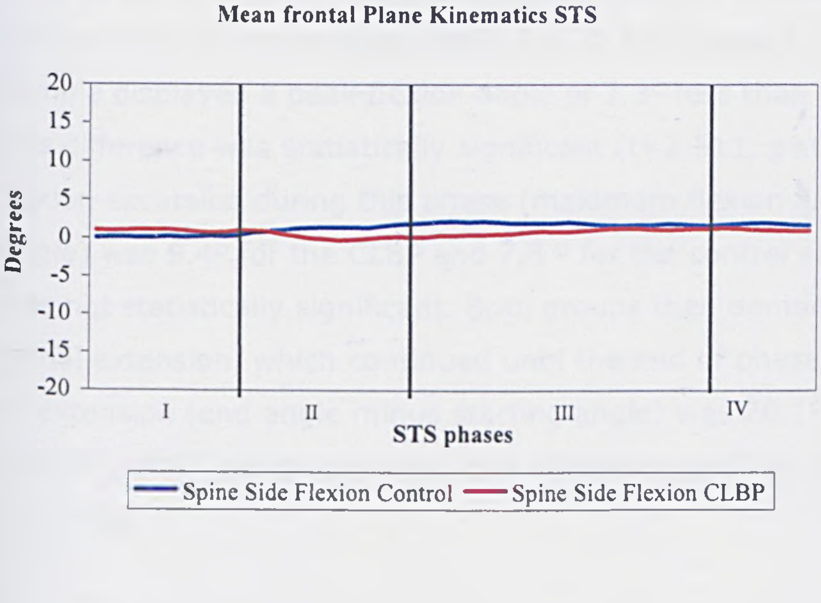


Figure 3.5.22: Mean spinal kinematics during Sit to Stand, frontal plane, n=28

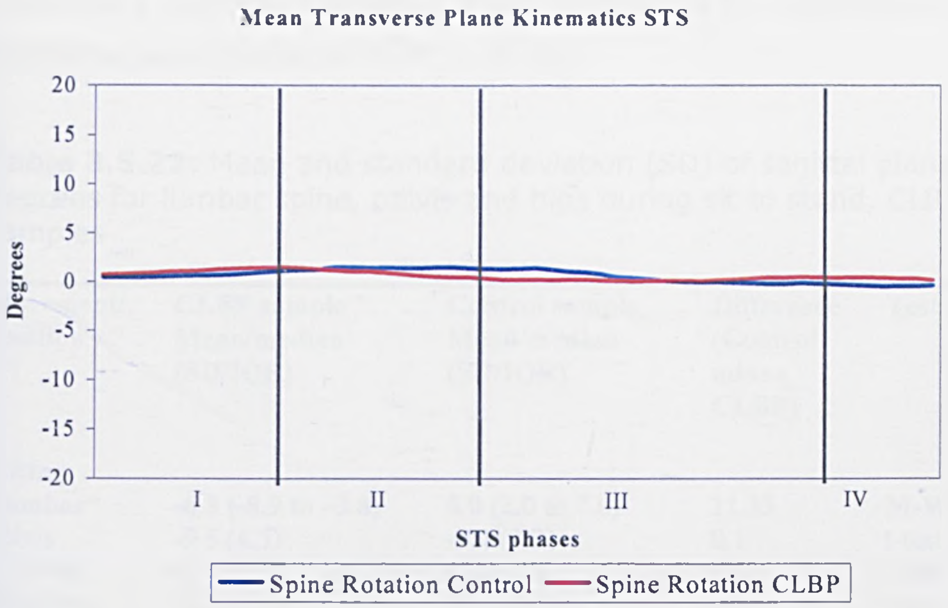


Figure 3.5.23: Mean spinal kinematics during Sit to Stand, transverse plane, n=28

Both groups began with a spinal flexion phase, reaching a maximum just after 25% of the STS cycle corresponding with the end of phase I (flexion-momentum). It can be seen (table 3.5.22 and graph 3.5.21) that the CLBP sample displayed a peak flexion angle of 7.3° less than the control sample; this difference was statistically significant (t=2.511, p=0.019). The mean flexion excursion during this phase (maximum flexion angle minus starting angle) was 9.4° for the CLBP and 7.8 ° for the control samples. This difference was not statistically significant. Both groups then demonstrated a phase of spinal extension, which continued until the end of phase III. The mean range of extension (end angle minus starting angle) was 20.1° for the CLBP and 24 ° for the control group. Likewise, this difference was not statistically significant (p>0.05).

The pelvis similarly displayed a flexion phase followed by an extension phase, with peak flexion being achieved just before 50% of the STS cycle, corresponding with the end of phase II (momentum-transfer). There were no statistically significant between-group differences for sagittal plane pelvic positions, peak flexion or ROM (p>0.05).

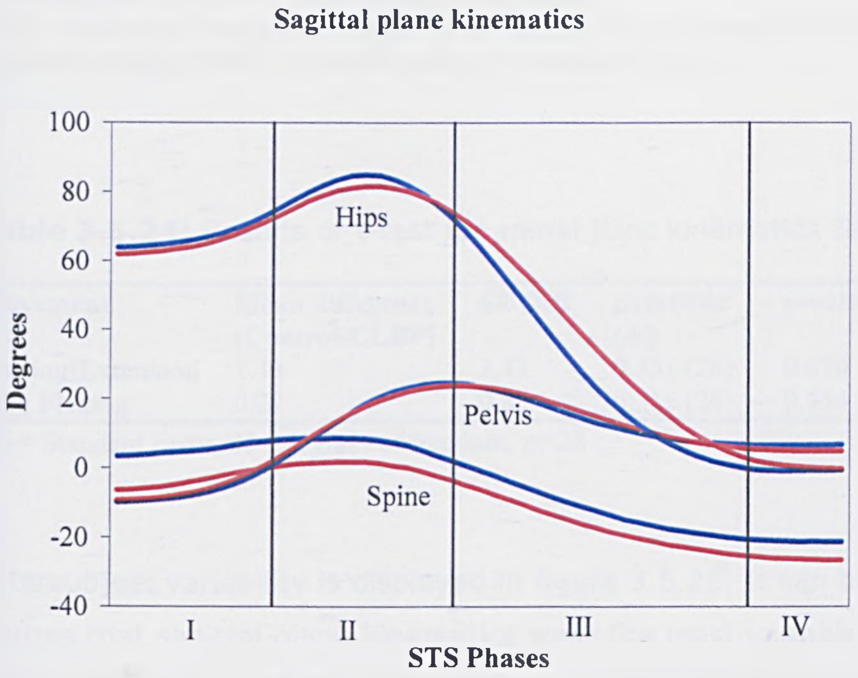
Table 3.5.22: Mean and standard deviation (SD) of sagittal plane angles in degrees for lumbar spine, pelvis and hips during sit to stand, CLBP and control samples

Movement/ Position	CLBP sample Mean/median (SD/IQR)	Control sample Mean/median (SD/IQR)	Difference (Control minus CLBP)	Test used	p- value
Sitting					
Lumbar*	**-6.3 (-8.9 to –3.8)**	**5.0 (2.0 to 7.0)**	**11.33**	**M-W U**	**0.001**
Pelvis	-9.5 (4.5)	-9.4 (7.3)	0.1	t-test	0.980
Left Hip	61.4 (6.3)	63.4 (7.6)	2.0	t-test	0.481
Right Hip	62.5 (6.3)	63.1 (7.5)	0.6	t-test	0.820
Standing					
Lumbar*	-23.5 (-32.6 to –21)	-19.5(-28.3 to –17)	4.0	M-W U	0.101
Pelvis	5 (6.1)	6 (5.9)	1.0	t-test	0.676
Left Hip	-1.3 (6.3)	-0.51 (5.1)	0.79	t-test	0.434
Right Hip	1 (6.8)	-0.47 (5.9)	-1.47	t-test	0.534
Peak flexion					
Lumbar	**3.1 (5.0)**	**10.4 (9.1)**	**7.3**	**t-test**	**0.019**
Pelvis	24.9 (4.8)	23.7 (10.7)	-1.2	t-test	0.726
Left Hip	82.5 (8.2)	86.3 (7.5)	3.8	t-test	0.200
Right Hip	83.8 (7.8)	85.9 (6.9)	2.1	t-test	0.441
Joint range					
Lumbar	30.6 (9.7)	32.1 (8.4)	1.5	t-test	0.670
Pelvis*	34.5 (31 to 36.6)	35.6 (31.2 to 39.5)	1.1	M-W U	0.691
Left Hip	83.8 (10)	87.9 (7.2)	4.1	t-test	0.225
Right Hip	82.7 (9.8)	87.2 (7.3)	4.5	t-test	1.185

Median and interquartile range (IQR) and Mann-Whitney U tests (M-W U) reported for non-normally distributed data*; mean and standard deviation (SD) and t-tests reported for normally distributed data.

For the frontal plane, spinal kinematics of a few degrees of side flexion can be observed for both groups (figure 3.5.22). From their starting positions, both groups remained fairly static with respect to side flexion, until just prior to the end of phase I. At this point the control sample tended to side flex towards the left and the CLBP sample towards the right. Both reached a maximum at approximately 50% STS (just after the end of phase II). For the transverse plane (figure 3.5.23), a small range of spinal kinematics was demonstrated with both groups displaying similar kinematic patterns. Pelvic kinematics are not reported for the frontal or transverse planes because the mean values were 0° for both samples.

Figure 3.5.24 displays sagittal plane kinematics for the spine and pelvis in relation to the hip joint. It can be seen that the spine reached peak flexion first. The hip reached peak flexion next, at approximately 35% STS, reaching 86° and 83° for the control and CLBP samples respectively. The pelvis then reached peak flexion of 23.7° and 24.9° just before 50% of the STS cycle. There were no statistically significant differences between the groups for either pelvic or hip peak flexion.



Key: Red = CLBP; Blue = Control

Figure 3.5.24: Mean pelvic, spinal and hip sagittal plane kinematics during Sit to Stand, CLBP and control samples

Table 3.5.23 displays the mean joint ROM in all three planes for the spine during STS for both groups, confirming the similar ranges for both the control and CLBP samples. Table 3.5.24 displays the results of the t-tests for differences between the groups for flexion/extension and side flexion, confirming that there were no statistically significant between group differences. The between-group difference in rotation was tested for statistical significance with a Mann-Whitney U test, which was also not statistically significant (U=95.5, p=0.604).

Table 3.5.23: Mean spinal joint kinematics (degrees) Sit to stand

	Control Mean/ median	**SD/IQR**	**CLBP Mean/ median**	**SD/IQR**
Flex/Ext	32.1	8.4	30.6	9.7
Side Flexion	6.45	2.32	6.18	2.16
Rotation*	4.45	2.61 to 5.29	3.88	3.26 to 4.49

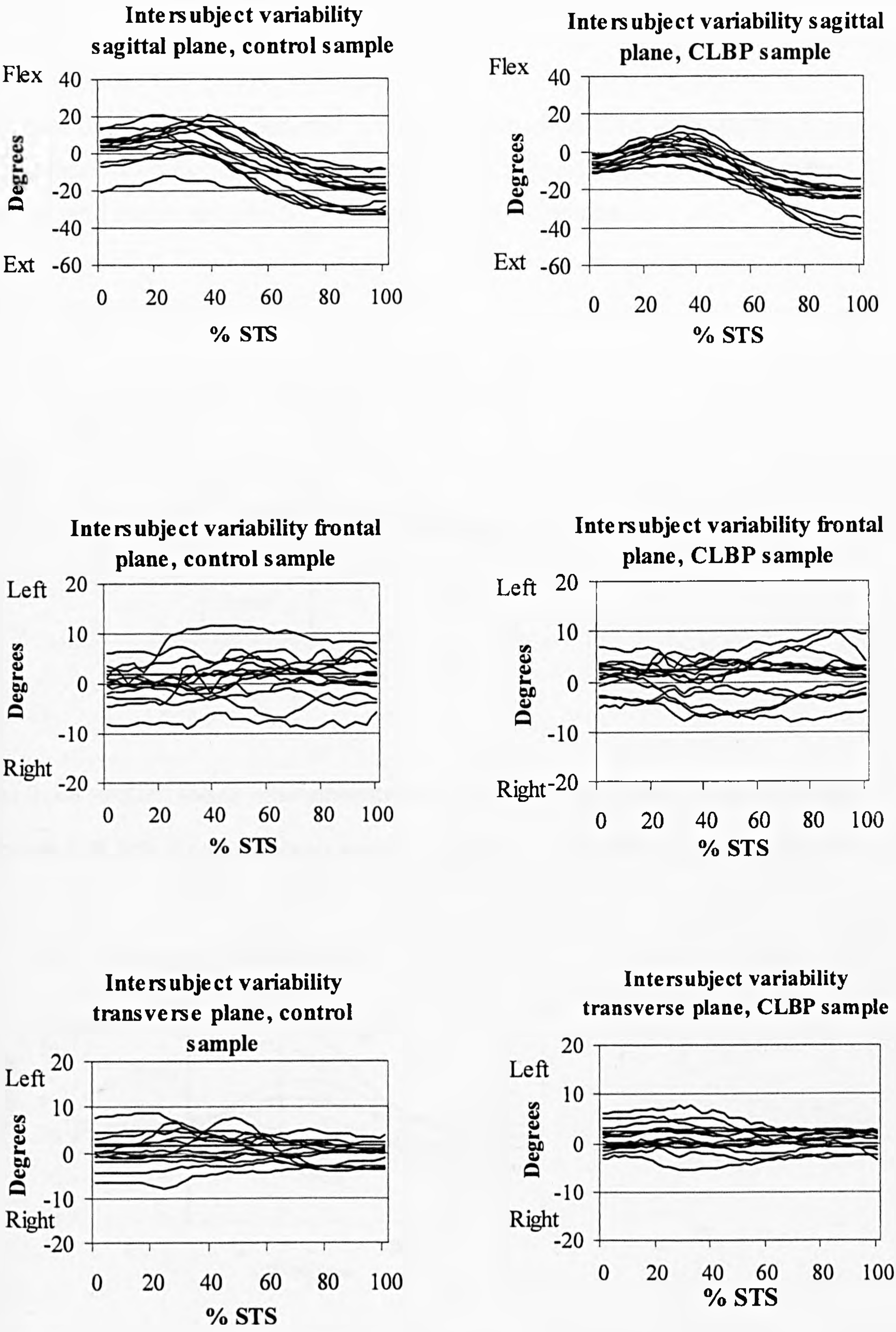
SD = Standard Deviation, IQR = Interquartile Range
n=28. Median and interquartile range (IQR) reported for non-normally distributed data*; mean and standard deviation (SD) reported for normally distributed data.

Table 3.5.24: Results of t-test for spinal joint kinematics Sit to stand

Movement	**Mean difference (Control-CLBP)**	**SE Diff**	**t-statistic (df)**	**p-value**
Flexion/Extension	1.48	3.43	0.431 (26)	0.670
Side Flexion	0.27	0.85	0.316 (26)	0.754

SE = Standard Error, df = degrees of freedom, n=28

Intersubject variability is displayed in figure 3.5.25. It can be seen from these figures that sagittal plane kinematics were the least variable, suggesting similar strategies of STS with respect to flexion/extension both within and between the samples. There was more variability for the smaller range frontal and transverse plane kinematics, the major source of variability being the starting position rather than the shape of the kinematic trace.



Intersubject variability sagittal plane, control sample

Intersubject variability sagittal plane, CLBP sample

Intersubject variability frontal plane, control sample

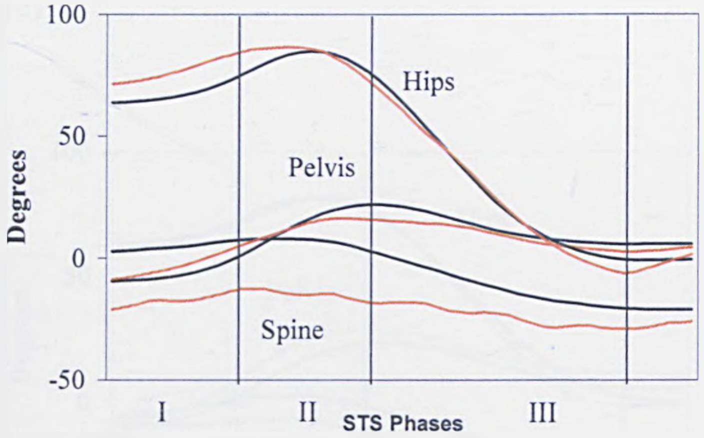
Intersubject variability frontal plane, CLBP sample

Intersubject variability transverse plane, control sample

Intersubject variability transverse plane, CLBP sample

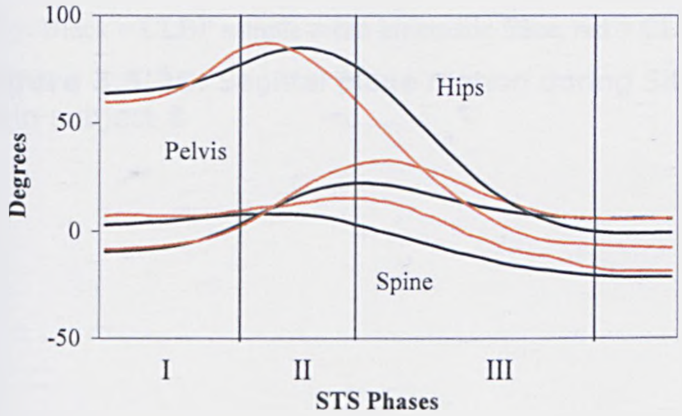
Figure 3.5.25: Intersubject variability lumbar spine kinematics during sit to stand, control sample (n=14) and chronic low back pain sample (n=14)

On close inspection of the individual graphical output, it was observed that two control and two CLBP subjects deviated from the sample mean pattern in the sagittal plane. The control subjects are shown in figures 3.5.26 and 3.5.27. The first demonstrates reduced lumbar flexion combined with slightly reduced pelvic flexion and unaltered hip motion. The second demonstrates delayed lumbar and pelvic extension, with earlier hip extension.



Key: Black = control sample mean kinematic trace, orange = control subject 6 kinematic trace

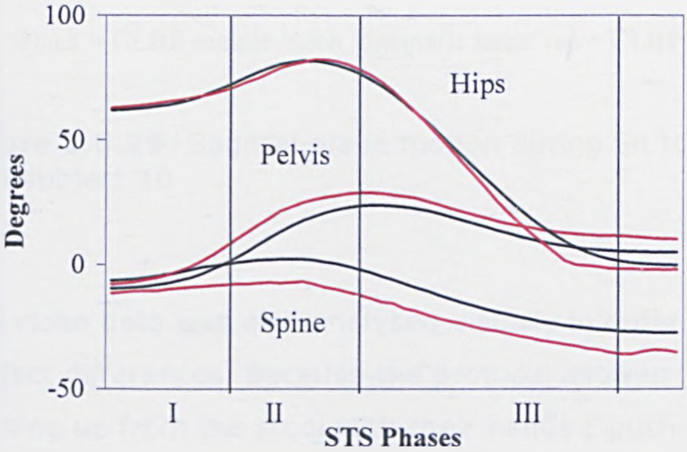
Figure 3.5.26: Sagittal plane motion during Sit to Stand control subject 6



Key: Black = control sample mean kinematic trace, orange = control subject 9 kinematic trace

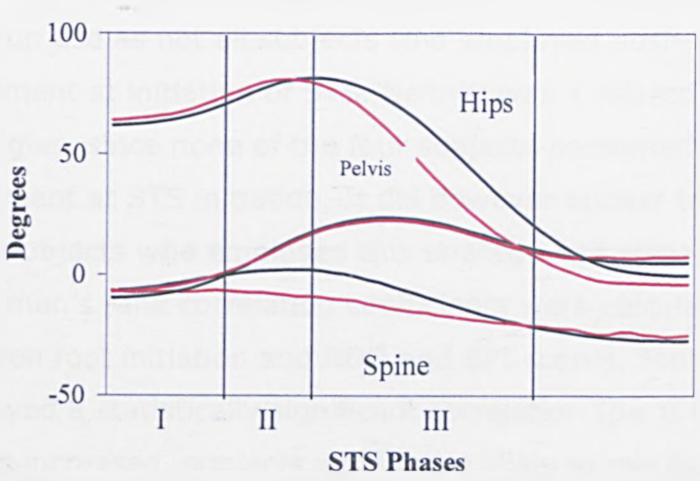
Figure 3.5.27: Sagittal plane motion during Sit to Stand control subject 9

The CLBP subjects who deviated from the mean pattern are displayed in figures 3.5.28 and 3.5.29. They both demonstrate reduced lumbar flexion. However, subject 8 displays slightly increased pelvic flexion, whereas in subject 10 pelvic flexion is unaltered but hip extension occurs earlier, indicating an earlier transition to phase III (extension). This subject did in fact have the shortest phase II (flexion-momentum) at 0.33 seconds (22.33% STS cycle).



Key: Black = CLBP sample mean kinematic trace, red = CLBP subject 8 kinematic trace

Figure 3.5.28: Sagittal plane motion during Sit to Stand, chronic low back pain subject 8



Key: Black = CLBP sample mean kinematic trace, red = CLBP subject 10 kinematic trace

Figure 3.5.29: Sagittal plane motion during Sit to Stand, chronic low back pain subject 10

The video data was also analysed visually in order to detect any other inter-subject differences. Because the protocol allowed subjects to choose between pushing up from the stool with their hands ("push-up") or keeping their arms by their sides this was evaluated first. In both the control and CLBP samples, five subjects chose to push up with their hands on the edge of the stool, whilst the remaining nine kept their arms by their side. This is illustrated in table 3.5.25. The five CLBP subjects who chose to push up were not the most disabled or painful according to their RDQ and BPI scores, suggesting that the choice was a matter of preference, as for the control sample. Neither of the CLBP subjects with altered STS kinematic strategies discussed above employed push-up as a strategy; however, both control subjects displaying an altered STS kinematic strategy also employed push-up.

Two different strategies for commencing the STS manoeuvre were detected, as table 3.5.25 also illustrates. The majority of CLBP and control subjects began with trunk flexion, keeping the feet static. However, a minority of both samples flexed the trunk and moved one or both feet backwards simultaneously. Only one control subject employed this strategy, compared with three CLBP subjects, one of whom moved both feet. This did not appear to be related to push-up use as not all subjects who employed push-up also employed foot movement at initiation of STS. Neither was it related to altered kinematic strategies, since none of the four subjects presented above employed foot movement at STS initiation. It did however appear to be related to RDQ score, since subjects who employed this strategy had some of the highest scores. Spearman's rank correlation coefficients were calculated for the relationship between foot initiation and RDQ and BPI scores. Foot initiation and RDQ scores displayed a statistically significant correlation ($\rho= 0.633, p=0.015$). As RDQ scores increased, subjects were more likely to use foot initiation as a movement strategy during STS. Since foot movement might also be related to Body Mass Index (BMI; Sibella et al, 2003), Spearman's rank correlation coefficient was also calculated for the relationship between BMI and foot initiation. There was a weak, non-significant correlation ($\rho = 0.410, p = 0.145$).

Table 3.5.25: Relationships between Sit to Stand strategies and symptom severity/disability in CLBP sample

Subject	**RDQ**	**BPI W**	**BPI M**	**BPI I**	**BPI N**	**Push-up**	**Foot initiation**
1	6	4	2	3	2	No	No
2	**15**	6	4	3	5	Yes	**Yes**
3	5	5	3	1	2	No	No
4	**10**	4	3	4	2	No	**Yes**
5	3	2	1	1	1	No	No
6	0	2	1	0	1	No	No
7	5	6	4	2	4	No	No
8	7	6	3	2	2	No	No
10	5	0	0	0	0	No	No
11	**11**	4	3	2	3	Yes	**Yes**
12	1	3	2	0	1	Yes	No
15	4	5	5	2	5	Yes	No
16	5	2	1	1	1	Yes	No
17	13	6	4	3	3	No	No

Key: RDQ = Roland Morris Disability Questionnaire, BPI W = Brief Pain Inventory “worst” subscale, BPIM = Brief Pain Inventory “Mean” subscale, BPII = Brief Pain Inventory “Interference subscale, BPI N = Brief Pain Inventory “now” subscale.

3.5.4 Relationship between objective measures and self-report tools

The relationship between the objective findings and the CLBP subjects self-report of symptom severity and disability are presented in table 3.5.26. For gait, there were no correlations between the spatial parameters that exhibited statistically significant between-group differences (stride length and step length normal walking speed) and either the RDQ scores or any of the BPI subscales. Neither were there any correlations between lumbar kinematics during fast gait and either RDQ or BPI scores. However, there was a statistically significant correlation between pelvic side flexion at fast speed and the BPI "now" subscale (ρ=0.563, p=0.019). Therefore, at fast speed, as BPI now scores increased, pelvic side flexion tended to increase. For STS, as described above, there were statistically significant correlations between foot initiation and RDQ scores.

Table 3.5.26: Results of Spearman's rank correlation coefficient for objective measures and self-report in CLBP sample

Parameter	**RDQ**	**BPI W**	**BPI M**	**BPI I**	**BPI N**
L step length	-0.319 (0.212)	0.179 (0.493)	0.207 (0.425)	-0.091 (0.728)	0.211 (0.417)
R step length	-0.340 (0.182)	0.088 (0.737)	0.169 (0.518)	-0.082 (0.754)	0.170 (0.515)
L stride length	-0.343 (0.178)	0.141 (0.590)	0.193 (0.458)	-0.105 (0.689)	0.187 (0.471)
R stride length	-0.952 (0.166)	0.131 (0.615)	0.184 (0.481)	-0.109 (0.678)	0.190 (0.466)
Side Flex pelvic kinematics normal gait	0.251 (0.331)	0.160 (0.540)	0.334 (0.190)	0.114 (0.663)	0.444 (0.074)
F/E lumbar kinematics fast gait	-0.262 (0.311)	-0.165 (0.528)	-0.193 (0.457)	-0.147 (0.573)	-0.271 (0.292)
Side Flex pelvic kinematics fast gait	0.069 (0.793)	0.227 (0.381)	0.478 (0.052)	0.178 (0.494)	**0.563** **(0.019)**
STS starting position	0.173 (0.553)	-0.099 (0.737)	0.095 (0.746)	0.462 (0.096)	0.228 (0.434)
STS Peak lumbar flexion	0.308 (0.283)	0.107 (0.716)	0.323 (0.260)	0.471 (0.089)	0.380 (0.180)
Foot initiation STS	**0.633** **(0.015)**	0.176 (0.546)	0.245 (0.399)	0.531 (0.051)	0.398 (0.158)

Correlation reported as correlation coefficient, ρ (p value)
Key: RDQ = Roland Morris Disability Questionnaire, BPI W = Brief Pain Inventory "worst" subscale, BPI M = Brief Pain Inventory "Mean" subscale, BPI I = Brief Pain Inventory "Interference subscale, BPI N = Brief Pain Inventory "now" subscale.

3.6: Discussion

This discussion is presented in two main sections, corresponding to the results presented above. Firstly, the results on repeatability of gait and STS are discussed, followed by the results on the effect of CLBP on gait and STS. Hypotheses are proposed to explain the findings, and their implications for physiotherapy practice and measurement in physiotherapy are considered.

3.6.1: Repeatability of gait and Sit to Stand

3.6.1.1: Spatial and temporal parameters of gait

Two previous studies have reported on the repeatability of the spatial and temporal parameters of gait measured using the Vicon motion analysis system. Table 3.6.1 compares their results to those of this study. In the studies by both Kadaba et al (1989) and Growney et al (1997) healthy subjects walked at self-selected normal walking speed. It can be seen that the sample average coefficient of variation (CV) values in the current study for the control sample at normal walking speed compare well with the results of Growney et al (1997). Two exceptions are speed and left stance, which are 0.5 to 1% higher in the present study. In comparison to the results of Kadaba et al (1989), this study's CV values were up to 1% higher, with the exception of cadence which was 0.5% lower. The small differences between this and the previous two studies might be explained by the ages of the samples. Kadaba et al (1989) recruited subjects aged 18 to 40; Growney et al (1997) did not disclose the ages of their small sample, whereas there was a broader age range in the present study (19 to 54). Nonetheless, there is sufficient proximity of results to conclude that the control subjects' gait at normal speed was as repeatable as that of previously reported samples.

This study also reported the repeatability of parameters not included in the two previous studies. It can be seen that stride and step time repeatability approximates to that of the other parameters. However, double support has the highest of all the CV values. Double support is the shortest event of the gait cycle (Whittle, 2002) making it susceptible to measurement error (Wall and Crosbie, 1996). A CV value of 5.4% in the control sample represents a difference in timing of 0.01 seconds, which is unlikely to be considered clinically significant. This highlights one limitation of the CV statistic, which can become unstable at small mean values (Growney et al, 1997).

Table 3.6.1: Comparison of sample average Coefficient of Variation values (%) in this study with those from previous studies

Parameter	Kadaba et al (1989)	Growney et al (1997)	Control Normal	Control Fast	CLBP Normal	CLBP Fast
Cadence	1.9	2.29	1.4	2.1	2.1	1.5
Left stride time	NR	NR	1.8	2.6	2.4	1.5
Right stride time	NR	NR	2.3	2.5	2.1	2.1
Left step time	NR	NR	3.0	5.1	5.1	3.2
Right step time	NR	NR	2.6	5.4	3.6	3.7
Left SS	NR	NR	2.7	5.1	4.7	2.4
Right SS	NR	NR	3.9	4.8	3.5	3.1
Double Support	NR	NR	5.4	14.5	8.3	11.7
Left stance (foot off)	NR	1.80	3.0	2.3	2.7	2.1
Right stance (foot off)	NR	1.58	1.5	2.7	3.1	2.0
Left stride length	1.7	2.83	2.2	2.2	2.4	1.5
Right stride length	1.7	2.83	2.2	2.3	2.2	1.5
Left step length	NR	2.88	2.4	2.6	3.5	2.8
Right step length	NR	2.84	2.9	2.7	3.8	2.5
Speed	2.9	2.69	3.4	2.9	3.8	2.9

Key: NR = Not reported

This study also reported the repeatability of gait at self-selected fast speed and that of CLBP patients. For control subjects walking at fast speed, statistically significantly increased CV values were observed for left and right step times and double support ($p<0.05$) suggesting that control subjects' gait may be slightly less repeatable at faster speeds. This may be reflective of the methodology. Subjects were first asked to walk at their normal, comfortable speed, which would presumably be familiar and well rehearsed. They were then asked to walk "as fast as comfortably possible". This would presumably be less familiar to many subjects who will by definition usually walk at "normal" speed. Therefore, it might be expected for gait to be less repeatable at fast speed.

For the CLBP sample, gait appeared slightly less repeatable than that of controls at normal speed; however the only difference to reach statistical significance was left single support. This is another short event in the gait cycle; therefore the clinical significance of this difference could also be questioned, as discussed for double support above. The CLBP sample's gait appeared slightly more repeatable than the control sample at self-selected fast speed, with many parameters approximating to the values reported by Kadaba et al (1989) and Growney et al (1997) for their healthy subjects. Since both samples walked at similar speeds on both occasions (normal and fast), these differences can not be attributed to a speed effect, but are more likely to represent real differences between normal and CLBP gait. Left single support and cadence reached statistical significance in this case. The clinical significance of small CV differences in single support has been discussed. The CV values for cadence were very low (1.5 and 2.1%) and therefore the clinical significance of these differences could also be questioned. However, from these results, it could be hypothesised that there is slightly more flexibility in the gait pattern of CLBP patients at normal speed as a strategy for being able to maintain the activity of walking without increasing pain levels. Small alterations in spatial or temporal parameters between subsequent walking trials might be required to prevent muscle fatigue and/or onset of pain. In order to walk at fast speeds however, it appears that there is less flexibility in the gait pattern. In the CLBP sample, the CV value for left single support was statistically significantly reduced at fast compared to slow speed ($p<0.01$) confirming the reduction in variability in this parameter at least. Perhaps this is indicative of the "guarded" gait patterns identified in early research on LBP (Keefe and Hill, 1985), only present in the current sample when challenged to walk outwith normal speed limits. This theory of a guarded gait in CLBP patients with related "stiffening" of the spine (Lamoth et al, 2006; Taylor et al, 2003) is discussed in full below.

It has been suggested that gait may be sufficiently reliable to base analysis on only one trial (Kadaba et al, 1989). However, these results suggest that this might be appropriate for control subjects walking at self-selected normal speed only, and not at faster speeds or for CLBP patients.

3.6.1.2: Spinal kinematics during gait

From the graphs (figures 3.5.3 to 3.5.8) it appeared that each subject's pelvic and spinal kinematics during gait were repeatable to within approximately 5° between the three trials and that the waveforms were similar for most subjects. Both samples demonstrated a similar range in average CV values for pelvic and spinal joint ROM; 7.2 to 16.5% for the control and 7.1 to 15.2% for the CLBP sample's respectively. At normal walking speed the CLBP sample demonstrated a statistically significant increase in the average CV value for spine side flexion compared to the control sample, suggesting reduced repeatability of this parameter. At fast speed however, the CLBP sample demonstrated a larger statistically significant reduction in average CV value for pelvic rotation, suggesting increased repeatability of this kinematic parameter at fast speed. These findings somewhat contradict the findings of Vogt et al (2001). They demonstrated increased variability of spinal kinematics in all three planes in CLBP patients walking at 1.25m/s, similar to the normal speed of the CLBP sample in the current study. However, although side flexion was the only statistically significant difference in the current study, there was a small non-significant increase in the CV value of rotation in the CLBP sample. Flexion/extension was similar to that of the control sample. Therefore, it is possible that the small sample size in the current study failed to detect significant differences in rotation. However, the subjects themselves might be responsible for the different results from the two studies. Vogt et al (2001) did not report the source of recruitment for their study, whether physiotherapy candidates or undergoing some other from of management such as consultant-based outpatient treatment or surgery. However, their subjects did report greater pain and disability levels at the time of testing their gait suggesting that symptom severity might be a factor in the repeatability of spinal kinematics. Vogt et al (2001) did not investigate the effect of speed on spinal kinematic repeatability; this appears to be the first study to report increased spinal kinematic repeatability during gait at self-selected fast speed. Although pelvic rotation was the only statistically significant difference, there were non-significant 2 to 5% reductions in CV values for spine side flexion and rotation and pelvic flexion/extension. This finding again suggests that CLBP patients' gait is less flexible at faster walking speeds, a finding which might relate to the guarded gait pattern introduced above, and discussed in full below.

The average CV values for both samples (control and CLBP) of between 7.1% and 16.5% were greater than those for most of the spatial and temporal parameters of gait, and it could be argued that differences of this magnitude may be clinically significant. This perhaps highlights the benefit of calculating the CV for the joint ROM, rather than the coefficient of multiple correlation (CMC) for repeatability of the entire waveform, as some authors report (Schache et al, 2002a; Kadaba et al, 1989; Growney et al, 1997). The CMC calculates the similarity of the waveform as a whole, and does not detect at which point any differences lie. Calculating the CV of the joint ROM has highlighted however that although the waveforms were similar in appearance, small but perhaps important differences in the mean joint ROM were detected. Previous authors have concluded that pelvic and lower limb kinematics during gait are highly reliable (Kadaba et al, 1989; Growney et al, 1997). However, the results of the current study and those of Vogt et al (2001) suggest that spinal kinematics in CLBP gait are not sufficiently repeatable to base analysis on one gait trial only.

3.6.1.3: Timing of Sit to Stand

Both the control and CLBP subjects displayed similar CV values for the timing of STS. In keeping with the kinematic parameters discussed above however, these values (14%) were elevated in comparison to the spatial and temporal parameters of gait. There was wide intersubject variability in the repeatability of STS in both the normal and control subjects, suggesting that some subjects' STS is more repeatable than others, and thus affecting the overall CV value. This may be related to methodology, since unlike some previous studies on STS (Schenkman et al, 1990) no attempt was made to control the timing of the STS manoeuvre, therefore some variability might be expected. STS was carried out at self-selected natural speed, which has previously been shown to provide less repeatable temporal measures than at slow speed (Yamada and Demura, 2005; Hanke et al, 1995). The timing of STS was short for both samples; therefore a CV of 14% represents variability in timing of 0.3seconds. Whether this would be considered clinically significant might perhaps be a matter of debate. It can be concluded from the results that subjects' timing of STS is less repeatable than timing of events during the gait cycle, and that consideration should be given to analysing more than one STS manoeuvre.

3.6.1.4: Spinal kinematics during Sit to Stand

Spinal kinematics during STS were the least repeatable of all the parameters investigated, equally so for the control and CLBP sample. Differences of up to 24% might be considered to have a clinically significant effect on the relatively small joint ranges involved. There was no previous research with which to compare these results. However, STS research appears to have been conducted using multiple trials for analysis (for example Coghlin and McFadyen, 1994 and Gioftos and Grieve, 1996 both evaluated five trials) and the results of this study support that approach.

In order to investigate spatial, temporal and kinematic parameters during gait and STS in both control and CLBP subjects, it appears that analysing the average of more than one trial will produce more reliable results, since choosing one "typical" trial will be problematic with the levels of variability involved. Averaging a number of trials was therefore the approach taken for the comparative and correlational aspects of this study.

3.6.2: Between sample differences in gait and Sit to Stand

3.6.2.1: Spatial and temporal parameters of gait

The self-selected walking speeds of the control sample were within previously published normal limits (Al-Obaidi et al, 2003; Crosbie et al, 1997a), therefore the control sample appeared to provide a reasonable comparison for the CLBP sample. The CLBP sample's self-selected walking speeds were somewhat faster than previously published results. Al-Obaidi et al (2003) reported a self-selected normal walking speed of 0.73 (females) to 0.98m/s (males), and self-selected fast walking speed of 1.24 (females) to 1.70m/s (males). In comparison, this study found a mean normal speed of 1.33m/s and a mean fast speed of 1.81m/s. Earlier studies also reported slower self-selected normal walking speeds in LBP patients (Khodadadeh and Eisenstein, 1993; Keefe and Hill, 1985). However, the earlier studies recruited subjects more likely to have severe symptoms than in the current study (for example chronic pain clinic patients and surgical candidates). The more recent study (Al-Obaidi et al, 2003) included subjects with a pain duration of seven weeks or longer, compared to the twelve weeks in this study; therefore the former may have included some patients with more acute and perhaps therefore more severe symptoms. This reflects the benefit that this study had in recruiting a sample representative of the types of CLBP patients typically seen by out-patient physiotherapists in Grampian. The results will be more readily generaliseable than those from some previous studies employing alternative recruitment strategies.

Both samples increased their walking speed between the self-selected normal and fast conditions by similar amounts, (40% control, 36% CLBP).

This suggests that CLBP patients have a similar range of walking speeds available to them as do pain-free controls. All spatial and temporal parameters were altered as a result of the increase in speed; all reached statistical significance except for left stance in the CLBP sample. However, the latter did near marginal significance (p=0.055), and both the small size of the actual difference (1.36% for left stance, 2.20% for right stance) and the small sample size involved may have affected this result, which is unlikely to be considered of clinical significance. The amount of difference in some parameters did however demonstrate differences between the samples in the mechanism of increasing walking speed, suggesting that CLBP patients decrease step time and therefore increase cadence to achieve an increased walking speed. This was in contrast to controls who increased single and reduced double support phases by a greater amount than CLBP patients in order to increase speed. CLBP patients therefore appear to favour taking more steps of a shorter duration in order to increase speed. This may be related to the guarded gait patterns at fast speed discussed above (section 3.6.1.1); It might be easier to guard the spine using more steps of a relatively short duration than an alternative strategy such as significantly increasing step and stride lengths which might necessitate increased spinal movement. Again, the theory relating to guarding the spine is further discussed below.

At normal speed, the spatial parameters of stride and step length demonstrated statistically significant between group differences. CLBP patients' step lengths were 5 to 6cm shorter than controls, with a subsequently shortened stride length of 10 to12cm; differences which could be considered clinically significant. There was no statistically significant difference in walking speed however. The CLBP patients appeared to compensate for their reduced stride and step lengths by decreasing step times and thereby increasing their cadence, which was slightly higher than the control sample (although not statistically significantly different), a strategy reported by Al-Obaidi et al (2003) at fast speed only. Walking speed has been recommended as an outcome measure for CLBP patients (Lee et al, 2002). However, these results suggest that measuring walking speed alone might not reveal any gait deviation in CLBP patients with mild to moderate symptoms, but that a more comprehensive measurement of the spatial parameters might be more informative.

The lack of correlation between the spatial parameters of stride and step length and either the RDQ or BPI scores suggests that gait analysis is not a direct measure of activity limitation. This is similar to the results of Al-Obaidi et al (2003) in which negligible relationships were reported between walking speed and pain or disability levels. This result however might support the use of gait analysis in CLBP patients, in order to measure each component of the WHO ICF (2001). The three components relating to functioning are impairment, activity limitation, and participation restriction (see chapter 1, p8). Gait analysis is arguably measuring impairment of body structures/function whilst self-report of disability is predominantly measuring activity limitation and participation restriction (Sigl et al, 2006). Therefore, combining gait analysis and a commonly used self-report measure such as the RDQ may provide a comprehensive measurement of all three ICF components.

At fast speed there were between-group differences of a similar magnitude for stride and step length and of a greater magnitude for cadence; these were not statistically significant however. This may be a limitation of the small sample sizes reducing the power of the statistical tests to detect differences of this magnitude (Bland, 2000). Lamoth et al (2006a; 2006b) did observe reductions in stride length at fast walking speed in their respective samples of 12 and 16 CLBP patients during treadmill gait. Clearly further research is required to determine whether these differences are present in level overground walking in a larger sample of CLBP patients with similar pain and disability levels to those in the current study. Possible theories to account for the differences in the CLBP patients' gait are considered below, following discussion of spinal kinematics at both speeds.

3.6.2.2: Spinal kinematics during gait

Joint Range of Motion control sample

The ranges of lumbar spinal joint motion for the control sample in all three planes were at the upper end of previously reported results, as table 3.6.2 demonstrates. However, it is difficult to draw direct comparisons with previous research due to the variability in methodology. This is the first study to report spinal kinematics during gait derived from a seven-camera three-dimensional optical measurement system. Several of the studies listed in table 3.6.2 have used fewer cameras (typically two or four). The use of more cameras in this study should increase the accuracy of the results, since markers are more likely to be seen by two cameras at any point in time which is the requirement for its three-dimensional co-ordinates to be calculated (Rowe, 1999). The ranges reported in this study do approximate to at least some previously reported results however.

Table 3.6.2: Comparison of control sample's lumbar joint range of motion during gait with previous studies

	Flex/Ext		Side Flex		Rotation	
	Normal	**Fast**	**Normal**	**Fast**	**Normal**	**Fast**
Current study	**8.26**	**10.67**	**13.56**	**13.92**	**10.84**	**11.00**
Taylor et al (2004)	3.3	NR	10.5	NR	6.4	NR
Feipel et al (2001)	6	7	11	12	13	16
Callaghan et al (1999)	6.5	6.5	8	8.36	8.76	8.78
Taylor et al (1999)	3.24	NR	12.84	NR	6.44	NR
Crosbie et al (1997)	3	4	9	13	4	5
Krebs et al (1992)	7	NR	9	NR	10	NR

Key: NR = Not Reported

The flexion at normal speed approximates to the value reported by Krebs et al (1992) and Feipel et al (2001). Side flexion at normal and fast speeds approximate to those of Taylor et al (1999) and Crosbie et al (1997a) respectively, and rotation approximates to that of Krebs et al (1992) and is a few degrees less than that reported by Feipel et al (2001). All ranges represent a fraction of the available spinal range of motion (Van Herp et al, 2000); Ten percent for flexion/extension, 25% side flexion and 40% rotation, suggesting that the joint ranges reported are anatomically and biomechanically feasible.

There are two possible conclusions that can be drawn. Firstly, it may be that the methodology used is accurately reporting spinal kinematic ranges during gait that have previously been under-estimated (with the exception of rotation). Half the studies in table 3.6.2 have used treadmill gait, which has been shown to underestimate spinal kinematic range in comparison to overground gait (Vogt et al, 2002). Therefore it is feasible that the current study in utilising overground walking, and an accurate optical measurement system, might be providing more reliable results. Secondly, the current methodology may be over-estimating spinal kinematic ranges. The most likely cause of this would be movement of the markers due to skin shifting

(Schache et al, 2002a; Feipel et al, 2001). This did not appear to be occurring during the data collection protocol, but cannot be entirely ruled out. However, even if there were an element of over-estimation, the magnitude would presumably be the same for all subjects, as the same protocol was followed throughout the data collection process. Therefore the relative differences between CLBP and control subjects, which are of interest in this study, should be unaffected.

Pattern of kinematic traces control sample

The findings presented in section 3.5.3 in relation to the kinematic traces are congruent with some of the previous findings reported in section 3.2.2.3, but are in disagreement with others. The main sources of agreement and disagreement are now highlighted, and possible reasons for these explained.

Lumbar Flexion/Extension

The results are similar to those of Saunders et al (2005), Callaghan et al (1999) and Syczewska et al (1999). All three studies reported flexion following heelstrike, during early and mid-stance, followed by an extension phase in late stance. This can be seen in the present findings also (figure 3.5.16). Callaghan et al (1999) reported maximal extension around heel contact, which the current findings replicate, and Syczewska et al (1999) reported flexion peaks at 25% and 75% of the gait cycle, also replicated in the current study. Crosbie et al (1997a) and Krebs et al (1992) reported flexion peaks at heelstrike, which conflicts with both the present study and the three studies reported above. That the current findings replicate those of Syczewska et al (1999) is re-assuring; their methodology enabled measurement of lumbar spinal motion, which was the purpose of the present study also. Some of the previous studies have measured a combination of lower thoracic and lumbar motion by applying their upper marker to the 12th thoracic vertebra (Saunders et al, 2005; Crosbie et al, 1997a). Therefore some parameters may be altered, as there are differences between thoracic and lumbar segments with respect to both phase relations (Crosbie et al, 1997a) and ROM (Hamill and Knutzen, 2003).

Side flexion

The current findings again replicate those of Syczewska et al (1999) who described lumbar side flexion as occurring towards the swing leg, and those of Callaghan et al (1999) who also reported side flexion towards the swing leg, peaking around toe-off. Syczewska et al (1999) measured lumbar motion as previously discussed. Callaghan et al (1999) attached their upper marker on a plate at the T12/L1 level, so it is possible that they measured some lower thoracic motion with this methodology, but perhaps not as pronounced as those who placed markers directly over the 12th thoracic vertebra.

Several studies in which the markers were attached to the 12th thoracic vertebra or higher are in disagreement with the current findings regarding lumbar side flexion (Saunders et al, 2005; Crosbie et al, 1997a; Krebs et al, 1992). These studies report side flexion as occurring towards the stance limb, in the opposite direction to pelvic side flexion (obliquity). The results of the current and previous studies (Callaghan et al, 1999; Syczewska et al, 1999) support the theory that lumbar side flexion follows the pelvis, but that lower thoracic side flexion occurs in the opposite direction.

Rotation

Syczewska et al (1999) did not report lumbar kinematics for the transverse plane; however the current results again replicate those of Callaghan et al (1999) who reported rotation towards the weight-bearing leg at heelstrike followed immediately by rotation to the opposite side. Callaghan et al (1999) reported peak rotation occurring at heelstrike; the current findings were of peak rotation slightly later, but still during the double support phase. Crosbie et al (1997a) also reported rotation towards the swing side during single support, reaching neutral at mid-stance and rotating to the opposite side at the next heelstrike. The current results replicate these findings also. Saunders et al (2005) and Krebs et al (1992) reported rotation as occurring in the opposite direction to that in the current study. However, both placed markers on the thoracic spine, therefore as for side flexion above, it appears that the lumbar spine follows the pelvis with respect to rotation, but the thoracic spine rotates in the opposite direction. Furthermore, since both side flexion and rotation of the lumbar spine during gait appear to occur towards the same side, this would suggest that the previously reported coupling of opposite rotation upon side flexion (Hindle et al, 1990) does not occur during gait. This is in part agreement with Feipel et al (2001) who could find no consistent relationship between rotation and side flexion in their pain-free sample during treadmill gait. This could be related to the small inter-segmental movements previously noted for normal gait that have been suggested to reduce the energy consumption during gait (Syczewska et al, 1999), and to the oscillating pattern of spinal motion during gait. It might be expected for these reasons that spinal motion during gait will not replicate inter-segmental movements observed during full-range rotation or side-flexion performed in a standing position (Hindle et al, 1990).

Effect of speed

The small increases in amplitude of lumbar spinal kinematics with increased speed have been previously reported (Saunders et al, 2005; Callaghan et al, 1999; Crosbie et al, 1997a; Taylor et al, 1996), as have the lack of change in pattern of kinematic traces (Saunders et al, 2005). Therefore, the control sample again provided a suitable comparison for the CLBP sample.

In conclusion, the current results have replicated those from the previous studies most likely to have measured true lumbar spinal kinematics. This suggests that the methodology was appropriate for this purpose, and that the control sample's kinematic traces provided a sound comparison for the CLBP sample.

Joint Range of Motion Chronic Low Back Pain sample: comparison to control sample

There was a statistically significant reduction in the range of lumbar flexion/extension during gait at self-selected fast walking speed ($p<0.005$). This has not been previously reported, however the previous studies that have investigated lumbar kinematic range during CLBP gait have either omitted to explore sagittal plane motion (flexion/extension) or gait at fast speed. Vogt et al (2001) based their conclusion that CLBP had no effect on kinematic amplitude on treadmill gait at a controlled speed of 1.25m/s, equivalent to the self-selected normal speeds in the current study. Lamoth et al (2006a; 2006b) did investigate kinematics at faster speeds but only the transverse plane movements of rotation, since the focus of their study was on rotational phase relations between spinal segments. Therefore, this appears to be the first study to report this finding.

There were also statistically significant between-group reductions in pelvic side-flexion of approximately 3° at both speeds ($p<0.03$) which were also not found by Vogt et al (2001). The reasons for the different findings in this study and that of Vogt et al (2001) are unclear. However, the latter recruited CLBP subjects with pain only between the area of T12 and the gluteal folds and analysed treadmill gait. The inclusion of six subjects with leg pain in this study and the analysis of overground walking might therefore account for the different results. Clearly, a larger study would be required to confirm this finding of altered pelvic side flexion in CLBP patients. There was a positive correlation ($\rho=0.563$, $p<0.02$) between pelvic side flexion at fast speed and the "pain now" subscale of the BPI such that despite pelvic side flexion being reduced in the CLBP sample, as pain increased so did lumbar side flexion. This suggests that either subjects with higher pain levels find it more difficult to "guard" or "stiffen" the spine at fast speeds, or that the increased pelvic side flexion that occurs with increased speed is associated with increased pain in some subjects.

Taylor et al (2003; 2004) also failed to detect differences between patients and controls with respect to lumbar kinematic range; however their studies were of patients with acute LBP (less than seven weeks duration).

The current findings suggest that differences in lumbar kinematics might only be present at fast walking speeds, whereas differences in pelvic kinematics might be present at both normal and fast speeds. This confirms the need to explore the effect of speed in this type of study.

The difference in lumbar flexion demonstrated by the CLBP sample in the current study was a reduction in amplitude of approximately 2.5° compared to the control sample, and evident as a flattening of the kinematic trace at both flexion peaks. There was not a complete failure to increase joint ROM in response to increased walking speed, but the CLBP sample did demonstrate a smaller increase in flexion than the control sample (2.41° control, 1.43° CLBP). The CLBP sample also demonstrated a reduced lumbar flexion ROM at normal speed compared to the control sample, but this was not statistically significant. The kinematic traces also appeared to demonstrate an increase in lumbar side flexion ROM for CLBP subjects compared to controls at fast walking speed. There was a difference of 2.76°, however this did not reach statistical significance, therefore either the sample size lacked the power to detect a difference of this magnitude, or altered lumbar kinematics are restricted to the sagittal plane only.

Pattern of kinematic traces Chronic Low Back Pain sample

As for the control sample, with the exception of the ROM differences discussed above and evident in the traces, there were no differences in the overall patterns of the kinematic traces. The lumbar spine retained a motion pattern that was in phase with the pelvis at both normal and fast walking speeds, replicating the results of Lamoth et al (2004) for experimental LBP and Lamoth et al (2006b) for CLBP.

Possible explanations for gait differences

The results suggest that CLBP patients increase walking speed within normal limits by decreasing step time (and thereby increasing cadence) to a greater degree than control subjects, who utilise relatively larger decreases in double support times. It has been suggested that LBP patients adopt strategies such as reducing stride length in order to walk at self-selected speed, and that increasing these parameters in order to increase walking speed are available to a greater degree than in the pain-free state (Taylor et al, 2003). However, this has been demonstrated in patients with acute LBP. In the current study stride and step lengths were increased to the same degree as for control subjects in order to increase speed, and other parameters (step time and thereby cadence) were altered to a greater degree to allow for increased speed. This suggests that in acute and chronic LBP different strategies are employed to cope with speed perturbations, and that the effect of CLBP on step and stride lengths is apparent at both fast and normal speeds. Although the differences between samples were not statistically significant at fast speed, the magnitude of difference in step and stride lengths were similar to a clinically significant degree. The decreased step and stride times during gait at self-selected speed may therefore allow acute LBP patients to increase these parameters in order to walk at fast speeds (Taylor et al 2003). However, there may be a more fixed adaptation of step and stride lengths in chronic LBP. The reasons for this are unclear, but may in part be in response to fear of pain and reinjury in the chronic state (Al-Obaidi et al, 2003). This is of relevance to the physiotherapist dealing with CLBP patients since decreased stride and step times might be indicative of a motor control impairment which could benefit from therapeutic strategies to re-educate motor control. This is discussed in full below, but it has been hypothesised that the three most likely mediators of altered motor control in the presence of LBP are the direct influence of pain on motor centres, fear-avoidance and changes in the sensory system (Hodges and Moseley, 2003).

The shortened step and stride lengths might also help to account for the differences in spinal and pelvic kinematics. By shortening the stride length it may be easier for subjects to stabilise or "splint" the low back (Lamoth et al, 2006; Taylor et al, 2003), evident in the reduced pelvic side flexion at both speeds. Therefore, the "guarded" gait patterns observed in earlier research (Keefe and Hill, 1985) appears to be associated with guarding or stiffening of the trunk itself. The lumbar spinal kinematics present more complex results, only being statistically significantly reduced at fast speed. However, the reductions in flexion are due to reductions in the flexion peaks which occur in mid single support. This is the point in the gait cycle where the swing leg is passing the stance leg and the trunk is reaching its highest point and slowing its forward progression in order to convert the kinetic energy of forward motion to the potential energy of height (Whittle, 2002). Reducing lumbar flexion at this point in the gait cycle may therefore represent an attempt to reduce perturbations in the spine by reducing the forward motion and therefore height of the trunk, achieving a relatively stiff or "splinted" spine (Lamoth et al, 2006; Taylor et al, 2003). That this only occurs at fast speed suggests that altering step and stride lengths and pelvic side flexion provide adequate strategies to the CLBP subject at normal speed. However, when speed is increased it may be more difficult to maintain spinal stiffness, and the additional strategy of altering lumbar flexion might therefore provide an additional strategy which enables the CLBP subject to maintain spinal stiffness when walking at this speed. The correlation between pelvic side flexion at fast speed and the "pain now" subscale of the BPI appears to support the theory that it is more difficult for CLBP subjects to maintain spinal stiffness at fast walking speed. It is at fast speeds that this strategy appears to fail in the more painful subjects, with increases in pelvic side flexion associated with increased pain levels.

The mechanism by which spinal and pelvic kinematics are reduced in CLBP patients might be explained by the alterations in muscle activity demonstrated in previous studies. There is now general agreement that CLBP patients demonstrate reduced activity of the deep intrinsic spinal muscles (for example transversus abdominis; Silfies et al, 2005) and increased activity of the more superficial muscles (for example rectus abdominis, internal and external obliques; Ferreira et al, 2004). This is in part in keeping with the pain-adaptation model proposed by Lund et al (1991) which suggests that pain decreases muscle activation when the muscle is active as an agonist and increases muscle activation when the muscle is active as an antagonist. Hence, reduced activity of the deep spinal muscles and relative increased activity of erector spinae will act to stabilise the spine as a whole and reduce pelvic and lumbar kinematics. Indeed, increased lumbar erector spinae activity has been demonstrated in CLBP patients during gait (Lamoth et al, 2006 a). This may be advantageous for CLBP patients in order to avoid pain-provoking stresses in injured structures (van Dieen et al, 2003), and in the chronic state may also be partly related to fear of pain and reinjury (Al-Obaidi et al, 2003).

Van Dieen et al (2003) proposed three hypotheses to explain why LBP patients require the additional stability provided by the mechanism of altering trunk muscle recruitment. Firstly, the passive stiffness of the spine may be reduced due to disc or ligamentous injury. Secondly, muscle force may be reduced in the painful state, and therefore the capacity to reduce perturbations is reduced. Finally, sensorimotor control is disturbed, interfering with corrective responses. There is evidence to support all three hypotheses and it is theoretically possible that some or all are present in individuals with CLBP to a greater or lesser extent.

The above discussion suggests that the impairment seen in the current study (of reduced pelvic and spinal kinematics) may be one of motor control rather than one of loss of joint ROM per se. The evidence for a link between CLBP and altered motor recruitment of the trunk combined with the finding of reduced step and stride lengths suggest that the reduced kinematics represent an attempt to stabilise the spine. Moreover, pelvic side-flexion was the only movement to demonstrate statistically significant reductions at both normal and fast walking speeds. Were the impairment due to reduction in joint ROM per se it might be expected that spine flexion/extension would be significantly reduced at normal and not only fast walking speed and that pelvic and lumbar kinematics in the other planes would also be affected. However, it is possible that the reduced pelvic and lumbar kinematics observed in this study represent a true reduction in joint ROM in this sample of CLBP patients, and it is feasible that the reduced range would necessitate reductions in stride and step length. The former hypothesis (of altered kinematics representing an attempt to stabilise the spine) is arguably more likely. This is due to the previous research in which reduced stride and step lengths have been present in the absence of reduced spinal and pelvic kinematic range (Lamoth et al, 2006a, Lamoth et al, 2006b, Taylor et al, 2004). However, the link between motor control impairment and altered spinal and pelvic kinematics in mild to moderate CLBP patients would need to be confirmed with a study combining kinematic analysis with EMG analysis of muscle activity. The same study should also investigate total ROM, since the possibility that there was a true reduction in joint range can not be ruled out in the present study.

It has been suggested that the pain-adaptation model of Lund et al (1991) is somewhat simplistic for describing motor control impairment in LBP (Hodges et al, 2003; van Dieen et al, 2003), since alterations in muscle activity are specific to both the individual patient and the task being performed (van Dieen et al, 2003). The inter-subject variability in the current study supports this theory, evident in the relatively large SD's for pelvic and lumbar joint ROM. Indeed, the high individual CV values for spinal kinematics suggests considerable intra-subject variability also.

In summary, the results of the current study support the theory that motor control is impaired in CLBP patients, and that CLBP patients employ strategies to increase spinal stability, evident in the reduced kinematics, in order to avoid pain-provoking stresses on the spine. This theory suggests that the strategy of increasing spinal stability is helpful to the CLBP patients in terms of reducing pain; however it has been suggested that there might be some negative consequences of such a strategy. Van Dieen et al (2003) suggested that hyperactivity could cause pain in the hyperactive muscles, increased co-contraction could increase forces acting on the spine, and the motor control impairment could limit the functioning of patients. Clearly, these are issues worthy of consideration by the physiotherapist, the most pertinent perhaps being whether the physiotherapist should attempt to restore "normal functioning" by re-educating motor control, perhaps in combination with interventions designed to address both the sensory system and the fear-avoidance components. Alternatively, if the "impairment" is in fact a helpful strategy that allows the CLBP patient to function at a reasonable level, it may be inappropriate to attempt to re-educate the alterations in motor control, thereby restoring "normal" spinal kinematics. This is considered in section 3.6.3 below.

3.6.2.3: Timing of Sit to Stand

Both groups performed the STS manoeuvre within previously reported normal limits (Tully et al, 2005; Kerr et al, 1997; Kerr et al, 1994). Therefore, as with gait, there was no effect of CLBP observed on overall speed of STS. There were also no between-group differences in the three phases of STS analysed. The phases for the control group differed from those reported in the original study by Schenkman et al (1990) who developed this definition of STS. In their study, phase I accounted for 28%, phase II 18% and phase III 54% of the STS cycle. In the current study, phase I was similar (25%), but phase II was longer (26 %) and III shorter (46%) than that reported by Schenkman et al (1990). However, this may be due to the current study reporting natural STS. Schenkman et al (1990) employed a metronome set at 52 beats per minute, and speed is known to affect the method of STS (Gross et al, 1998). It is unlikely to be due to other methodological differences since the same events were used to identify the start and end of phases II and III. However, the seven-camera Vicon system used in the present study may be more accurate than the four-camera Selspot system employed by Schenkman et al (1990), and may in part account for the differences.

The lack of difference between the CLBP and control groups is in contrast to the findings of Coghlin and McFadyen (1994), whose small all-male sample performed STS slightly faster than their control sample. However, direct comparison is difficult due to the differences in measurement tools and definitions of STS. This finding is also in contrast to that of Shum et al (2005) in which subacute LBP subjects took longer to stand than controls. Shum et al (2005) also reported that their LBP subjects took longer to reach maximum hip and lumbar spine flexion, therefore their LBP subjects would have displayed a longer momentum-transfer phase (II) than their control group. This finding was not present in the current study. This may be related to pain and disability levels since the subjects in the study by Shum et al (2005) reported pain and disability scores at least twice that of the subjects in the present study. Therefore, it is possible that timing of STS is affected by moderate to severe LBP symptoms. It may also be reflective of an adaptation that occurs in the chronic state, but has not yet taken place in the subacute state, to allow STS to be performed at normal speeds. This adaptation might conceivably be one of motor control or one of psychologically adapting to the pain that does not occur in the more acute phase. It has been suggested that altered motor control strategies might account for the ability of some CLBP patients to perform trials of lumbar positioning activities with levels of precision and variability similar to control subjects (Descarreaux et al, 2005). If this is the case, altered motor control might also provide a useful strategy towards maintaining speed of STS.

The above findings suggest that simple timing of one STS manoeuvre would fail to detect differences from the norm in CLBP subjects. However, some differences were detected in the STS strategy employed and these are now discussed.

3.6.2.4: Spinal kinematics and overall strategy of Sit to Stand

Joint range of motion

Hip joint ROM in the control sample was congruent with that reported by Shum et al (2005) for their control sample but approximately 10° less than that reported by Tully et al (2005). However, direct comparisons are difficult due to different measurement tools used in this and the two previous studies. This is also evident in the findings for lumbar ROM which was 10^{o} less than that reported by Shum et al (2005) and 7° less than that reported by Tully et al (2005) for their respective control samples. The measurement tools used may be the reason for this difference; either the current tool (Vicon) underestimating or the electromagnetic tracking device (Fastrak) used by Shum et al (2005) and the digitised video used by Tully et al (2005) overestimating lumbar motion during STS. It is unlikely that the current tool was underestimating lumbar motion, since it has already been discussed in section 3.6.2.2 that the current findings for gait demonstrated lumbar joint ranges in excess of most previously reported studies. Clearly, comparison of the different measurement systems and their relative accuracy for STS analysis would be beneficial. It is also possible that differences in the control samples account for the differences in reported joint ROM. In the current study the control sample were mostly females with an average age of 33, whereas the sample in the study by Tully et al (2005) were male and female with an average age of 20. The sample in Shum et al's (2005) study had an average age of 42 but the proportion of males and females was not reported. This finding again highlights the difficulty of comparing results from studies utilising different measurement and recruitment protocols.

The results showing no differences between groups with respect to joint ROM in the current study again suggests that the intensity or chronicity of symptoms may be important factors. Shum et al (2005) observed significant reductions in hip and lumbar ROM in subacute LBP subjects compared to controls; findings that were not present in the current study. This again suggests that, as for timing of STS, either a certain level of pain and disability is required to affect joint ROM, or a motor control or pain adaptation has taken place in the chronic state. This is considered further below.

Pattern of kinematic traces

It has been shown that there were no between-group differences in the patterns of kinematic traces for the lumbar spine, pelvis or hips (figure 3.5.24, p317). However, the most obvious differences in kinematics were the starting position and peak flexion of the lumbar spine, shifting the entire kinematic trace downwards for the CLBP sample, a finding that was statistically significant ($p< 0.02$). The finding of increased lumbar lordosis (extension) in sitting was also reported by Dankaerts et al (2006b) in a subgroup of CLBP patients whom they identified as presenting with an "active extension pattern". This classification was made on the basis of presenting with a motor control impairment in which lumbar extension provoked symptoms and patients tended to hold the lumbar spine in segmental hyperextension. Dankaerts et al (2006b) suggested that this was related to the lack of lumbar repositioning sense in the CLBP lumbar spine reported in previous studies (for example O'Sullivan et al, 2003), resulting in an inability to locate the "neutral zone" (Panjabi, 1992) and therefore a tendency to sit at the extremes of available range. Dankaerts et al (2006b) also described a second subgroup with a "flexion pattern" in which lumbar flexion aggravated symptoms and patients tended to lack segmental lumbar lordosis. Clearly this was not present in the current study and may be due to the small sample size. Despite this previous finding, however, the increased lumbar lordosis in the current study may also represent a compensatory strategy. By sitting relatively more extended, STS can be performed with normal joint ranges, kinematic patterns and timing but with a reduction in the peak lumbar flexion required; the current findings reported a statistically significant reduction in peak lumbar flexion during STS ($p<0.02$). This may represent further the "splinting" of the spine discussed above (section 3.6.2.2), thereby avoiding extremes of lumbar flexion which may be pain-provoking. It could however also represent a true loss of lumbar flexion in this sample; clearly further research is required in order to determine the cause of the reduced peak flexion. As suggested for gait (p341) a study combining kinematic and EMG analysis of STS with measurement of full lumbar and pelvic ROM should be conducted. Furthermore, the role of fear-avoidance in the altered sitting posture and peak flexion would be interesting to study in a larger sample of CLBP patients. The other studies reporting on STS in LBP patients (Shum et al, 2005; Coghlin and McFadyen, 1994) did not detect different sitting positions. However, they instructed all their subjects to sit upright, whereas in the current study subjects were asked to sit comfortably with no standardisation of the spinal starting position. Therefore, the current study has arguably analysed a more natural sitting position.

Overall strategy of Sit To Stand

The finding of foot movement during STS initiation and its statistically significant positive correlation with Roland Morris score ($\rho=0.633$, $p<0.02$) might be interesting to physiotherapists, since this strategy would be relatively easy to assess in the clinical environment. The small numbers involved in this study and the number of statistical tests conducted on the data require this result to be interpreted with caution. The significant result might be a chance finding, and a further study would clearly be required to determine the presence of this relationship in a larger sample of CLBP subjects, taking account of other possible confounding variables. Nonetheless this might represent further evidence of motor control impairment in CLBP. Moving one or both feet backwards whilst minimising trunk flexion has been shown to decrease loading of the low back during STS in obese subjects (Sibella et al, 2003). CLBP subjects in the current study reduced peak flexion of the lumbar spine by starting from a position of relatively increased extension. That the more disabled subjects also employed foot movement to initiate STS suggests that some CLBP subjects might employ this additional strategy to further ensure "splinting" of the spine in order to reduce loading and/or movement in a pain-provoking direction. Alternatively, if there was a true loss of spinal flexion then foot movement might represent a necessary compensatory strategy to allow STS to be conducted. The significant positive correlation with RDQ score also suggests that it might provide an objective measure of activity.

In summary, the results for STS appear to complement those for gait in supporting the theory of motor control impairment in CLBP patients. The CLBP patients in this study appeared to employ strategies to increase spinal stiffness during STS, evident in the reduced peak lumbar flexion and the use of foot movement in the more disabled subjects. As discussed for gait, the implications for physiotherapy treatment will depend on whether the strategy represents a helpful adaptive change in which case physiotherapists would not want to alter such a strategy. However, it may be argued that in the chronic state it is more likely to represent an unwanted residual from a former injury, in which case re-education of motor control by the physiotherapist would be desirable. These results suggest that this might involve re-education of the "neutral zone" (Panjabi, 1992) in sitting as well as the overall strategy of rising to stand.

3.6.3: Possible influence of results on clinical practice

Physiotherapy management

Many treatment approaches are recommended for the rehabilitation of CLBP patients, without consensus as to the most effective (Dankaerts et al, 2006). If, as the current results suggest, altered gait and STS parameters are a component of motor control impairment, then treatment aimed at restoring the individual's motor control might be important to include in the overall approach to management of that individual. Within the past ten years there has been a trend towards rehabilitation of motor control being recommended as an approach to CLBP treatment (Richardson et al, 2004). Success of this approach combined with education on pain physiology has been shown to be effective (Moseley, 2003). In addition, work has been and continues to be undertaken to improve the classification of motor control impairments in order to target treatment more appropriately (Dankaerts et al, 2006a). This seems relevant considering the large individual variability in motor control impairments previously discussed and the general agreement that CLBP treatment is not congruent with a one size fits all philosophy. Identifying altered gait parameters, spinal kinematics, sitting posture and STS strategies might provide an additional method of classifying patients, identifying those likely to benefit from treatment aimed at re-educating motor control and implementing rehabilitation programmes specific to the individual's needs. Such measurements might also provide an additional quantifiable measure of outcome with which to evaluate this treatment approach. Indeed, the benefit of combining objective measurements with a traditional physical examination was highlighted in a recent case study in which both methods were used to subclassify a patient with CLBP and to evaluate the effects of treatment aimed at improving motor control (Dankaerts at al, 2007). In this case study, objective measurement was directed at a traditional impairment measure (forward flexion in standing); the current research suggests that objective measurement of activities of daily functioning might also be useful. Therefore, methods of measuring the parameters found to be most relevant in the current study that could be conducted in the physiotherapeutic clinical environment are now considered.

Measurement and evaluation in the clinical setting

Spatial parameters during gait

Measuring the timing or endurance aspects of gait, both of which have been suggested as outcome measures for LBP patients (Lee et al, 2002; Simmonds et al, 1998) may lead to the conclusion that the CLBP patient's gait is normal. However, measuring the spatial parameters of gait may identify the altered stride and step lengths observed at normal speed in the current study, the magnitude of which (10 cm reduction in stride length) would arguably be clinically relevant. Clearly the laboratory-based methodology employed in this study is not practical for routine measurement of CLBP patients; however, there are less costly and technology-dependent methods of measuring the spatial parameters. The instrumented GAITRite mat, initially considered as a measurement tool for the current study and discussed in section 3.4.5.1, p234 could provide a valid, reliable and user-friendly method of measuring these parameters in clinical practice. It is unlikely that simple observational techniques (in real-time) would identify the impairments, particularly as stride and step lengths were reduced bilaterally; therefore simple observational gait analysis is unlikely to be of help in assessing or evaluating mild to moderate non-specific CLBP patients. However, other simple techniques such as counting the strides taken over a known distance allows stride length to be calculated (Whittle et al, 2002). Perhaps more time-consuming (and messy) is the use of talcum powder on the feet and walking on a polished floor or paper; however it allows fairly straightforward measurement of right and left step as well as stride lengths from the foot-fall patterns (Whittle et al, 2002).

Pelvic and spinal kinematics during gait

As described above, identifying altered pelvic and lumbar kinematics during gait might aid the classification, treatment planning and outcome evaluation of CLBP patients. Although the differences in joint kinematics were small they accounted for a loss of approximately 25% of the joint ROM during gait which could be considered clinically relevant. Again, the methodology employed in the current study is not practical for routine use. However, the electromagnetic tracking device (Fastrak), which was initially considered for this study, does show some potential for use in the clinical environment. The methodological considerations discussed in section 3.4 would require to be addressed however, particularly with respect to being able to measure over a large enough area to ensure free-speed gait was being recorded. Lower limb kinematics during treadmill gait have been successfully recorded with an electromagnetic tracking device (Mills et al, 2007); further research would be required to establish valid and reliable methodology for measuring lumbar and pelvic kinematics during overground walking. Observational analysis is again unlikely to detect the impairments in pelvic and spinal kinematics, due to their magnitude, and therefore simple observational gait analysis is unlikely to be of help in assessing or evaluating mild to moderate non-specific CLBP patients.

Sit to stand

Measuring the timing of one STS manoeuvre might lead to the conclusion that CLBP patients' perform this in a normal manner. Measurement of repeated STS, which was not investigated in this study but has been suggested as an outcome measure for use with LBP patients (Simmonds et al, 1998; Weiner et al, 2003) might be useful since it incorporates a measure of endurance. However, repeated STS also focuses on the speed of completing the movement pattern and not the quality of the movement pattern itself. The results of the current study suggest that usual sitting posture, use of foot movement to initiate STS, and peak lumbar flexion achieved during STS might identify CLBP patients demonstrating these motor control impairments. Usual posture is arguably included in physiotherapy assessments at present, and assessment of this requires no specialist equipment. However, suggestions such as observing the patient's sitting posture when in the waiting room (Gross et al, 2002) or during history taking (McKenzie and May, 2003), whilst the patient is fully clothed, might not reveal the degree of altered lumbar extension observed in this study. Observation of both sitting and standing posture is recommended (for example by McKenzie and May, 2003); however specific assessment of moving between the two static postures does not appear to be widely recommended, particularly with reference to lumbar kinematics or foot movement. Foot movement could easily be assessed by visual observation alone; however further work on a larger sample is required to understand its relationship with CLBP. It is unlikely that reductions in peak lumbar flexion can be detected by visual observation alone; measurement equipment would be necessary to detect alterations of the magnitude observed in the current study. As discussed for gait, the laboratory-based methodology employed in this study is not practical for routine clinical use, but Fastrak shows some potential for the measurement of STS and has been used in a study of subacute LBP patients (Shum et al, 2005). The methodological considerations (section 3.4) would require to be addressed, as would the accuracy given the difference in lumbar motion reported for the control sample in the current study and that of Shum et al (2005). However, Fastrak might provide a portable method of further analysing the effect of CLBP on STS in the clinical environment and of evaluating physiotherapy aimed at restoring motor control impairments in CLBP.

3.6.4: Strengths and limitations of study

3.6.4.1: Sample strengths and limitations

Sample size

The samples were smaller than originally intended because of slower than anticipated recruitment of subjects. A pilot study on gait analysis in CLBP patients had indicated that sample sizes of 27 per group would be required to detect differences between CLBP patients and controls for spatial and temporal parameters, and 40 to detect 5^{o} differences in lower limb kinematics (Cooper, 2002). The samples were clearly large enough to detect statistically significant differences in spatial parameters of gait at normal speed, some kinematic parameters of gait at normal and fast speeds and STS strategies. However, the sample lacked enough power to detect statistically significant differences in spatial parameters of gait at fast speed and some pelvic and lumbar kinematic parameters.

A convenience sampling strategy was employed in this study for pragmatic reasons (see section 3.4.3.4, p231) which involved both the researcher and physiotherapists in the recruitment process. Recruitment of CLBP patients took place over a seven-month period, resulting in only seventeen subjects. This was far fewer than anticipated, given the numbers of CLBP patients attending the participating departments. However, there are several possible reasons for the small numbers of subjects. All the potential subjects may not have been issued with study information, due to the time-pressures in busy outpatient physiotherapy departments and the many other priorities which physiotherapists face. It is also possible that some CLBP patients may have been willing to participate but did not get as far as filling out and posting the reply-slip. It was not possible within the study design to follow-up non-respondents, since consent was not sought for this when issuing the study information; therefore it is not known what proportion of potential subjects were willing but did not participate. The location of the study may have been off-putting for some, since the location of the University within Aberdeen would necessitate a journey from outwith the City or across the City for most participants. Although the refund of travel expenses was outlined in the study information sheet, it is possible that some people may have viewed the time required and inconvenience as off-putting. Finally, there was no direct benefit to participants for taking part, which may have affected potential subjects' motivation. Those who did take part expressed altruistic reasons for doing so; a desire to help future CLBP sufferers was commonly expressed.

The recruitment process for the control sample took place over a shorter time resulting in a sample size of twenty, which was deemed appropriate given the size of the CLBP sample.

It was necessary to adopt a pragmatic approach to recruitment largely due to time constraints, and like most clinical research the "patients to hand" (Bland, 2000, p32) were sampled. Despite this, the sample was sufficient to detect some statistically significant differences in gait parameters. Nonetheless, the results must be interpreted with respect to the limitations resulting from the sample size.

Gender of subjects

There were fewer male subjects in the control sample than in the CLBP sample; however both samples contained a majority of female participants (90% in control and 60% in CLBP sample). The pragmatic approach to sampling discussed above meant that it was not possible to sex-match subjects in each sample, and the exploratory nature of this study is likely to necessitate further research, which could be designed to control for gender bias. However, previous research has failed to demonstrate significant gender differences for gait (Al-Obaidi et al, 2003; Crosbie et al, 1997b) therefore this may not present a major limitation for this section of analysis. There are conflicting results for STS however with one study reporting no major gender differences (Kerr et al, 1997), and one reporting differences in timing of repeated STS (Novy et al, 1999). Therefore, it is possible that gender differences could affect the results, but the composition of both samples (majority female) might lessen the impact of any effect.

Age of subjects

The CLBP sample was an average of 15 years older than the control sample, with a wider age range; this difference was statistically significant. This is another limitation that must be recognised when interpreting the results, due to the effects of advancing age on walking speed previously reported (Menz et al, 2004) and as discussed for gender, any age bias would need to be eliminated in future research. However, in relation to spinal kinematics, Crosbie et al (1997b) demonstrated age-related changes in thoracic but not lumbar spinal kinematics during gait; therefore these results may not be affected by the age difference of the samples. Age-related changes in STS speed and kinematics have been demonstrated (Gross et al, 1998; Ikeda et al, 1991). However, these differences have been demonstrated between young subjects (under 30 years old) and the elderly (over 65 years old in both studies). Whether there would be significant age-related changes between two samples of under 65 year olds with a difference in mean age of 15 years is perhaps less likely, but must be considered a possibility.

Height and weight of subjects

There were small, non-significant differences between the two samples for weight and height; the lack of significant differences means that any bias due to these two parameters is eliminated (Polgar and Thomas, 1999).

Chronic Low Back Pain symptoms

The CLBP sample could be described as reporting mild to moderate symptoms, particularly when compared to samples from previous research. For example, Al-Obaidi et al (2003), who investigated spatial and temporal gait parameters, reported average RDQ scores of 14 out of 24 in their LBP sample, considerably higher than the 5 out of 24 reported in this study. Vogt et al (2001), who investigated spinal kinematics during gait, reported an average Visual Analogue pain score of 3.7 out of 10, in comparison to the "pain now" BPI subscale of 2 out of 10 in the current study. This may be a limitation when making comparisons to previous research. However, the current study sought to investigate the usefulness of gait and STS analysis in CLBP patients presenting for physiotherapy, a population that is previously under-researched in terms of gait and STS analysis. The sampling was inclusive in nature; therefore CLBP patients' who had symptoms of 12 weeks duration or longer were included, but the severity or intensity of these symptoms were not specific criteria. It could therefore be argued that the current sample reflects the general nature of CLBP patients commonly seen in out-patient physiotherapy departments that would not have been obtained by only including those whose symptom severity was above a pre-determined threshold. Therefore, the results may be more relevant to physiotherapists who commonly encounter CLBP patients with mild to moderate symptom severity and disability, and the symptom severity of the sample can be considered a strength of the study.

3.6.4.2: Measurement tool

Validity and reliability of Vicon was discussed in full in section 3.5, concluding that Vicon was a valid tool for the measurements conducted in this study. The limitation of using Vicon was that the research took place in a laboratory rather than routine clinical setting. However the strength was in the validity and reliability of the results obtained.

Although a reliable and valid measurement tool was employed, potential sources of error remain; primarily marker placement and inherent variability within subjects. Every possible effort was taken to limit potential sources of error but they cannot be ruled out completely.

3.6.4.3: Data collection protocol strengths and limitations

The data collection protocol resulted in all subjects' data being included in the gait analysis section of the study; therefore it can be concluded that the protocol was suitable for this section of the data analysis. However several subjects, from both the control and CLBP samples, were excluded from the STS section of the study. This arose due to the location of the cameras in the gait laboratory. The cameras are wall mounted at a distance of 2.1m from the floor, with the exception of one camera which is 1.5 m from the floor. This set-up has been found to be adequate for gait analysis, the main purpose for which this laboratory is used. Initial pre-pilot work for this study without controlling arm position indicated that the cameras failed to track some markers adequately during the STS manoeuvre; this was particularly noticeable for the anterior superior iliac spine (ASIS) markers. This was not related to the subject's BMI, but did appear to be related to the position of the arms during STS (for example placing the hands on the thighs caused the ASIS markers to be obscured). When the arm position was controlled such that the subject's arms were not in front of the ASIS markers the cameras were able to track the markers and the data was processed adequately. Therefore, the protocol used in the study controlled the arm position in this way. However, it was found that for some subjects (six controls and three CLBP patients) the cameras still failed to adequately track the ASIS markers and the data could not be processed.

It is unclear why this only occurred in some, and not other, subjects, as it was not related to the height or BMI of the subject, or on the STS strategy. Manually processing the data using Vicon Bodybuilder software was considered. However, much of the data had such large amounts missing that it was not possible to guarantee a valid representation of the STS kinematics. Therefore, it was decided to omit these trials from analysis of STS realising that this reduced the sample size for this section of the data analysis, with its resulting limitations on the generalisability of the findings.

It was possible in six of these instances to determine the temporal parameters of STS (four controls and two CLBP patients), since there was adequate data for this purpose. For the remaining three subjects there was not sufficient data for lower limb as well as pelvic kinematics, making it impossible for identification of the beginning and end of the STS manoeuvre. Therefore, whilst the data collection protocol was adequate for gait analysis, it was not as reliable for STS analysis. The alternative to this protocol would have involved altering the position of some, or all, cameras within the gait laboratory, and this should be considered for future studies on STS. However, had the limitations of the protocol been anticipated in this study, the drawback of moving the cameras for the combined gait and STS analysis would have been the duration of time required for data collection. This would have necessitated an unnecessarily long measurement session for each subject. Therefore, multiple sessions would have been required with each subject in order to analyse gait and STS on separate occasions and alter the camera positions accordingly for the start of each session; a protocol which would have risked the drop-out of subjects between sessions.

The protocol used was therefore reliable for gait analysis but less consistently so for the analysis of STS. However, the use of a single measurement session removed the risk of between-session drop-out of subjects. The results need to be interpreted within the limitations of the sample size, and future research on STS using this methodology should carefully consider the position of the cameras and collection of more than three trials to allow for occasional failure in the tracking of ASIS markers.

In summary, the main limitations to this study were the small sample size, a measurement protocol not easily transferable to the clinical setting, and the exclusion of some subjects' data from the STS part of the study. However, this must be balanced by the three main strengths of the study, which were as follows. Firstly, the recruitment of a typical sample of CLBP patients attending out-patient physiotherapy in Grampian. Secondly, the use of a valid and reliable measurement tool. Finally, the avoidance of lengthy or multiple measurement sessions which may have resulted in drop-outs.

3.7: Conclusion

3.7.1: Key findings

This study demonstrated that some parameters of CLBP patients' gait were less repeatable at slow speed than those of subjects without low back pain (left single support, spine side flexion; $p<0.05$). In addition, some parameters of CLBP patients' gait were more repeatable at fast walking speed (cadence, left single support, pelvis rotation; $p<0.05$). Spinal and pelvic kinematics during gait were less repeatable than the spatial and temporal parameters. STS parameters were the least repeatable. Analysis of gait and STS should be based on the average of more than one trial.

This study identified statistically and clinically significant differences in the spatial and kinematic parameters of gait and the strategy of conducting STS in CLBP patients compared to control subjects without LBP. CLBP patients with mild to moderate symptoms have been shown to walk at self-selected normal speed with an average 10cm reduction in stride length ($p<0.05$) and 3° reduction in pelvic side flexion ($p<0.01$). They have been shown to walk at self-selected fast speed with an average 2.7° reduction in pelvic side flexion ($p<0.01$) and 2.4° reduction in spine flexion ($p<0.05$). Finally, CLBP patients have been shown to begin the STS manoeuvre in 11° greater spinal extension than subjects without LBP ($p<0.01$), and to achieve 7° less peak flexion during STS ($p<0.05$).

This study demonstrated a statistically significant moderate correlation between pelvic side flexion during fast gait and "pain now" on the BPI ($p<0.05$); increased pelvic side flexion was associated with increased pain intensity. A statistically significant moderate correlation was also demonstrated between the use of foot movement to initiate STS and RDQ scores ($p<0.05$); use of foot movement was associated with increased RDQ scores.

This study demonstrated that objective measurement of impairment during day-to-day activities can yield useful information regarding CLBP patients which might, when used alongside existing self-report measures, be used to classify patients, plan specific individually tailored treatments and evaluate outcomes in individual and groups of patients. Although the tools used in the current study were not suitable for routine clinical use, the findings presented here suggest that further work to develop measurement protocols using portable and user-friendly equipment in the clinical setting would be beneficial.

3.7.2: Implications for practice, education and further research

Implications for physiotherapy practice: Gait analysis as an outcome measure

- Consideration should be given to replacing measures of walking speed with those of the spatial parameters
- Parameters should be evaluated at a range of speeds and not only "comfortable" walking speed
- Analysis should be based on the results of more than one walking trial

Implications for physiotherapy practice: Sit to Stand analysis

- A thorough assessment of sitting posture and the patient's "neutral zone" might enhance the assessment of CLBP patients
- Consideration should be given to assessing the strategy of STS used by CLBP patients

Implications for education

Both undergraduate and postgraduate education may be required on the following

- Methods of objectively measuring impairment during activities of daily functioning in order to comprehensively assess, classify, plan treatment for and evaluate outcome in CLBP patients, and in order to ensure that measurement relates to the activity limitations of individual patients.

Suggestions for further research

The results of this study suggest that further research is indicated in the following areas:

- Confirmation of gait and STS impairments detected in this study in a larger sample of patients with mild to moderate CLBP symptoms
- Combined kinematic and EMG analysis of gait and STS to explore the relationship between motor control impairment and altered lumbar and pelvic kinematics. This would include analysis of full available joint range of motion in all three planes in order to explore the contribution of loss of joint range
- Development of measurement protocols/pilot of tools suitable for use in the clinical setting to evaluate CLBP patients. This could include: GAITRite (spatial and temporal gait parameters), Fastrak (spinal kinematics gait and STS), Video (STS) and observational analysis tools (STS)
- Following protocol/tool development, studies to investigate the use of objective assessment of gait and STS in classifying, planning treatment for and measuring outcome in CLBP patients
- Prospective studies to investigate changes in gait and STS impairments with physiotherapy treatment aimed at restoring motor control impairment

This concludes the study on objective measurement of CLBP patients. The final chapter (4) considers these findings and those on patients' perceptions of physiotherapy, in order to explore the relationship between the two components of this thesis and how they might enhance physiotherapy for CLBP patients.

Chapter 4: Management and measurement: A combined interpretation

4.1: Enhancing physiotherapy for Chronic Low Back Pain patients

This thesis has taken a novel approach in combining a qualitative study on patients' perceptions of physiotherapy and a quantitative study on objective measurement in order to inform and improve the physiotherapy management of CLBP patients in primary care. Implications for physiotherapy practice, education and further research have been presented from both studies. However this chapter discusses how, in considering the results as a whole, they might contribute to the overall enhancement of physiotherapy for the CLBP patient.

Figure 4.1 demonstrates the overall hypothesis to be discussed: that enhanced assessment of the CLBP patient will lead to enhanced diagnosis and classification allowing for more appropriate individualised physiotherapy management. This will ultimately therefore lead to enhanced outcome for the CLBP patient, which can be demonstrated using a variety of outcome measures. This process needs to take place within both a biopsychosocial and patient-centred framework. The findings are discussed in relation to each of the four stages in figure 4.1.

Enhanced assessment

The importance of assessment in the physiotherapy management of CLBP patients is not a new phenomenon (Kirkness and Korner-Bitensky, 2002; Liebenson and Yeomans, 1997). However, the optimum method and tools of assessment have not yet been agreed upon, as the extensive literature on evaluating assessment and outcome measurement tools demonstrates (for example, Campbell et al, 2006; Dankaerts et al, 2006a;Peterson et al, 2004; Schaufele and Boden, 2003). One of the findings in the qualitative component of this research was that patients appeared to value assessment as an important part of their physiotherapy management. A thorough assessment by an apparently skilled physiotherapist was rated highly by the respondents, and perceived as contributing to physiotherapy that was patient-centred and related to patients' individual needs. The importance of the physiotherapist assessing the CLBP patient's individual needs, expectations of physiotherapy, and activity limitations/participation restrictions were also emergent findings from the qualitative component.

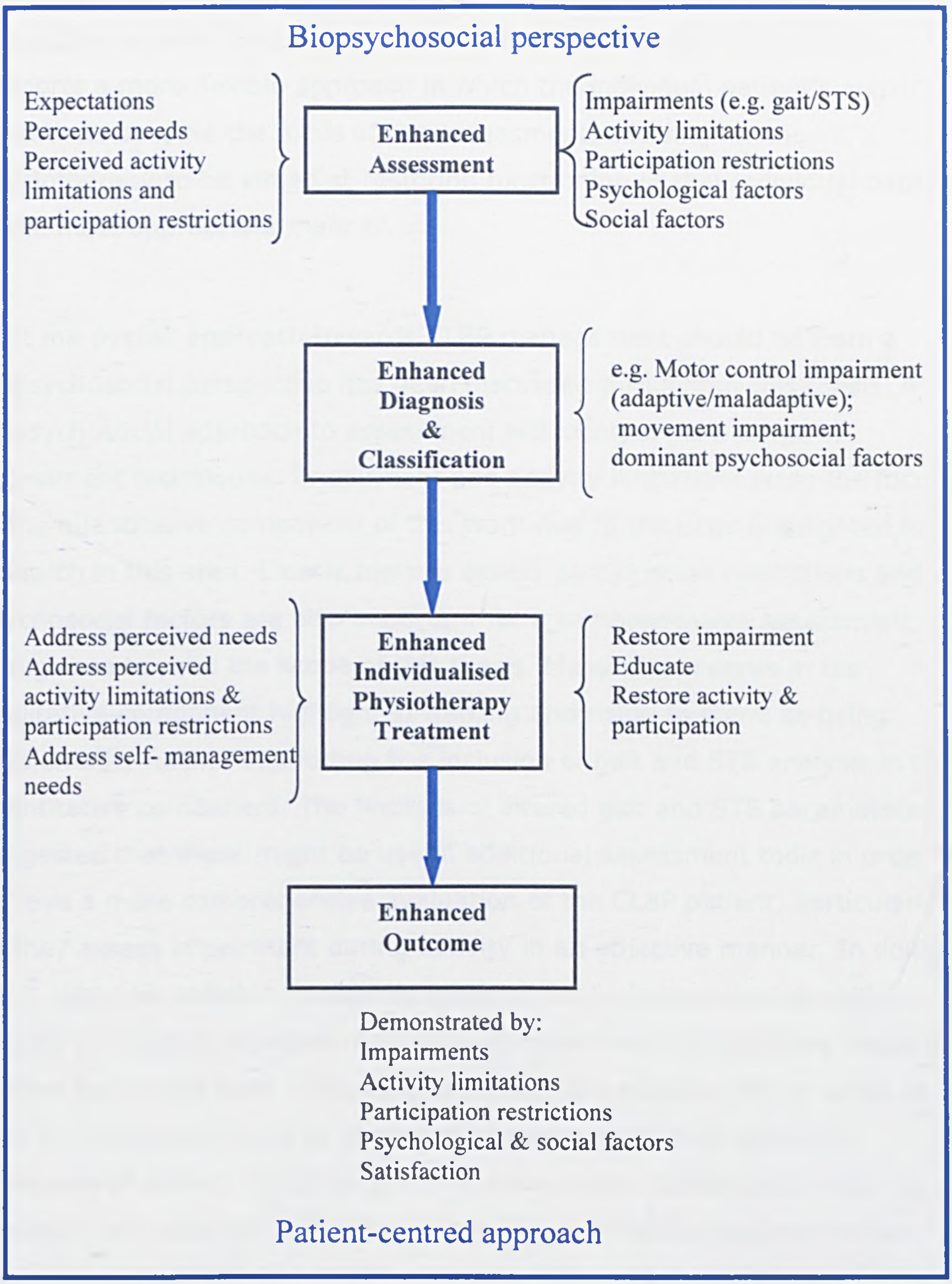


Figure 4.1: Hypothesis for enhancing physiotherapy for chronic low back pain patients

Assessing individual activity limitations appears to be important, particularly when considered alongside the finding that in most cases the respondents did not feel that physiotherapy had addressed these limitations. Only by adequately assessing what the individual patient's limitations are will treatment be aimed appropriately and therefore more likely to result in a positive outcome. This research therefore challenges the current practice of conducting a generic spinal assessment with CLBP patients. Instead it supports a more flexible approach in which the individual patient's activity limitations become the focus of the assessment, allowing for the physiotherapy to be aimed at restoring functioning of that individual patient in the most appropriate manner.

That the overall approach towards CLBP management should be from a biopsychosocial perspective has been discussed throughout this thesis. A biopsychosocial approach to assessment will incorporate a range of assessment techniques. Impairment and activity limitations were the focus of the quantitative component of this work due to the need highlighted for research in this area. Clearly tools to assess participation restrictions and psychosocial factors are also important for a comprehensive assessment, though are beyond the scope of this thesis. Many respondents in the qualitative component highlighted walking and rising to stand as being problematic, further supporting the inclusion of gait and STS analysis in the quantitative component. The findings of altered gait and STS parameters suggested that these might be useful additional assessment tools in order to achieve a more comprehensive evaluation of the CLBP patient, particularly as they assess impairment during activity in an objective manner. In doing so, it might be possible to address some of the limitations and doubtful validity of existing objective measures of impairment (for example range of motion performed from a standing position). It is possible that in order to take a truly patient-centred approach to assessment other objective measures of activity might be useful in some cases. These could relate to patients' self-report of functional limitations, and the development of an assessment toolkit as previously suggested (Smeets et al, 2006a; Ljungquist et al, 2003) might be relevant for objective measures. The most appropriate tools could then be used following discussion with the patient, in order to assess their particular limitations. This might lead to more individualised and patient-centred assessment and outcome measurement.

Enhanced diagnosis and classification

There is a clear need to enhance the diagnosis and classification of CLBP patients, (Mercer at al, 2006; O'Sullivan, 2005). Moving away from an all-encompassing diagnosis of "non-specific CLBP" towards one of more specific sub-classifications (where possible) should allow for treatment to be targeted appropriately (Lebouef-Yde et al, 1997). The qualitative component suggested that a well-explained diagnosis was valued and in many cases expected by CLBP patients. Therefore, measurement tools that aid diagnosis and/or sub-classification will be helpful to both physiotherapists and their patients. Recent work in this area has proposed a classification system based on excesses or deficits in spinal stability (O'Sullivan, 2005). The quantitative findings presented here of altered gait and STS parameters, hypothesised to be related to spinal stability, suggested that measurement of these parameters might be useful in classifying CLBP patients in relation to impairments in motor control of the spine. Further research is required to explore this area, but the need for improved diagnosis and sub-classification supports the need for such research to be conducted.

Enhanced individualised physiotherapy treatment

As figure 4.1 demonstrates, enhanced assessment and diagnosis should lead to enhanced individualised physiotherapy treatment of CLBP patients. This will occur as a result of the physiotherapist having a detailed knowledge of all the factors that need to be considered in the design of a physiotherapy intervention for CLBP. The intervention itself might be aimed at restoring impairments in motor control or ROM, detected with traditional physiotherapy assessment techniques and the addition of the objective measures discussed above. The intervention might be delivered as a cognitive-behavioural approach (O'Sullivan, 2005) in order to address psychosocial factors also, and education and restoration of activity and participation will be important components. An enhanced assessment and sub-classification system will identify which patients require which aspects of physiotherapy intervention, and in what amounts. For example, for some the emphasis might be on re-educating motor control whilst for others this might be detrimental as rehabilitation needs to focus on altering unhelpful beliefs about pain. An enhanced assessment and sub-classification system will aid in identifying patients for whom physiotherapy alone is insufficient, and who require a multidisciplinary approach to CLBP management (O'Sullivan, 2005).

The manner in which the physiotherapy intervention is delivered is arguably as important as the intervention itself. Adopting a patient-centred approach as outlined in the qualitative component should enhance the patient's experience. Addressing the patient's perceived needs, including their desired level of involvement in decision-making, their individual activity limitations/participation restrictions and their self-management needs are clearly also important factors to consider in the delivery of physiotherapy for CLBP. In addition, the general organisation of physiotherapy services was highlighted in the qualitative component as being important. Enhancing the way in which patients' enquiries and discharge arrangements are dealt with, and ensuring that patients are informed of the potential content, purpose and benefit of physiotherapy could provide simple methods of enhancing physiotherapy for the CLBP patient. Therefore, this research challenges the current management of CLBP patients, suggesting that fundamental areas such as communication skills of physiotherapists require to be addressed. In addition, it challenges the current philosophy of a "course" of treatment for CLBP, and suggests that physiotherapists may have a crucial role to play in facilitating and supporting patients' self-management.

Enhanced outcome

Enhanced outcome should arise from enhanced assessment, diagnosis and physiotherapy treatment, and it is important to measure outcome in order to evaluate the efficacy of such treatment. As for assessment, this should involve a range of measures within a biopsychosocial perspective. Objective assessment of impairment during day-to-day activities therefore might provide an additional measure of one domain (impairment) which, when used in conjunction with measures of the other domains (activity limitations, participation restrictions) and of psychosocial factors, could provide a thorough outcome assessment of all the relevant factors. This is crucial in order to develop the most appropriate physiotherapy interventions for individual patients and for subgroups identified from effective sub-classification systems. Satisfaction, arguably one of the most important outcomes, should also be measured in an ongoing attempt to incorporate the views of CLBP patients in enhancing physiotherapy.

4.2: The benefits of a combined approach

The qualitative and quantitative components presented in this thesis have in combination enabled the exploration of both physiotherapy management and objective measurement in CLBP patients in an NHS primary care setting. The qualitative component allowed for an in-depth understanding of a sample of CLBP patients' views on several aspects of their physiotherapy experience. These views led to proposals for changes in the delivery of physiotherapy to CLBP patients in Grampian. They also resulted in recommendations for education and for further research which will in combination enhance the physiotherapy experience of CLBP patients. Therefore, this component has addressed the way in which physiotherapy is delivered. It has provided evidence for delivering physiotherapy interventions in a way that is, from the patients perspective, patient-centred, and in a way that should enhance functioning and enable self-management, the two primary goals of physiotherapy for CLBP (Bekkering et al, 2003).

The way in which physiotherapy is delivered is important but not at the cost of the interventions physiotherapists should be delivering. Although the actual interventions were not the focus of either component of this work, objective measurement might allow for interventions to be more appropriately tailored to individual's needs and allow their efficacy to be evaluated. The quantitative findings suggested that gait and STS measures might prove useful for assessing impairments, sub-classifying CLBP patients and importantly assessing the outcome of the component of physiotherapy intervention aimed at addressing impairments. This could prove vital in establishing the efficacy of sub-classification systems and treatment approaches such as that based on motor control impairment theory discussed in this thesis. Therefore the quantitative component of this research has produced knowledge of potential methods of evaluating physiotherapy interventions in an objective, quantifiable manner. When considered alongside existing subjective measures of outcome, these should provide a more comprehensive evaluation of existing and developing physiotherapy interventions, and ultimately enhance physiotherapy for CLBP patients.

Each component has therefore contributed to knowledge in its specific area of physiotherapy for CLBP. However, in combination the results provide new knowledge on ways to improve the delivery of physiotherapy services to CLBP patients, methods of evaluating what is delivered, and methods for measuring patient outcome. Therefore, together they inform the overall enhancement of physiotherapy for CLBP patients. What is actually delivered has not been evaluated in this study; much future research needs to focus on evaluating different treatment interventions and developing methods of delivering the most appropriate intervention, in the most appropriate way, for the individual patient. It is intended that the findings presented here will go some way towards fulfilling that aim.

4.3: Conclusion

This research has provided new knowledge in several areas of physiotherapy management for CLBP patients. The studies were small and generalisation therefore limited. However, the implications for practice and education, in combination with the body of ongoing research in this area of CLBP management, are important in attempts to produce an overall enhancement of physiotherapy for this complex multidimensional condition. In addition to the ongoing body of research, several recommendations for further research can be made on the basis of these findings, including the following:

- Further development of a theoretical model of patient-centred physiotherapy for CLBP
- The efficacy of strategies to inform patients of the content, purpose and potential outcome of physiotherapy for CLBP
- Evaluating the efficacy of educating physiotherapists on communication skills and self-management education techniques
- Evaluating the efficacy of enhancing current physiotherapy with self-management education and/or support
- Analysing gait and STS in a large sample of CLBP patients to confirm the results presented here
- Further exploring the relationship between motor control impairment and altered spinal kinematics during gait and STS
- Developing measurement tools suitable for routine clinical use

- Exploring the validity and reliability of gait and STS analysis in the subclassification, treatment planning and outcome measurement of CLBP patients

Therefore, this novel approach to researching physiotherapy for CLBP has resulted in challenges to the way in which physiotherapy is delivered, challenges to the way in which CLBP patients are assessed and measured, and important directions for future research. All are crucial areas for enhancing physiotherapy for CLBP patients.

References

ABERDEENSHIRE COUNCIL, statistics by location [Homepage of Aberdeenshire Council], [Online]. Available: http://www.aberdeenshire.gov.uk/statistics/area/index.asp [07/02/2005].

AIRAKSINEN, O., BROX, J.I., CEDRASCHI, C., HILDEBRANDT, J., KLABER MOFFETT, J., KOVACS, F., MANNION, A.F., REIS, S., STAAL, J.B., USRIN, H. and ZANOLI, G., 2004. *European guidelines for the management of chronic non-specific low back pain.* COST B13 Working Group on Guidelines for Chronic Low Back Pain.

AL-OBAIDI, S.M., NELSON, R.M., AL-AWADHI, S.A. and AL-SHUWAIE, N., 2000. The Role of Anticipation and Fear in the Persistence of Avoidance Behaviour in Patients With Chronic Low Back Pain. *Spine,* **25**(9), pp. 1126-1131.

AL-OBAIDI, S.M., AL-ZOABI, B., AL-SHUWAIE, N., AL-ZAABIE, N. and NELSON, R.M., 2003. The influence of pain and pain-related fear and disability beliefs on walking velocity in chronic low back pain. *International Journal of Rehabilitation Research,* **26**(2), pp. 101-108.

AMIRI, M., JULL, J. and BULLOK-SAXTON, J., 2003. Measuring range of active cervical rotation in a position of full head flexion using the 3D Fastrak measurement system: an intra-tester reliability study. *Manual Therapy,* **8**(3), pp. 176-179.

ANDERSON, K.O., DOWDS, B.N., PELLETZ, R.E., EDWARDS, W.T. and PEETERS-ASDOURIAN, C., 1995. Development and initial validation of a scale to measure self-efficacy beliefs in patients with chronic pain. *Pain,* **63**, pp. 77-84.

ANDERSSON, G.B., 1999. Epidemiological features of chronic low-back pain. *Lancet,* **354**(9178), pp. 581-585.

ANDRIACCHI, T.P., OGLE, J.A. and GALANYE, J.O., 1997. Walking speed as a basis for normal and abnormal gait measurements. *Journal of Biomechanics,* **10**, pp. 261-268.

ARENDT-NIELSEN, L., GRAVEN-NIELSEN, T., SVARRER, H. and SVENSSON, P., 1995. The influence of low back pain on muscle activity and coordination during gait: a clinical and experimental study. *Pain,* **64**(2), pp. 231-240.

ARMSTRONG, M., MCDONOUGH, S. and BAXTER, D., 2005. Reliability and repeatability of the shuttle walk test in patients with chronic low back pain. *International Journal of Therapy and Rehabilitation,* **12**(10), pp. 438-443.

ARNETZ, J.E., ALMIN, I., BERGSTROM, K., FRANZEN, Y. and NILSSON, H., 2004. Active patient involvement in the establishment of physical therapy goals: Effects on treatment outcome and quality of care. *Advances in Physiotherapy,* **6**(2), pp. 50-69.

ASSENDELFT, W. J. J., MORTON, S.C., SUTTORP, M.J. and SHEKELLE, P.G., 2003. Spinal manipulative therapy for low-back pain (review). http://www3.interscience.wiley.com/cgi-bin/mrwhome/106568753/HOME. UK: The Cochrane Database of Systematic Reviews.

BackCare helpline [Homepage of BackCare], [Online]. Available: www.backpain.org/pages/h-pages/helpline.php [16/08, 2006].

BAER, G.D. and ASHBURN, A.M., 1995. Trunk movements in older subjects during sit-to-stand. *Archives of Physical Medicine and Rehabilitation,* **76**(9), pp. 844-849.

BAER, G.D. and DURWARD, B.R., 1999. Rising to stand and sitting down. In: G.D. BAER, B.R. DURWARD and P.J. ROWE, eds, *Functional Human Movement.* First edn. Oxford: Butterworth-Heinemann, pp. 77-92.

BAKER, R., 1997. Pragmatic model of patient satisfaction in General Practice: Progress towards a theory. *Quality in Health Care,* **6**, pp. 201-204.

BARBANEL, D., ELDRIDGE, S. and GRIFFITHS, C., 2003. Can a self-management programme delivered by a community pharmacist improve asthma control? A randomised trial. *Thorax,* **58**(10), pp. 851-854.

BARKER, S., CRAIK, R., FREEDMAN, W., HERRMANN, N. and HILLSTROM, H., 2006. Accuracy, reliability, and validity of a spatiotemporal gait analysis system. *Medical engineering and physics,* **28**(5), pp. 460-467.

BARLOW, J., WRIGHT, C., SHEASBY, J., TURNER, A. and HAINSWORTH, J., 2002. Self-management approaches for people with chronic conditions: a review. *Patient Education and Counseling,* **48**, pp. 177-187.

BARRETT, C.J., SINGER, K.P. and DAY, R., 1999. Assessment of combined movements of the lumbar spine in asymptomatic and low back pain subjects using a three-dimensional electromagnetic tracking system. *Manual Therapy,* **4**(2), pp. 94-99.

BATTERHAM, A.M. and GEORGE, K.P., 2000. Reliability in evidence-based clinical practice: a primer for allied health professionals. *Physical Therapy in Sport,* **1**, pp. 54-61.

BEATTIE, P., 1996. The Relationship Between Symptoms and Abnormal Magnetic Resonance Images of Lumbar Intervertebral Disks. *Physical Therapy,* **76**(6), pp. 601-608.

BEATTIE, P. and MAHER, C., 1997. The role of functional status questionnaires for low back pain. *Australian Physiotherapy,* **43**(1), pp. 29-38.

BEATTIE, P.F., PINTO, M.B., NELSON, M.K. and NELSON, R., 2002. Patient satisfaction with outpatient physical therapy :Instrument validation. *Physical Therapy,* **82**(6), pp. 557-565.

BEATTIE, P., TURNER, C., DOWDA, M., MICHENER, L. and NELSON, R., 2005. The MedRisk Instrument for Measuring Patient Satisfaction With Physical Therapy Care: a psychometric analysis. *Journal of Orthopaedic and Sports Physical Therapy,* **35**(1), pp. 24-32.

BEKKERING, G.E., HENDRIKS, H.J., KOES, B.W., OOSTENDORP, R.A., OSTELO, R.W., THOMASSEN, J.M. and VAN TULDER, M.W., 2003. Dutch physiotherapy guidelines for low back pain. *Physiotherapy,* **89**(2), pp. 82-96.

BEKKERING, G.E., VAN TULDER, M.W., HENDRIKS, E.J., KOOPMANSCHAP, M.A., KNOL, D.L., BOUTER, L.M. and OOSTENDORP, R.A., 2005. Implementation of clinical guidelines on physical therapy for patients with low back pain: randomized trial comparing patient outcomes after a standard and active implementation strategy. *Physical Therapy,* **85**(6), pp. 544-555.

BELL, F., SHAW, L.M., RAFFERTY, D., RENNIE, J. and RICHARDS, J.D., 1996. Movement analysis in clinical practice. *Physical Therapy Reviews,* **1**, pp. 13-22.

BERGNER, M., BOBBITT, R.A., CARTER, W.B. and GILSON, B.S., 1981. The Sickness Impact Profile: development and final revision of a health status measure. *Medical care,* **19**(8), pp. 787-805.

BERNARDI, M., ROSPONI, A., CASTELLANO, V., RODIO, A., TRABALLESI, M., DELUSSU, A.S. and MARCHETTI, M., 2004. Determinants of sit-to-stand capability in the motor impaired elderly. *Journal of Electromyography and Kinesiology,* **14**, pp. 401-410.

BERTOCCO, P., BACCALARO, G., MONTESANO, A., VISMARA, L., PARISIO, C. and GALLI, M., 2002. The analysis of sit-to-stand movement in obese and normal subjects: biomechanic evaluations and postural changes between groups. *Europa Medicophysica,* **38**(3), pp. 131-137.

BILNEY, B., MORRIS, M. and WEBSTER, K., 2003. Concurrent related validity of the GAITRite walkway system for quantification of the spatial and temporal parameters of gait. *Gait and posture,* **17**(1), pp. 68-74.

BLACKLEDGE, C., 2005. What do we mean by Patient-Centred Care? *Physiotherapy Frontline,* **Suppl**, pp. 3.

BLAND, J.M. and ALTMAN, D.G., 1995. Multiple significance tests: the Bonferroni method. *British Medical Journal,* **310**(6973), pp. 170.

BLAND, J.M., 2000. An introduction to medical statistics. Third edn. Oxford: Oxford University Press.

BLYTH, F.M., MARCH, L.M., NICHOLAS, M.K. and COUSINS, M.J., 2005. Self-management of chronic pain: a population-based study. *Pain,* **113**(3), pp. 285-292.

BODENHEIMER, T., LORIG, K., HOLMAN, H. and GRUMBACH, K., 2002a. Patient self-management of chronic disease in primary care. *Journal of the American Medical Association,* **288**, pp. 2469-2475.

BODENHEIMER, T., WAGNER, E.H. and GRUMBACH, K., 2002b. Improving primary care for patients with chronic illness. *Journal of the American Medical Association,* **288**(14), pp. 1775-1779.

BOHANNON, R.W., 1997. Comfortable and maximum walking speed of adults aged 20-79 years: reference values and determinants. *Age and Ageing,* **26**, pp. 15-19.

BOMBARDIER, C., 2000. Outcome assessments in the evaluation of treatment of spinal disorders: summary and general recommendations. *Spine,* **25**(24), pp. 3100-3103.

BORKAN, J., REIS, S., HERMONI, D. and BIDERMAN, A., 1995. Talking about the pain: A patient-centred study of low back pain in primary care. *Social Science in Medicine,* **40**(7), pp. 977-988.

BORKAN, J.M., KOES, B., REIS, S. and CHERKIN, D., 1998. A report from the second international forum for primary care research on low back pain. Reexamining priorities. *Spine,* **23**, pp. 1992-1995.

BOUTER, L.M., VAN TULDER, M.W. and KOES, B.W., 1998. Methodologic issues in low back pain research in primary care. *Spine,* **23**(18), pp. 2014-2020.

BOWLING, A., 2002. Research methods in health: investigating health and health services. Second edn. Buckingham: Open University Press.

BROUWER, S., KUIJER, W., DIJKSTRA, P.U., GOEKEN, L.N.H., GROOTHOFF, J.W. and GEERTZEN, J.H.B., 2004. Reliability and stability of the Roland Morris disability questionnaire: intra class correlation and limits of agreement. *Disability and Rehabilitation,* **26**(3), pp. 162-165.

BRUTON, A., CONWAY, J.H. and HOLGATE, S.T., 2000. Reliability: What is it, and how is it measured? *Physiotherapy,* **86**(2), pp. 94-99.

BRYMAN, A., 2004. Social Research Methods. 2nd edn. UK: Oxford University press.

BUCHBINDER, R., JOLLEY, D. and WYATT, M., 2001. 2001 Volvo award winner in clinical studies: Effects of a media campaign on back pain beliefs and its potential influence on management of low back pain in general practice. *Spine,* **26**(23), pp. 2535-2542.

BUHRMAN, M., FALTENHAG, S., STROM, L. and ANDERSSON, G., 2004. Controlled trial of Internet-based treatment with telephone support for chronic back pain. *Pain,* **111**(3), pp. 368-377.

BURCKHARDT, C.S. and JONES, K.D., 2003. Adult Measures of Pain. *Arthritis and Rheumatism,* **49**(5S), pp. S96-S104.

BURNETT, A.F., BARRETT, C.J., MARSHALL, R.N., ELLIOTT, B.C. and DAY, R.E., 1998. Three-dimensional measurement of lumbar spine kinematics for fast bowlers in cricket. *Clinical Biomechanics,* **13**, pp. 574-583.

BURTON, A.K., MCCLUNE, T.D., CLARKE, R.D. and MAIN, C.J., 2004. Long-term follow-up of patients with low back pain attending for manipulative care: outcomes and predictors. *Manual Therapy,* **9**, pp. 30-35.

CALLAGHAN, J.P., PATLA, A.E. and MCGILL, S.M., 1999. Low back three-dimensional joint forces, kinematics, and kinetics during walking. *Clinical Biomechanics,* **14**(3), pp. 203-216.

CAMPBELL, H., RIVERO-ARIAS, O., JOHNSTON, K., GRAY, A., FAIRBANK, J. and FROST, H., 2006. Responsiveness of objective, disease-specific, and generic outcome measures in patients with chronic low back pain: An assessment for improving, stable, and deteriorating patients. *Spine,* **31**(7), pp. 815-822.

CASSIDY, J.D., COTE, P., CARROLL, L.J. and KRISTMAN, V., 2005. Incidence and course of low back pain episodes in the general population. *Spine,* **30**(24), pp. 2817-2823.

CHANSIRINUKOR, W., MAHER, C.G. and LATIMER, J., 2004. Evaluation of the multi-level Roland-Morris disability questionnaire. *Physiotherapy Theory and Practice,* **20**, pp. 1-15.

CHARTERED SOCIETY OF PHYSIOTHERAPY, 2004. Physiotherapy Pain association recommendations for low back pain related functional limitation outcome measures. *Chartered Society of Physiotherapy.*

CHARTERED SOCIETY OF PHYSIOTHERAPY, 2005. *Core standards of physiotherapy practice.* London: The Chartered Society of Physiotherapy.

CHERKIN, D.C., EISENBERG, D., SHERMAN, K.J., BARLOW, W., KAPTCHUK, T.J., STREET, J. and DEYO, R.A., 2001. Randomized trial comparing traditional Chinese medical acupuncture, therapeutic massage, and self-care education for chronic low back pain. *Archives of Internal Medicine,* **161**(8), pp. 1081-1088.

CHOCKALINGAM, N., DANGERFIELD, P. and COCHRANE, T., 2005. Reliability of marker placements and optoelectronic systems for analysing spinal movement. *International Journal of Therapy and Rehabilitation,* **12**(5), pp. 208-214.

CHOU, S.W., WONG, A.M., LEONG, C.P., HONG, W.S., TANG, F.T. and LIN, T.H., 2003. Postural control during sit-to stand and gait in stroke patients. *American Journal of Physical Medicine and Rehabilitation,* **82**(1), pp. 42-47.

CLEELAND, C., 1991. Pain assessment in cancer. In: D. OSOBA, ed, *Effect of cancer on quality of life.* First edn. Florida: CRC Press, pp. 293-306.

CLEELAND, C.S., 2004-last update, brief pain inventory (short form) [Homepage of Pain research Group, MD Anderson Cancer Centre, The University of Texas], [Online]. Available: www.mdanderson.org/departments/prg [11/12, 2004].

COGHLIN, S.S. and MCFADYEN, B.J., 1994. Transfer strategies used to rise from a chair in normal and low back pain subjects. *Clinical Biomechanics,* **9**, pp. 85-92.

COOK, F.M. and HASSENKAMP, A.M., 2000. Active rehabilitation for chronic low back pain: The patients' perspective. *Physiotherapy,* **86**(2), pp. 61-68.

COOPER, H., BOOTH, K., FEAR, S. and GILL, G., 2001. Chronic disease patient education: lessons from meta-analyses. *Patient Education and Counseling,* **44**, pp. 107-117.

COOPER, K., 2002. Gait analysis in chronic low back pain patients presenting for physiotherapy. MSc Thesis. Queen Margaret University College, Edinburgh.

COTTALORDA, J., 1999. Gait Analysis: Matching the Method to the Goal. *Revue du Rheumatisme,* **66**(7-9), pp. 367-369.

CRESSWELL, J.W., 2003. Research design. Qualitative, Quantitative, and mixed methods approaches. 2nd edn. Thousand Oaks, California: Sage Publications.

CROSBIE, J., VACHALATHITI, R. and SMITH, R., 1997a. Patterns of spinal motion during walking. *Gait and Posture,* **5**, pp. 6-12.

CROSBIE, J., VACHALATHITI, R. and SMITH, R., 1997b. Age, gender and speed effects on spinal kinematics during walking. *Gait and Posture,* **5**(1), pp. 13-20.

CUNHA, I.T., PROTAS, E.J. and JONES, S., 2002. Back pain, Physical function, and estimates of Aerobic capacity. What are the relationships among methods and measures. *American Journal of Physical Medicine and Rehabilitation,* **81**, pp. 913-920.

CUTLIP, R.G., MANCINELLI, C., HUBER, F. and DIPASQUALE, J., 2000. Evaluation of an instrumented walkway for measurement of the kinematic parameters of gait. *Gait and Posture,* **12**(2), pp. 134-138.

DALTROY, L.H., CATS-BARIL, W.L., KATZ, J.N., FOSSEL, A.H. and LIANG, M.H., 1996. The North American Spine Society Lumbar Spine Outcome Assessment Instrument. Reliability and validity tests. *Spine,* **21**(6), pp. 741-749.

DANKAERTS, W.; O'SULLIVAN, P.B.; BURNETT, A.F.; STRAKER, L.M., 2007. The use of a mechanism-based classification system to evaluate and direct management of a patient with non-specific chronic low back pain and motor control impairment – A case report. *Manual Therapy*, **12**, pp. 181-191.

DANKAERTS, W., O'SULLIVAN, P.B., STRAKER, L.M., BURNETT, A.F. and SKOUEN, J.S., 2006a. The inter-examiner reliability of a classification method for non-specific chronic low back pain patients with motor control impairment. *Manual Therapy,* **11**, pp. 28-39.

DANKAERTS, W., O'SULLIVAN, P., BURNETT, A. and STRAKER, L., 2006b. Differences in sitting postures are associated with nonspecific chronic low back pain disorders when patients are subclassified. *Spine,* **31**(6), pp. 698-704.

DANNESKIOLD-SAMSOE, B. and BARTELS, E.M., 2004. Idiopathic low back pain: Classification and differential diagnosis. *Journal of Musculoskeletal Pain,* **12**(3-4), pp. 93-99.

DAUT, R.L., CLEELAND, C.S. and FLANERY, R.C., 1983. Development of the Wisconsin Brief Pain Questionnaire to assess pain in cancer and other diseases. *Pain,* **17**(2), pp. 197-210.

DAVIDSON, M. and KEATING, L., 2002. A comparison of five low back disability questionnaires: Reliability and responsiveness. *Physical therapy,* **82**(1), pp. 8-24.

DAY, J.S., DUMAS, G.A. and MURDOCH, D.J., 1998. Evaluation of a long-range transmitter for use with a magnetic tracking device in motion analysis. *Journal of Biomechanics,* **31**(10), pp. 957-961.

DEAN, S.G., SMITH, J.A., PAYNE, S. and WEINMAN, J., 2005. Managing time: an interpretative phenomenological analysis of patients' and physiotherapists' perceptions of adherence to therapeutic exercise for low back pain. *Disability and Rehabilitation,* **27**(11), pp. 625-636.

DENZIN, N.K. and LINCOLN, Y.S., 1994. Handbook of qualitative research. California: Sage publications.

DESCARREAUX, M., BLOUIN, J.S. and TEASDALE, N., 2005. Repositioning accuracy and movement parameters in low back pain subjects and healthy control subjects. *European Spine Journal,* **14**(2), pp. 185-191.

DEYO, R.A. and CENTOR, R.M., 1986. Assessing the responsiveness of functional scales to clinical change: An analogy to diagnostic test performance. *Journal of Chronic Disease,* **39**(11), pp. 897-906.

DEYO, R.A., BATTIE, M., BEURSKENS, A.J.H.M., BOMBARDIER, C., CROFT, P., KOES, B., MALVIRAARA, A., ROLAND, M., VON KORFF, M. and WADDELL, G., 1998. Outcome measures for low back pain research. A proposal for standardised use. *Spine,* **23**(18), pp. 2003-2013.

DURWARD, B.R., BAER, G.D. and ROWE, P.J., 1999. Measurement issues in functional human movement. In: B.R. DURWARD, G.D. BAER and P.J. ROWE, eds, *Functional Human Movement.* First edn. Oxford: Butterworth-Heinemann, pp. 1-12.

DYSVIK, E., VINSNES, A.G. and EIKELAND, O., 2004. The effectiveness of a multidisciplinary pain management programme managing chronic pain. *International Journal of Nursing Practice,* **10**, pp. 224-234.

EHARA, Y., FUJIMOTO, H., MIYAZAKI, S., TANAKA, S. and YAMAMOTO, S., 1995. Comparison of the performance of 3D camera systems. *Gait and Posture,* **3**(3), pp. 166-169.

EHARA, Y., FUJIMOTO, H., MIYAZAKI, S., MOCHIMARU, M., TANAKA, S. and YAMAMOTO, S., 1997. Comparison of the performance of 3D camera systems II. *Gait and Posture,* **5**(3), pp. 251-255.

EHRLICH, G.E., 2003. Low back pain. *Bulletin of the World Health Organisation,* **81**(9), pp. 671-676.

ELLIOTT, A.,M., SMITH, B. and CHAMBERS, W.A., 2003. Measuring the severity of chronic pain: a research perspective. *Expert review of neurotherapeutics,* **3**(5), pp. 581-590.

EVANS, R.L., MAIERS, M.J. and BRONFORT, B., 2003. What do patients think? Results of a mixed methods pilot study assessing sciatica patients' interpretations of satisfaction and improvement. *Journal of manipulative and physiological therapeutics,* **26**(8), pp. 502-509.

FAIRBANK, J., DAVIES, J., COUPER, J. and OBRIEN, J., 1980. The Oswestry low back pain disability questionnaire. *Physiotherapy,* **66**(8), pp. 271-273.

FALLOWFIELD, L., JENKINS, V., FAREWELL, V., SAUL, J., DUFFY, A. and EVES, R., 2002. Efficacy of a Cancer Research UK communication skills training model for oncologists: a randomised controlled trial. *The Lancet,* **359**, pp. 650-656.

FARASYN, A. and MEEUSEN, R., 2006. Validity of the new Backache index (BAI) in patients with low back pain. *The Spine Journal,* **6**, pp. 565-571.

FEIPEL V.MESMAEKER, T., KLEIN, P. and ROOZE, M., 2001. Three-dimensional kinematics of the lumbar spine during treadmill walking at different speeds. *Clinical Orthopaedics and Related Research,* **10**(1), pp. 16-22.

FERREIRA, P.H., FERREIRA, M.L. and HODGES, P.W., 2004. Changes in recruitment of the abdominal muscles in people with low back pain: ultrasound measurement of muscle activity. *Spine,* **29**(22), pp. 2560-2566.

FINLAY, L., 2006. 'Rigour', 'ethical integrity' or 'artistry'? Reflexively reviewing criteria for evaluating qualitative research. *British Journal of Occupational Therapy,* **69**(7), pp. 319-326.

FISHER, K. and HARDIE, R.J., 2002. Goal attainment scaling in evaluating a multidisciplinary pain management programme. *Clinical rehabilitation,* **16**(8), pp. 871-877.

FORD, J.; STORY, I.; O'SULLIVAN, P.; MCMEEKEN, J., 2007. Classification systems for low back pain: A review of the methodology for development and validation. *Physical Therapy Reviews,* **12**, pp. 33-42.

FOSTER, N.E., THOMPSON, K.A., BAXTER, G.D. and ALLEN, J.M., 1999. Management of nonspecific low back pain by physiotherapists in Britain and Ireland. A descriptive questionnaire of current clinical practice. *Spine,* **24**(13), pp. 1332-1342.

FRITZ, J.M., BRENNAN, G.P., CLIFFORD, S.N., HUNTER, S.J. and THACKERAY, A., 2006. An examination of the reliability of a classification algorithm for subgrouping patients with low back pain. *Spine,* **31**(1), pp. 77-82.

FROST, H., MOFFETT, J.A.K., MOSER, J.S. and FAIRBANK, J.C.T., 1995. Randomised controlled trial for evaluation of fitness programme for patients with chronic low back pain. *British Medical Journal,* **310**(6973), pp. 151-4.

FROST, H., LAMB, S.E. and SHACKLETON, C.H., 2000. A functional restoration programme for chronic low back pain. *Physiotherapy,* **86**(6), pp. 285-293.

GALVIN, K., 2005. Navigating a qualitative course in programme evaluation. In: I. HOLLOWAY, ed, *Qualitative research in health care.* First edn. Maidenhead: Open University Press, pp. 229-249.

GEORGE, S.Z. and HIRSH, A.T., 2005. Distinguishing patient satisfaction with treatment delivery from treatment effect: a preliminary investigation of patient satisfaction with symptoms after physical therapy treatment of low back pain. *Archives of Physical Medicine and Rehabilitation,* **86**(7), pp. 1338-1344.

GERTEIS, M., EDGMAN-LEVITAN, S., DALEY, J. and DELBANCO T L., 1993. Through the patient's eyes: Understanding and promoting patient-centred care. San Francisco, CA: Jossey Bass.

GIBSON, B.E. and MARTIN, D.K., 2003. Qualitative research and evidence-based practice. *Physiotherapy,* **89**(6), pp. 350-358.

GILLEARD, W.; CROSBIE, J.; SMITH, R (In press) Rising to stand from a chair: Symmetry, and frontal and transverse plane kinematics and kinetics. *Gait and posture (2006),* doi: 10.1016/j.gaitpost.2006.11.002.

GILLESPIE, R., FLORIN, D. and GILLAM, S., 2004. How is patient-centred care understood by the clinical, managerial and lay stakeholders responsible for promoting this agenda? *Health Expectations,* **7**, pp. 142-148.

GIOFTSOS, G. and GRIEVE, D.W., 1996. The use of artificial neural networks to identify patients with chronic low-back pain conditions from patterns of sit-to-stand manoeuvres. *Clinical Biomechanics,* **11**(5), pp. 275-280.

GLOMSROD, B., LONN, J.H., SOUKUP, M.G., BO, K. and LARSEN, S., 2001. "Active back school", prophylactic management for low back pain: Three-year follow-up of a randomised controlled trial. *Journal of Rehabilitation Medicine,* **33**, pp. 26-30.

GOK, H., ERGIN, S. and YAVUZER, G., 2002. Reliability of gait measurements in normal subjects. *Journal of Rheumatology and Medical Rehabilitation,* **13**(2), pp. 76-80.

GOLDINGAY, S., 2006. Communication and assessment. The skills of information gathering. In: L. GIFFORD, ed, *Topical issues in pain 5.* First edn. Cornwall: CNS Press, pp. 69-88.

GOLDSTEIN, M.S., ELLIOTT, S.D. and GUCCIONE, A.A., 2000. The development of an instrument to measure satisfaction with physical therapy. *Physical Therapy,* **80**(9), pp. 853-862.

GOLDSTEIN, M.S., MORGENSTERN, H., HURWITZ, E.L. and YU, F., 2002. The impact of treatment confidence on pain and disability among patients with low-back pain: results from the University of California, Los Angeles, low-back pain study. *The Spine Journal,* **2**, pp. 391-401.

GRABOIS, M., 2005. Management of Chronic Low Back Pain. *American Journal of Physical Medicine and Rehabilitation,* **84**, pp. S29-S41.

GRACEY, J.H., MCDONOUGH, S.M. and BAXTER, G.D., 2002. Physiotherapy management of low back pain: a survey of current practice in Northern Ireland. *Spine,* **27**(4), pp. 406-411.

GRAY, J.A.M., 2004. Self-management in chronic illness. *Lancet,* **364**, pp. 1467-1468.

GRBICH, C., 1999. Qualitative research in health. An introduction. London: Sage Publications.

GREEN, J. and THOROGOOD, N., 2004. Qualitative methods for health research. London: Sage publications.

GREENOUGH, C.G. and FRASER, R.D., 1992. Assessment of outcome in patients with low back pain. *Spine,* **17**(1), pp. 36-41.

GRIMMER, K., SHEPHERD, L., PITT, M., MAGAREY, M. and TROTT, P., 1999. Differences in stakeholder expectations in the outcome of physiotherapy management of acute low back pain. *International Journal for quality in health care,* **11**(2), pp. 155-162.

GRIMSHAW, J.M., SHIRRAN, L., THOMAS, R., MOWATT, G., FRASER, C., BERO, L., GRILLI, R., HARVEY, E., OXMAN, A. and O'BRIEN, M.A., 2001. Changing provider behavior: an overview of systematic reviews of interventions. *Medical care,* **39**(8 Suppl 2), pp. 2-45.

GROSS, M.M., STEVENSON, P.J., CHARETTE, S.L., PYKA, G. and MARCUS, R., 1998. Effect of muscle strength and movement speed on the biomechanics of rising from a chair in healthy elderly and young women. *Gait and Posture,* **8**, pp. 175-185.

GROSS, J.M., FETTO, J., ROSEN, E., 2002. Musculoskeletal examination. Oxford, Blackwell Science.

GROTLE, M., BROX, J.I. and VOLLESTAD, N.K., 2004. Functional status and disability questionnaires: what do they assess? A systematic review of back-specific outcome questionnaires. *Spine,* **30**(1), pp. 130-140.

GROWNEY, E., MEGLAN, D., JOHNSON, M., CAHALAN, T. and AN, K., 1997. Repeated measures of adult normal walking using a video tracking system. *Gait and Posture,* **6**, pp. 147-162.

GRUMAN, J. and VON KORFF, M., 1999. Self-management services. Their role in disease management. *Disease Management and health outcomes,* **6**(3), pp. 151-158.

HALL, J.A., MILBURN, M.A., ROTER, D.L. and DALTROY, L.H., 1998. Why are sicker patients less satisfied with their medical care? Tests of two explanatory models. *Health Psychology,* **17**(1), pp. 70-75.

HAMILL, J. and KNUTZEN, K.M., 2003. Biomechanical basis of human movement. Second edn. Philadelphia: Lippincott, Williams & Wilkins.

HANKE, T.A., PAI, Y. and ROGERS, M.W., 1995. Reliability of measurements of body center-of-mass momentum during sit-to-stand in healthy adults. *Physical Therapy,* **75**(2), pp. 105-118.

HARDING, G., PARSONS, S., RAHMAN, A. and UNDERWOOD, M., 2005. "It struck me that they didn't understand pain": the specialist pain clinic experience of patients with chronic musculoskeletal pain. *Arthritis and Rheumatism,* **53**(5), pp. 691-696.

HARDING, V.R., WILLIAMS, A.C., RICHARDSON, P.H., NICHOLAS, M.K., JACKSON, J.L., RICHARDSON, I.H. and PITHER, C.E., 1994. The development of a battery of measures for assessing physical functioning of chronic pain patients. *Pain,* **58**(3), pp. 367-375.

HARLICK, J.C., MILOSAVLJEVIC, S. and MILBURN, P.D., 2007. Palpation identification of spinous processes in the lumbar spine. *Manual Therapy,* **12**, pp. 56-62.

HARRIS, G.F. and WERTSCH, J.J., 1994. Procedures for Gait Analysis. *Archives of Physical Medicine and Rehabilitation,* **75**, pp. 216-225.

HARRISON, K. and WILLIAMS, S., 2000. Exploring the power balance in physiotherapy. *British Journal of Therapy and Rehabilitation,* **7**(8), pp. 355-361.

HAUSDORFF, J.M., LADIN, Z. and WEI, J.Y., 1995. Footswitch system for measurement of the temporal parameters of gait. *Journal of Biomechanics,* **28**(3), pp. 347-351.

HAWLEY, K., 2005. *Report on the EPP parent pilot course.* Department of Health.

HAYDEN, J.A., VAN TULDER, M.W., MALMIVAARA, A. and KOES, B.W., 2005. http://www3.interscience.wiley.com/cgi-bin/mrwhome/106568753/HOME. UK: The Cochrane database of Systematic Reviews.

HENBEST, R.J. and STEWART, M., 1990. Patient-centredness in the consultation. 2: Does it really make a difference? *Family Practice,* **7**(1), pp. 28-33.

HERZOG, W., NIGG, B.M., ROBINSON, R.O. and READ, L.J., 1987. Quantifying the effects of spinal manipulations on gait, using patients with low back pain: a pilot study. *Journal of Manipulative and Physiological Therapeutics,* **10**(6), pp. 295-299.

HILLS, R. and KITCHEN, S., 2007. Satisfaction with outpatient physiotherapy: A survey comparing the views of patients with acute and chronic musculoskeletal conditions. *Physiotherapy Theory and Practice,* **23** (1), pp. 21-36.

HINDLE, R.J., PEARCY, M.J., CROSS, A.T. and MILLER, D.H.T., 1990. Three-dimensional kinematics of the human back. *Clinical Biomechanics,* **5**(4), pp. 218-228.

HIRSCH, A.T., ATCHISON, J.W., BERGER, J.J., WAXENBERG, L.B., LAFAYETTE-LUCEY, A., BULCOURF, B.B. and ROBINSON, M.E., 2005. Patient satisfaction with treatment for chronic pain. *Clinical Journal of Pain,* **21**(4), pp. 302-310.

HOANES, C. and HARKER, S., 2005. *Compact Oxford English dictionary of current English.* 3rd Edition, Oxford University Press, UK.

HODGES, P.W., 2003. Core stability exercise in chronic low back pain. *Orthopedic Clinics of North America,* **34**(2), pp. 245-254.

HODGES, P.W. and MOSELEY, G.L., 2003. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. *Journal of Electromyography and Kinesiology,* **13**(4), pp. 361-370.

HODGES, P.W., MOSELEY, G.L., GABRIELSSON, A. and GANDEVIA, S.C., 2003. Experimental muscle pain changes feedforward postural responses of the trunk muscles. *Experimental Brain Research,* **151**(2), pp. 262-271.

HOLDSWORTH, L.K., WEBSTER, V.S. and MCFADYEN, A.K., 2006. Self-referral to physiotherapy: deprivation and geographical setting. Is there a relationship? Results of a national trial. *Physiotherapy,* **92**(1), pp. 16-25.

HOLDSWORTH, L.K., WEBSTER, V.S. and MCFADYEN, A.K., 2007. What are the costs to NHS Scotland of self-referral to physiotherapy? Results of a national trial. *Physiotherapy,* **93**(1), pp. 3-11.

HOLLOWAY, I. and WHEELER, S., 2002. Qualitative research in nursing. 2nd edn. Oxford: Blackwell.

HOLROYD, K.A., TALBOT, F., HOLM, J.E., PINGEL, J.D., LAKE, A.E. and SAPER, J.R., 1996. Assessing the dimensions of pain: A multitrait-multimethod evaluation of seven measures. *Pain,* **67**(2-3), pp. 259-265.

HORSEY, M., THOMAS, P. and ADLEM, L., 2003. Effect of triage on patient outcomes. *Practice Development in Health Care,* **2**(1), pp. 29-32.

IKEDA, E.R., SCHENKMAN, M.L., O RILEY, P. and HODGE, W.A., 1991. Influence of age on dynamics of rising from a chair. *Physical Therapy,* **71**(6), pp. 473-481.

INTERNATIONAL ASSOCIATION FOR THE STUDY OF PAIN, 1986. *Pain,* (Suppl 3), pp. S1-S225.

IPHOFEN, R., 2005. Ethical issues in qualitative health research. In: HOLLOWAY, I, ed, *Qualitative research in health care.* Open University Press, Maidenhead, pp17-35.

JANSSEN, W.G., BUSSMANN, H.B. and STAM, H.J., 2002. Determinants of the sit-to-stand movement: a review. *Physical Therapy,* **82**(9), pp. 866-879.

JENG, S.F., SCHENKMAN, M., RILEY, P.O. and LIN, S.J., 1990. Reliability of a clinical kinematic assessment of the sit-to-stand movement. *Physical Therapy,* **70**(8), pp. 511-520.

JENSEN, M.P., KAROLY, P. and BRAVER, S., 1986. The Measurement of Clinical Pain Intensity: a Comparison of Six Methods. *Pain,* **27**, pp. 117-126.

JENSEN, M.P., NIELSON, W.R., TURNER, J.A., ROMANO, J.M. and HILL, M.L., 2004. Changes in readiness to self-manage pain are associated with improvement in multidisciplinary pain treatment and pain coping. *Pain,* **111**, pp. 84-95.

JERANT, A.F., VON FRIEDERICHSFITZWATER, M.M. and MOORE, M., 2005. Patients' perceived barriers to active self-management of chronic conditions. *Patient education and counseling,* **57**(3), pp. 300-307.

JETTE, A.M., 2006. Toward a common language for function, disability, and health. *Physical Therapy,* **86**(5), pp. 726-34.

JORDAN, J.E. and OSBORNE, R.H., 2007. Chronic disease self-management education programs: challenges ahead. *Medical Journal of Australia,* **86**(2), pp. 84-87.

JORDAN, K., DZIEDZIC, K., JONES, P.W., ONG, B.N. and DAWES, P.T., 2000. The reliability of the three-dimensional FASTRAK measurement system in measuring cervical spine and shoulder range of motion in healthy subjects. *Rheumatology,* **39**, pp. 382-388.

JORDAN, K., HAYWOOD, K.L., DZIEDZIC, K., GARRATT, A.M. and JONES, P.W., 2004. Assessment of the 3-Dimensional Fastrak Measurement System in Measuring Range of Motion in Ankylosing Spondylitis. *The Journal of Rheumatology,* **31**(11), pp. 2207-2215.

JOUSSET, N., FANELLO, S., BONTOUX, L., DUBUS, V., BILLABERT, C., VIELLE, B., ROQUELAURE, Y., PENNEAUFONTBONNE, D. and RICHARD, I., 2004. Effects of Functional Restoration Versus 3 Hours per Week Physical Therapy: A Randomized Controlled Study. *Spine,* **29**(5), pp. 487-494.

KADABA, M.P., RAMAKRISHNAN, H.K. and WOOTTEN, M.E., 1990. Measurement of Lower Extremity Kinematics During Level Walking. *Journal of Orthopaedic Research,* **8**(3), pp. 383-392.

KADABA, M.P., RAMAKRISHNAN, H.K., WOOTTEN, M.E., GAINEY, J., GORTON, G. and COCHRAN, G.V.B., 1989. Repeatability of Kinematic, Kinetic, and Electromyographic Data in Normal Adult Gait. *Journal of Orthopaedic Research,* **7**, pp. 849-860.

KALAUOKALAMI, D., CHERKIN, D.C., SHERMAN, K., KOEPSELL, T.D. and DEYO, R.A., 2001. Lessons from a trial of acupuncture and massage for low back pain. *Spine,* **26**(13), pp. 1418-1424.

KANE, R., 1994. Looking for physiotherapy outcomes. *Physical Therapy,* **74**, pp. 425-429.

KAPPA, E.H., FRANTSI, K., SARNA, S. and MALMIVAARA, A., 2006. Multidisciplinary group rehabilitation versus individual physiotherapy for chronic nonspecific low back pain. A randomised trial. *Spine,* **31**(4), pp. 371-376.

KEEFE, F.J. and HILL, R.W., 1985. An objective approach to quantifying pain behavior and gait patterns in low back pain patients. *Pain,* **21**(2), pp. 153-161.

KELLER, S., BANN, C.M., DODD, S.L., SCHEIN, J., MENDOZA, T.R. and CLEELAND, C.S., 2004. Validity of the Brief Pain Inventory for Use Documenting the Outcomes of Patients With Noncancer Pain. *Clinical Journal of Pain,* **20**(5), pp. 309-318.

KENDALL, N., 1997. Developing outcome assessments: A Step-by-step approach. *New Zealand Journal of Physiotherapy*, pp. 11-17.

KENNEDY, A., GASK, L. and ROGERS, A., 2005. Training professionals to engage with and promote self-management. *Health Education Research,* **20**(5), pp. 567-578.

KENT, P.M. and KEATING, J.L., 2005. The epidemiology of low back pain in primary care. *Chiropractic and Osteopathy,* **13**(7), pp. 1-7.

KERNS, R.D., TURK, D.C. and RUDY, T.E., 1985. The West Haven-Yale Multidimensional Pain Inventory (WHYMPI). *Pain,* **23**, pp. 345-356.

KERNS, R.D., ROSENBERG, R., JAMISON, R.N., CAUDILL, M.A. and HAYTHORNTHWAITE, J., 1997. Readiness to adopt a self-management approach to chronic pain: the Pain Stages of Change Questionnaire (PSOCQ). *Pain,* **72**(1-2), pp. 227-234.

KERR, K.M., WHITE, J.A., BARR, D.A. and MOLLAN, R.A., 1994. Standardization and definitions of the sit-stand-sit movement cycle. *Gait and Posture,* **2**(3), pp. 182-190.

KERR, K.M., WHITE, J.A., BARR, D.A. and MOLLAN, R.A.B., 1997. Analysis of the sit-stand-sit movement cycle in normal subjects. *Clinical Biomechanics,* **12**(4), pp. 236-245.

KHODADADEH, S., EISENSTEIN, S., SUMMERS, B. and PATRICK, J., 1988. Gait asymmetry in patients with chronic low back pain. *Neuro-Orthopedics,* **6**(1), pp. 24-27.

KHODADADEH, S. and EISENSTEIN, S.M., 1993. Gait analysis of patients with low back pain before and after surgery. *Spine,* **18**(11), pp. 1451-1455.

KIRKNESS, C. and KORNER-BITENSKY, N., 2002. Prevalence of Outcome Measure use by Physiotherapists in the management of Low Back Pain. *Physiotherapy Canada,* **54**(4), pp. 249-257.

KIRTLEY, C., 2006. Clinical gait analysis. Theory and practice. First edn. London: Elsevier.

KLABER MOFFETT, J., and FROST, H., 2000. Back to Fitness programme: the manual for physiotherapists to set up the classes. *Physiotherapy,* **86**(6), pp. 295-305.

KLABER MOFFETT, J.A., NEWBRONNER, E., WADDELL, G., CROUCHER, K. and SPEAR, S., 2000. Public perceptions about low back pain and its management: a gap between expectations and reality? *Health Expectations,* **3**, pp. 161-168.

KLABER MOFFETT, J., 2002. Back pain: encouraging a self-management approach. *Physiotherapy Theory and Practice,* **18**(4), pp. 205-212.

KLABER MOFFETT, J., JACKSON, D.A., RICHMOND, S., HAHN, S., COULTON, S., FARRIN, A., MANCA, A. and TORGERSON, D.J., 2005. Randomised trial of a brief physiotherapy intervention compared with usual physiotherapy for neck pain patients: outcomes and patients' preference. *British Medical Journal,* **330**(7482), pp. 75-78.

KLABER MOFFETT, J., GREEN, A. and JACKSON, D., 2006. Words that help, words that harm. In: L. GIFFORD, ed, *Topical issues in pain 5.* First edn. Cornwall: CNS Press, pp. 105-125.

KOPEC, J.A., ESDAILE, J.M., ABRAHAMOWICS, M., ABENHAIM, L., WOOD-DAUPHINEE, S., LAMPING, D.L. and WILLIAMS, J.I., 1995. The Quebec Back Pain Disability Scale. *Spine,* **20**(3), pp. 341-352.

KOPEC, J.A., 2000. Measuring functional outcomes in persons with back pain. *Spine,* **24**, pp. 3110-3114.

KRALJ, A., JAEGER, R.J. and MUNIH, M., 1990. Analysis of standing up and sitting down in humans: definitions and normative data presentation. *Journal of Biomechanics,* **23**(11), pp. 1123-1138.

KREBS, D.E., WONG, D., JEVSEVAR, D., O'RILEY, P. and HODGE, W.A., 1992. Trunk Kinematics During Locomotor Activities. *Physical Therapy,* **72**(7), pp. 505-514.

KRISMER, M. and VAN TULDER, M.W., 2007. Low back pain (non-specific). *Best Practice and Research in Clinical Rheumatology,* **21**(1), pp. 77-91.

KRUPAT, E., ROSENKRANZ, S.L., YEAGER, C.M., BARNARD, K., PUTNAM, S.M. and INUI, T.S., 2000. The practice orientations of physicians and patients: the effect of doctor-patient congruence on satisfaction. *Patient Education and Counseling,* **39**(1), pp. 49-59.

KUTZLEB, J. and REINER, D., 2006. The impact of nurse-directed patient education on quality of life and functional capacity in people with heart failure. *Journal of the American Academy of Nurse Practitioners,* **18**(3), pp. 116-123.

LAERUM, E., AAGE, I. and SKOUEN, J.S., 2006. What is "the good-back consultation?" A combined qualitative and quantitative study of chronic low back pain patients' interaction with and perceptions of consultations with specialists. *Journal of Rehabilitation Medicine,* **38**, pp. 255-262.

LAMOTH, C.J., MEIJER, O.G., WUISMAN, P.I., VAN DIEEN, J.H., LEVIN, M.F. and BEEK, P.J., 2002. Pelvis-thorax coordination in the transverse plane during walking in persons with nonspecific low back pain. *Spine,* **27**(4), pp. E92-9.

LAMOTH, C.J., DAFFERTSHOFER, A., MEIJER, O.G., LORIMER MOSELEY, G., WUISMAN, P.I. and BEEK, P.J., 2004. Effects of experimentally induced pain and fear of pain on trunk coordination and back muscle activity during walking. *Clinical Biomechanics,* **19**(6), pp. 551-563.

LAMOTH, C.J., DAFFERTSHOFER, A., MEIJER, O.G. and BEEK, P.J., 2006a. How do persons with chronic low back pain speed up and slow down? Trunk-pelvis coordination and lumbar erector spinae activity during gait. *Gait and posture,* **23**(2), pp. 230-239.

LAMOTH, C.J., MEIJER, O.G., DAFFERTSHOFER, A., WUISMAN, P.I. and BEEK, P.J., 2006b. Effects of chronic low back pain on trunk coordination and back muscle activity during walking: changes in motor control. *European Spine Journal,* **15**(1), pp. 23-40.

LANG, E., LIEBIG, K., KASTNER, S., NEUNDORFER, B. and HEUSCHMANN, P., 2003. Multidisciplinary rehabilitation versus usual care for chronic low back pain in the community: effects on quality of life. *Spine Journal: Official Journal of the North American Spine Society,* **3**(4), pp. 270-276.

LAW, M., BAPTISTE, S. and MILLS, J., 1995. Client-centred practice: what does it mean and does it make a difference? *Canadian Journal of Occupational Therapy,* **62**(5), pp. 250-257.

LAWLISS, G.F., CUENCAS, R., SELBY, D. and MCCOY, C.E., 1989. The development of the Dallas Pain Questionnaire. An assessment of the impact of spinal pain on behaviour. *Spine,* **14**(5), pp. 511-516.

LAYZELL, M., 2001. Back pain management: a patient satisfaction study of services. *British Journal of Nursing,* **10**(12), pp. 800-807.

LEBOUEF-YDE, C., LAURITSEN, J.M. and LAURITZEN, T., 1997. Why has the search for causes of low back pain largely been inconclusive? *Spine,* **22**(8), pp. 877-81.

LEBOW, J., 1982. Consumer satisfaction with mental health treatment. *Psychological Bulletin,* **91**(2), pp. 244-259.

LECLAIRE, R., BLIER, F., FORTIN, L. and PROULX, R., 1997. A cross-sectional study comparing the Oswestry and Roland-Morris functional scales in two populations of patients with low back pain of different levels of severity. *Spine,* **22**(1), pp. 68-71.

LEE, C.E., SIMMONDS, M.J., NOVY, D.M. and JONES, S.C., 2002. Functional self-efficacy, perceived gait ability and perceived exertion in walking performance of individuals with low back pain. *Physiotherapy Theory and Practice,* **18**(4), pp. 193-203.

LEGARD, R., KEEGAN, J., WARD, K. In-depth interviews. In: J. RITCHIE and J. LEWIS, eds, *Qualitative research practice. A guide for social science students and researchers.* First edn. London, UK: Sage publications, pp. 138-169.

LEVINE, D. and WHITTLE, M.W., 1997 The Effects of Pelvic Movement on Lumbar Lordosis in the Standing Position. *Journal of Orthopaedic and Sports Physical Therapy,* **24**(3), pp. 130-135.

LEWIS, J. and RITCHIE, J., 2003. Generalising form qualitative research. In: J. RITCHIE and J. LEWIS, eds, 1st edn. London: Sage Publications, pp. 263-286.

LEWIS, J.S., HEWITT, J.S., BILLINGTON, L., COLE, S., BYNG, J. and KARAYIANNIS, S., 2005. A randomized clinical trial comparing two physiotherapy interventions for chronic low back pain. *Spine,* **30**(7), pp. 711-721.

LI, L.C. and BOMBARDIER, C., 2001. Physical therapy management of low back pain: an exploratory survey of therapist approaches. *Physical Therapy,* **81**(4), pp. 1018-1028.

LIEBENSON, C. and YEOMANS, S., 1997. Outcomes assessment in musculoskeletal medicine. *Manual Therapy,* **2**(2), pp. 67-74.

LINDE, K., WITT, C.M., STRENG, A., WEIDENHAMMER, S.W., BRINKHAUS, B., WILLICH, S.N. and MELCHART, D., 2007. The impact of patient expectations on outcomes in four randomized controlled trials of acupuncture in patients with chronic pain. *Pain,* **128**, pp. 264-271.

LITTLE, P., EVERITT, H., WILLIAMSON, I., WARNER, G., MOORE, M., GOULD, C., FERRIER, K. and PAYNE, S., 2001. Preferences for patient centred approach to consultation in primary care: observational study. *British Medical Journal,* **322**, pp. 1-7.

LITTLEWOOD, C. and MAY, S., 2006. Measurement of range of movement in the lumbar spine - what methods are valid? A systematic review. *Physiotherapy,* In Press: doi:10.1016/j.physio.2006.10.006 [accessed online 14/12/2006].

LJUNGQUIST, T., JENSEN, I.B., NYGREN, A. and HARMS-RINGDAHL, K., 2003. Physical performance tests for people with long-term spinal pain: aspects of construct validity. *Journal of Rehabilitation Medicine,* **35**(2), pp. 69-75.

LORIG, K.R., SOBEL, D.S., STEWART, A.L., BROWN, B.W., BANDURA, A., RITTER, P., GONZALEZ, V.M., LAURENT, D.D. and HOLMAN, H.R., 1999. Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization: A randomized trial. *Medical Care,* **37**(1), pp. 5-14.

LORIG, K.R., SOBEL, D.S., RITTER, P.L., LAURENT, D. and HOBBS, M., 2001. Effect of a self-management program on patients with chronic disease. *Effective Clinical Practice,* **4**(6), pp. 256-262.

LORIG, K.R., LAURENT, D.D., DEYO, R.A., MARNELL, M.E., MINOR, M.A. and RITTER, P.L., 2002. Can a Back Pain E-mail Discussion Group improve health status and lower health care costs? A randomized study. *Archives of Internal Medicine,* **162**(7), pp. 792-796.

LORIG, K., 2003. Self-management education. More than a nice extra. *Medical care,* **41**(6), pp. 699-701.

LORIG, K.R. and HOLMAN, H., 2003. Self-management education: history, definition, outcomes, and mechanisms. *Annals of Behavioral Medicine,* **26**(1), pp. 1-7.

LOU, S.Z., CHOU, Y.L., CHOU, P.H., LIN, C.J., CHEN, U.C. and SU, F.C., 2001. Sit-to-stand at different periods of pregnancy. *Clinical Biomechanics,* **16**(3), pp. 194-198.

LUND, J.P., WIDMER, C.G. and STOHLER, C.S., 1991. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. *Canadian journal of physiology and pharmacology,* **69**, pp. 683-694.

MAGNUSSEN, L., STRAND, L.I. and LYGREN, H., 2004. Reliability and Validity of the back Performance Scale: Observing Activity Limitation in Patients with Back Pain. *Spine,* **29**(8), pp. 903-907.

MAITLAND, G.D., BANKS, K., ENGLISH, K. and HENGEVELD, E., eds, 2001. *Maitland's Vertebral Manipulation.* 6 edn. Oxford, UK: Butterwoeth-Heinemann.

MANIADAKIS, N. and GRAY, A., 2000. The economic burden of back pain in the UK. *Pain,* **84**, pp. 95-103.

MANNICHE, C., ASMUSSEN, K., LAURITSEN, B., VINTERBERG, H., KREINER, S. and JORDAN, A., 1994. Low back pain rating scale: validation of a tool for assessment of low back pain. *Pain,* **57**, pp. 317-326.

MAY, S.J., 2001. Patient satisfaction with management of back pain: part 2: an explorative, qualitative study into patients' satisfaction with physiotherapy. *Physiotherapy,* **87**(1), pp. 10-20.

MAYO, N.E., 1994. Outcome measures or measuring outcome. *Physiotherapy Canada,* **46**(3), pp. 145-148.

MAYS, N. and POPE, C., 2000. Qualitative research in health care: assessing quality in qualitative research... first in a series of three articles. *British Medical Journal,* **320**(7226), pp. 50-52.

MCCARTHY, C.J., OLDHAM, J.A. and SEPHTON, R., 2005. Expectations and satisfaction of patients with low back pain attending a rehabilitation service. *Physiotherapy research international,* **10**(1), pp. 23-31.

MCDOWELL, I. and NEWELL, C., 1996. Measuring health. A guide to rating scales and questionnaires. Second edn. New York: Oxford University Press.

MCKENZIE, R. and MAY, S., 2003. The lumbar spine: Mechanical diagnosis and therapy. Second edn. New Zealand: Spinal Publications.

MCKINSTRY, B., 1992. Paternalism and the doctor-patient relationship in general practice. *British Journal of General Practice,* **42**(361), pp. 340-342.

MCPHILLIPS-TANGUM, C.A., CHERKIN, D.C., RHODES, L.A. and MARKHAM, C., 1998. Reasons for repeated medical visits among patients with chronic back pain. *Journal of general internal medicine,* **13**, pp. 289-295.

MEAD, J., 2000. Patient partnership. *Physiotherapy,* **86**(6), pp. 282-284.

MEAD, N. and BOWER, P., 2000. Patient-centredness: a conceptual framework and review of the empirical literature. *Social science and medicine,* **51**(7), pp. 1087-1110.

MELDRUM, D., 2005. A pilot study to investigate the reliability of computerised measurement of human gait using the Vicon motion analysis. *Physiotherapy Ireland,* **26**(2), pp. 39-41.

MELZACK, R., 1975. The McGill Pain Questionnaire: Major Properties and Scoring Methods. *Pain,* **1**, pp. 277-299.

MENZ, H.B., LATT, M.D., TIEDEMANN, A., MUN SAN KWAN, M. and LORD, S.R., 2004. Reliability of the GAITRite walkway system for the quantification of temporo-spatial parameters of gait in young and older people. *Gait and posture,* **20**(1), pp. 20-25.

MERCER, C., JACKSON, A., HETTINGA, D., BARLOS, D., FERGUSON, S., GREENHALGH, S., HARDING, V., HURLEY OSING, D., KLABER MOFFETT, J., MARTIN, D., MAY, S., MONTEATH, J., ROBERTS, L., TAYLOR, N. and WOBY, S., 2006. *Clinical guidelines for the physiotherapy management of persistent low back pain, part 1: exercise.* London: Chartered Society of Physiotherapy.

METCALFE, C.J. and KLABER MOFFETT, J.A., 2005a. Do patients' expectations of physiotherapy affect treatment outcome? Part 1: Baseline data. *International Journal of Therapy and Rehabilitation,* **12**(2), pp. 55-62.

METCALFE, C.J. and KLABER MOFFETT, J.A., 2005b. Do patients' expectations of physiotherapy affect treatment outcome? Part 2: Survey results. *International Journal of Therapy and Rehabilitation,* **12**(3), pp. 112-119.

MILLER, C.A. and VERSTRAETE, M.C., 1996. Determination of the step by step duration of gait initiation using a mechanical energy analysis. *Journal of Biomechanics,* **29**(9), pp. 1195-1199.

MILLER, E.R., SCHENK, R.J., KARNES, J.L. and ROUSSELLE, J.G., 2005. A comparison of the McKenzie approach to a specific spine stabilization program for chronic low back pain. *Journal of Manual and Manipulative Therapy,* **13**(2), pp. 103-112.

MILLER, J.S., STANLEY, I. and MOORE, K., 2004. Videotaped exercise instruction: A randomised controlled trial in musculoskeletal physiotherapy. *Physiotherapy Theory and Practice,* **20**(3), pp. 145-154.

MILLINGTON, P.J., MYKELBUST, B.M. and SHAMBES, G.M., 1992. Biomechanical analysis of the sit-to-stand motion in elderly persons. *Archives of Physical Medicine and Rehabilitation,* **73**, pp. 609-617.

MILLION, R., HALL, W., NILSEN, K.H., BAKER, R.D. and JAYSON, M.I.V., 1982. Assessment of the progress of the back pain patient. *Spine,* **7**(3), pp. 204-212.

MILLS, P.M., MORRISON, S., LLOYD, D.G. and BARRETT, R.S., 2007. Repeatability of 3D gait kinematics obtained from an electromagnetic tracking system during treadmill locomotion. *Journal of Biomechanics,* **40**, pp. 1505-1511.

MOE-NILSSEN, R., LJUNGGREN, A.E. and TOREBJORK, E., 1999. Dynamic adjustments of walking behavior dependent on noxious input in experimental low back pain. *Pain,* **83**(3), pp. 477-485.

MONNINKHOF, E., VAN DER AA, M., VAN DER VALK, P., VAN DER PALEN, J., ZIELHUIS, G., KONING, K. and PIETERSE, M., 2004. A qualitative evaluation of a comprehensive self-management programme for COPD patients: effectiveness from the patients' perspective. *Patient Education and Counseling,* **55**, pp. 177-184.

MOORE, J.E., VON KORFF, M., CHERKIN, D., SAUNDERS, K. and LORIG, K., 2000. A randomized trial of a cognitive-behavioral program for enhancing back pain self care in a primary care setting. *Pain,* **88**(2), pp. 145-153.

MORAG, E., HURWITZ, D.E., ANDRIACCHI, T.P., HICKEY, M. and ANDERSSON, G.B.J., 2000. Abnormalities in Muscle Function During Gait in relation to the Level of Lumbar Disc Herniation. *Spine,* **25**(7), pp. 829-833.

MORLOCK, R.J., LAFATA, J.E., NERENZ, D., SCHILLER, M. and ROSENBLUM, M., 2002. Expectations, outcomes, and medical costs in patients with low back pain referred to physical therapy. *Disease Management,* **5**(4), pp. 185-188.

MOSELEY, G.L., 2003. Joining forces - Combining cognition-targeted motor control training with group or individual pain physiology education: A successful treatment for chronic low back pain. *Journal of Manual and Manipulative Therapy,* **11**(2), pp. 88-94.

MULLER, U., DUETZ, M.S., ROEDER, C. and GREENOUGH, C.G., 2004. Condition-specific outcome measures for low back pain. Part I: Validation. *European spine journal,* **13**, pp. 301-313.

NATTRASS, C.L., NITSCHE, J.E., DISLER, P.B., CHOU, M.J. and OOI, K.T., 1999. Lumbar spine range of motion as a measure of physical and functional impairment:an investigation of validity. *Clinical Rehabilitation,* **13**, pp. 211-218.

NAYLOR, M.R., HELZER, J.E., NAUD, S. and KEEFE, F.J., 2002. Automated telephone as an adjunct for the treatment of chronic pain: A pilot study. *Journal of Pain,* **3**(6), pp. 429-438.

NEWMAN, S., STEED, L. and MULLIGAN, K., 2004. Self-management interventions for chronic illness. *Lancet,* **364**, pp. 1523-1537.

NHS GRAMPIAN PHYSIOTHERAPY LOW BACK PAIN WORKING GROUP, 2005. *Physiotherapy low back pain pathway.* NHS Grampian.

NICHOLS, D.P., 1998-last update, choosing an intraclass correlation coefficient [Homepage of UCLA], [Online]. Available: www.ats.ucla.edu/stat/spss/library/whichicc.htm [09/07, 2005].

NIEMISTO, L., LAHTINENSUOPANKI, T., RISSANEN, P., LINDGREN, K.A., SARNA, S. and HURRI, H., 2003. A randomized trial of combined manipulation, stabilizing exercises, and physician consultation compared to physician consultation alone for chronic low back pain. *Spine,* **28**(19), pp. 2185-91.

NOLTE, S., ELSWORTH, G.R., SINCLAIR, A.J. and OSBORNE, R.H., 2007. The extent and breadth of benefits from participating in chronic disease self-management courses: A national patient-reported outcomes survey. *Patient Education and Counseling,* **65**, pp. 351-360.

NOVY, D.M., SIMMONDS, M.J., OLSON, S.L., LEE, C.E. and JONES, S.C., 1999. Physical performance: differences in men and women with and without low back pain. *Archives of Physical Medicine and Rehabilitation,* **80**(2), pp. 195-198.

NOVY, D.M., SIMMONDS, M.J. and LEE, C.E., 2002. Physical performance tasks: what are the underlying constructs? *Archives of Physical Medicine and Rehabilitation,* **83**(1), pp. 44-47.

NUZIK, S., LAMB, R., VAN SANT, A. and HIRT, S., 1986. Sit to stand movement pattern. A kinematic study. *Physical Therapy,* **66**(11), pp. 1708-1713.

NYIENDO, J., HAAS, M. and GOODWIN, P., 2000. Patient characteristics, practice activities, and one-month outcomes for chronic, recurrent low-back pain treated by chiropractors and family medicine physicians: A practice-based feasibility study. *Journal of manipulative and physiological therapeutics,* **23**(4), pp. 239-245.

NYIENDO, J., HAAS, M., GOLDBERG, B. and LLOYD, C., 2001. A descriptive study of medical and chiropractic patients with chronic low back pain and sciatica: management by physicians (practice activities) and patients (self-management). *Journal of Manipulative and Physiological Therapeutics,* **24**(9), pp. 543-551.

OBERG, B., ENTHOVEN, P., KJELLMAN, G. and SKARGREN, G., 2003. Back Pain in Primary Care: a prospective Cohort Study of Clinical Outcome and Healthcare Consumption. *Advances in Physiotherapy,* **5**, pp. 98-108.

OGON, M., KRISMER, M., SOLLNER, W., KANTNER-RUMPLMAIR, W. and LAMPE, A., 1996. Chronic low back pain measurement with visual analogue scales in different settings. *Pain,* **64**, pp. 425-428.

O'HAIRE, C.O. and GIBBONS, P., 2000. Inter-examiner and intra-examiner agreement for assessing sacroiliac anatomical landmarks using palpation and observation: pilot study. *Manual Therapy,* **5**(1), pp. 13-20.

OLESEN, F., 2004. Striking the balance: from patient-centred to dialogue-centred medicine. *Scandinavian Journal of Primary Health Care,* **22 (Editorial)**.

OSBORN, M. and SMITH, J.A., 1998. The personal experience of chronic benign lower back pain: An interpretative phenomenological analysis. *British Journal of Health Psychology,* **3**, pp. 65-83.

OSTELO, R.W., DE VET, H.C., KNOL, D.L. and VAN DEN BRANDT, P.A., 2004. 24-item Roland-Morris Disability Questionnaire was preferred out of six functional status questionnaires for post-lumbar disc surgery. *Journal of clinical epidemiology,* **57**(3), pp. 268-276.

OSTLUND, G., CEDERSUND, E., ALEXANDERSON, K. and HENSING, G., 2001. "It was really nice to have someone" -- lay people with musculoskeletal disorders request supportive relationships in rehabilitation. *Scandinavian journal of public health,* **29**(4), pp. 285-291.

O'SULLIVAN, P.B., BURNETT, A., FLOYD, A.N., GADSDON, K., LOGUIDICE, J., MILLER, D. and QUIRKE, H., 2003. Lumbar Repositioning Deficit in a Specific Low Back Pain Population. *Spine,* **28**(10), pp. 1074-1079.

O'SULLIVAN, P., 2005. Diagnosis and classification of chronic low back pain disorders: Maladaptive movement and motor control impairments as underlying mechanism. *Manual Therapy,* **10**(4), pp. 242-255.

PAIN ASSOCIATION SCOTLAND, homepage [Homepage of Pain Association Scotland], [Online]. Available: www.painassociation.com [16/08, 2006].

PANJABI, M.M., 1992. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of spinal disorders,* **5**(4), pp. 383-389.

PAPA, E. and CAPPOZZO, A., 2000. Sit-to-stand motor strategies investigated in able-bodied young and elderly subjects. *Journal of Biomechanics,* **33**(9), pp. 1113-1122.

PATRICK, D.L., DEYO, R.A., ATLAS, S.J., SINGER, D.E., CHAPIN, A. and KELLER, R.B., 1995. Assessing health-related quality of life in patients with sciatica. *Spine,* **20**(17), pp. 1899-1909.

PAYTON, O.D. and NELSON, C.E., 1996. A preliminary study of patients' perceptions of certain aspects of their physical therapy experience. *Physiotherapy Theory and Practice,* **12**, pp. 27-38.

PAYTON, O.D., NELSON, C.E. and HOBBS, M.S., 1998. Physical therapy patients' perceptions of their relationships with health care professionals. *Physiotherapy theory and practice,* **14**, pp. 211-221.

PEARCY, M.J., GILL, J.M., WHITTLE, M.W. and JOHNSON, G.R., 1987. Dynamic back movement measured using a three-dimensional television system. *Journal of Biomechanics,* **20**(10), pp. 943-949.

PERNEGER, T.V., 1998. What's wrong with Bonferroni adjustments. *British Medical Journal,* **316**(7139), pp. 1236-1238.

PETERSEN, T., KRYGER, P., EKDAHL, C., OLSEN, S. and JACOBSEN, S., 2002. The effect of McKenzie therapy as compared with that of intensive strengthening training for the treatment of patients with subacute or chronic low back pain: A randomized controlled trial. *Spine,* **27**(16), pp. 1702-1709.

PETERSEN, T., OLSEN, S., LASLETT, M., THORSEN, H., MANNICHE, C., EKDAHL, C. and JACOBSEN, S., 2004. Inter-tester reliability of a new diagnostic classification system for patients with non-specific low back pain. *Australian Journal of Physiotherapy,* **50**, pp. 85-91.

PETRIE, A. and SABIN, C., 2005. Medical statistics at a glance. Second edn. Oxford: Blackwell Publishing.

PHAREM, A.R.G., GALER, B.S., LACOUTURE, P., DOMINGOS, J. and SCHLAGHECK, T., 2003. Effectiveness and Safety of New Oxycodone/Acetaminophen Formulations With Reduced Acetaminophen for the Treatment of Low Back Pain. *Pain Medicine,* **4**(1).

PINCUS, T., VOGEL, S., SAVAGE, R. and NEWMAN, S., 2000. Patients' satisfaction with osteopathic and GP management of low back pain in the same surgery. *Complementary therapies in medicine,* **8**(3), pp. 180-186.

POITRAS, S., LOISEL, P., PRINCE, F. and LENAIRE, J., 2000. Disability measurement in persons with back pain: A validity study of spinal range of motion and velocity. *Archives of Physical Medicine and Rehabilitation,* **81**, pp. 1394-1400.

POLGAR, S. and THOMAS, S.A., 1999. Introduction to research in the health sciences. 3rd edn. Australia: Churchill Livingstone.

POLHEMUS, 2001. Fastrak. Product brochure. Colchester, Vermont, USA.

PORTER - MOFFITT, S., GATCHEL, R.J., ROBINSON, R.C., DESCHNER, M., POSAMENTIER, M., POLATIN, P. and LOU, L., 2006. Biopsychosocial profiles of different pain diagnostic groups. *Journal of Pain,* **7**(5), pp. 308-318.

POTTER, M., GORDON, S. and HAMER, P., 2003a. The physiotherapy experience in private practice: the patients' perspective. *Australian Journal of Physiotherapy,* **49**(3), pp. 195-202.

POTTER, M., GORDON, S. and HAMER, P., 2003b. Identifying physiotherapist and patient expectations in private practice physiotherapy. *Physiotherapy Canada,* **55**(4), pp. 195-202.

RAINVILLE, J., HARTIGAN, C., JOUVE, C. and MARTINEZ, E., 2004a. The influence of intense exercise-based physical therapy program on back pain anticipated before and induced by physical activities. *Spine Journal: Official Journal of the North American Spine Society,* **4**(2), pp. 176-183.

RAINVILLE, J., HARTIGAN, C., MARTINEZ, E., LIMKE, J., JOUVE, C. and FINNO, M., 2004b. Exercise as a treatment for chronic low back pain. *Spine Journal: Official Journal of the North American Spine Society,* **4**(1), pp. 106-115.

RAMAKRISHNAN, H.K. and KADABA, M.P., 1991. On the estimation of Joint Kinematics During Gait. *Journal of Biomechanics,* **24**(10), pp. 969-977.

RENEMAN, M.F., JORRITSMA, W., SCHELLEKENS, J.M.H. and GOEKEN, L.N.H., 2002. Concurrent Validity of Questionnaire and Performance-Based Disability Measurements in Patients With Chronic Nonspecific Low back Pain. *Journal of Occupational Rehabilitation,* **12**(3), pp. 119-128.

RESNIK, L. and DOBRZYKOWSKI, E., 2003. Guide to Outcomes Measurement for Patients With Low Back Pain Syndromes. *Journal of Orthopaedic and Sports Physical Therapy,* **33**(6), pp. 307-316.

RESNIK, L. and JENSEN, G.M., 2003. Using clinical outcomes to explore the theory of expert practice in physical therapy. *Physical Therapy,* **83**(12), pp. 1090-1106.

RICE, J., KALISZER, M., WALSH, M., JENKINSON, A. and O'BRIEN, T., 2004. Movements at the low back during normal walking. *Clinical Anatomy,* **17**(8), pp. 662-666.

RICHARDSON, C., JULL, G., HODGES, P. and HIDES, J., 1999. Therapeutic exercise for spinal segmental stabilization in low back pain. Scientific basis and clinical approach. First edn. Edinburgh: Churchill Livingstone.

RIDDLE, D.L. and STRATFORD, P.W., 2002. Roland-Morris Scale reliability. Letter to the editor. *Physical Therapy,* **82**(5), pp. 512-517.

RILEY, P.O.; PAOLINI, G.; CROCE, U.D.; PAYLO, K.W.; KERRIGAN, D.C. A kinematic and kinetic comparison of overground and treadmill walking in healthy subjects. *Gait and Posture* (2006), doi: 10.1016/j.gaitpost.2006.07.003.

RITCHIE, J. and SPENCER, L., 1994. Qualitative data analysis for applied policy research. In: A. BRYMAN and R.G. BURGESS, eds, *Analyzing qualitative data.* London: Routledge.

RITCHIE, J., 2003. The applications of qualitative methods to social research. In: J. RITCHIE and J. LEWIS, eds, *Qualitative research practice. A guide for social science students and researchers.* First edn. London, UK: Sage publications, pp. 24-46.

RITCHIE, J. and LEWIS, J., eds, 2003. *Qualitative research practice. A guide for social science students and researchers.* First edn. London, UK: Sage publications.

RITCHIE, J., SPENCER, L. and O'CONNOR, W., 2003. Carrying out qualitative analysis. In: J. RITCHIE and J. LEWIS, eds, *Qualitative research practice.* 1st edn. London: Sage Publications, pp. 220-262.

RITCHIE, J.E., 1999. Using qualitative research to enhance the evidence-based practice of health care providers. *Australian Journal of Physiotherapy,* **45**(4), pp. 251-256.

ROACH, K.E., BROWN, M.D., DUNIGAN, K.M., KUSEK, C.L. and WALAS, M., 1997. Test-retest Reliability of Patient Reports of Low Back Pain. *Journal of Orthopaedic and Sports Physical Therapy,* **26**(5), pp. 253-259.

ROBERTS, L., 2006. First impressions: an information leaflet for patients attending a musculoskeletal outpatient department. *Physiotherapy,* **92**(3), pp. 179-186.

ROBSON, C., 2002. Real World Research. 2nd edn. Oxford, UK: Blackwell Publishing.

ROEBROECK, M.E., DOORENBOSCH, C.A.M., HARLAAR, J., JACOBS, R. and LANKHORST, G.J., 1994. Biomechanics and muscular activity during sit-to-stand transfer. *Clinical Biomechanics,* **9**(4), pp. 235-244.

ROGERS, A., KENNEDY, A., NELSON, E. and ROBINSON, A., 2005. Uncovering the limits of patient-centredness: Implementing a self-management trial for chronic illness. *Qualitative Health Research.* **15**(2), pp. 224-239.

ROLAND, M. and MORRIS, R., 1983. A study of the natural history of back pain. Part I: Development of a reliable and sensitive measure of disability in low back pain. *Spine,* **8**(2), pp. 141-144.

ROWE, P.J. and WHITE, M., 1996. Three dimensional, lumbar spinal kinematics during gait, following mild musculo-skeletal low back pain in nurses. *Gait and Posture,* **4**(3), pp. 242-251.

ROWE, P.J., 1999. Measurement systems. In: B.R. DURWARD, G.D. BAER and P.J. ROWE, eds, *Functional Human Movement: measurement and analysis.* 1st edn. Oxford: Butterworth-Heinemann.

RUTA, D.A., GARRATT, A.M., WARDLAW, D. and RUSSELL, I.T., 1994. Developing a valid and reliable measure of health outcome for patients with low back pain. *Spine,* **19**(17), pp. 1887-1896.

SAKAUCHI, M., NARUSHIMA, K., SONE, H., KAMIMAKI, Y., YAMAZAKI, Y., KATO, S., TAKITA, T., SUZUKI, N. and MORO, K., 2001. Kinematic approach to gait analysis in patients with rheumatoid arthritis involving the knee joint. *Arthritis and Rheumatism,* **45**(1), pp. 35-41.

SAUNDERS, S.W., SCHACHE, A., RATH, D. and HODGES, P.W., 2005. Changes in three-dimensional lumbo-pelvic kinematics and trunk muscle activity with speed and mode of locomotion. *Clinical Biomechanics,* **20**, pp. 784-793.

SCHACHE, A.G., BLANCH, P.D., RATH, D.A., WRIGLEY, T.V., STARR, R. and BENNELL, K.L., 2002a. Intra-subject repeatability of the three-dimensional angular kinematics within the lumbo-pelvic-hip complex during running. *Gait and Posture,* **15**, pp. 136-145.

SCHACHE, A.G., BLANCH, P., RATH, D., WRIGLEY, T. and BENNELL, K., 2002b. Three-dimensional angular kinematics of the lumbar spine and pelvis during running. *Human Movement Science,* **21**(2), pp. 273-293.

SCHAUFELE, M.K. and BODEN, S.D., 2003. Outcome research in patients with chronic low back pain. *Orthopaedic Clinics of North America,* **34**(2).

SCHENKMAN, M., BERGER, R.A., O RILEY, P., MANN, R.W. and HODGE, W.A., 1990. Whole-body movements during rising from sitting. *Physical Therapy,* **70**(10), pp. 638-648.

SCOTTISH EXECUTIVE, 2004. *Scottish Executive Urban Rural Classification.* Edinburgh: Her Majesty's Stationery Office.

SCOTTISH EXECUTIVE HEALTH DEPARTMENT, 2001-last update, our national health delivering change [Homepage of HMSO, Edinburgh], [Online]. Available: www.scotland.gov.uk/library3/health/onhdc-00.asp [26/09, 2006].

SCOTTISH EXECUTIVE HEALTH DEPARTMENT, Feb, 2003-last update, partnership for care. Scotland's health white paper. Available: www.scotland.gov.uk/Publications/2003/02/16476/18730 [26/09, 2006].

SCOTTISH EXECUTIVE HEALTH DEPARTMENT, 2005a. *Delivering for Health.* Edinburgh: Scottish Executive.

SCOTTISH EXECUTIVE HEALTH DEPARTMENT, 2005 b. *National framework for service change in the NHS: towards a more collaborative approach..* Edinburgh: Scottish Executive.

SCOTTISH EXECUTIVE HEALTH DEPARTMENT, 2006. *Delivering care, enabling health. Harnessing the nursing, midwifery and allied health professions' contribution to implementing Delivering for Health in Scotland.* Edinburgh: Scottish Executive.

SCULCO, A.D., PAUP, D.C., FERNHALL, B. and SCULCO, M.J., 2001. Effects of aerobic exercise on low back patients in treatment. *The Spine Journal,* **1**, pp. 95-101.

SELLES, R.W., WAGENAAR, R.C., SMIT, T.H. and WUISMAN, P.I., 2001. Disorders in trunk rotation during walking in patients with low back pain: a dynamical systems approach. *Clinical Biomechanics,* **16**(3), pp. 175-181.

SHELOKOV, A., HAIDERI, N. and ROACH, J., 1993. Residual Gait Abnormalities in Surgically Treated Spondylolisthesis. *Spine,* **18**(15), pp. 2201-2205.

SHEPARD, K.F., JENSEN, G.M., SCHMOLL, B.J., HACK, L.M. and GWYER, J., 1993. Alternative approaches to research in physical therapy: Positivism and phenomenology. *Physical Therapy,* **73**(2), pp. 88-97.

SHROUT, P.E. and FLEISS, J.L., 1979. Intraclass Correlations: Uses in assessing rater reliability. *Psychological Bulletin,* **86**(2), pp. 420-428.

SHUM, G.L.K., CROSBIE, J. and LEE, R.Y.W., 2005. Effect of Low Back Pain on the Kinematics and Joint Coordination of the Lumbar Spine and Hip During Sit-to-Stand and Stand-to-Sit. *Spine,* **30**(17), pp. 1998-2004.

SIBELLA, F., GALLI, M., ROMEI, M., MONTESANO, A. and CRIVELLINI, M., 2003. Biomechanical analysis of sit-to-stand movement in normal and obese subjects. *Clinical Biomechanics,* **18**(8), pp. 745-750.

SIGL, T., CIEZA, A., BROCKOW, T., CHATTERJI, S., KOSTANJSEK, N. and STUCKI, G., 2006. Content comparison of low back pain-specific measures based on the International Classification of Functioning, Disability and health (ICF). *Clinical Journal of Pain,* **22**(2), pp. 147-153.

SIGRELL, H., 2001. Expectations of chiropractic patients: The construction of a questionnaire. *Journal of manipulative and physiological therapeutics,* **24**(7), pp. 440-444.

SILFIES, S.P., SQUILLANTE, D., MAURER, P., WESTCOTT, S. and KARDUNA, A.R., 2005. Trunk muscle recruitment in specific low back pain populations. *Clinical Biomechanics,* **20**, pp. 456-473.

SIM, J. and WATERFIELD, J., 1997. Validity, reliability and responsiveness in the assessment of pain. *Physiotherapy Theory and Practice,* **13**, pp. 23-37.

SIM, J. and WRIGHT, C., 2000. Research in health care. Concepts, designs and methods. 1st edn. Cheltenham: Stanley Thornes.

SIMMONDS, M.J. and CLAVEAU, Y., 1997. Measures of pain and physical function in patients with low back pain. *Physiotherapy Theory and Practice,* **13**(1), pp. 53-65.

SIMMONDS, M.J., OLSON, S.L., JONES, S., HUSSEIN, T., LEE, C.E., NOVY, D. and RADWAN, H., 1998. Psychometric characteristics and clinical usefulness of physical performance tests in patients with low back pain. *Spine,* **23**(22), pp. 2412-2421.

SMEETS, R.J., HIJDRA, H.J., KESTER, A.D., HITTERS, M.W. and KNOTTNERUS, J.A., 2006a. The usability of six physical performance tasks in a rehabilitation population with chronic low back pain. *Clinical rehabilitation,* **20**(11), pp. 989-997.

SMEETS, R.J.E.M., VLAEYEN, J.W.S., HIDDING, A., KESTER, A.D.M., VAN DER HEIJDEN, G.J.M.G., VAN GEEL, A.C.M. and KNOTTNERUS, J.A., 2006b. Active rehabilitation for chronic low back pain: Cognitive-behavioral, physical, or both? First direct post-treatment results from a randomized controlled trial [ISRCTN22714229]. *BMC Musculoskeletal Disorders,* **7** Number: 516p. Date of Publication: 20 JAN 2006.

SMITH, B.H., ELLIOTT, A.M., HANNAFORD, P.C., CHAMBERS, A.C. and SMITH, W.C., 2004. Factors related to the Onset and Persistence of Chronic Back Pain in the Community. Results From a General Population Follow-up Study. *Spine,* **29**(9), pp. 1032-1040.

SMITH, B.H. and ELLIOTT, A.M., 2005. Active self-management of chronic pain in the community. *Pain,* **113**(3), pp. 249-250.

SNAPE, D. and SPENCER, L., 2003. The foundations of qualitative research. In: J. RITCHIE and J. LEWIS, eds, *Qualitative research practice. A guide for social science students and researchers.* First edn. London, UK: Sage publications, pp. 1-23.

SPENCER, L., RITCHIE, J. and O'CONNOR, W., 2003. Analysis: Practices, principles and processes. In: J. RITCHIE and J. LEWIS, eds, *Qualitative research practice.* 1st edn. London: Sage Publications, pp. 199-218.

STANISZEWSKA, S. and AHMED, L., 1999. The concepts of expectation and satisfaction: do they capture the way patients evaluate their care? *Journal of advanced nursing,* **29**(2), pp. 364-372.

STEVENSON, K., LEWIS, M. and HAY, E., 2006. Does physiotherapy management of low back pain change as a result of an evidence-based educational programme? *Journal of Evaluation in Clinical Practice,* **12**(3), pp. 365-375.

STILLMAN, B. and MCMEEKEN, J., 1996. Use of a video time display in determining general gait measures. *Australian Physiotherapy,* **42**(3), pp. 213-217.

STOKES, V.P., ANDERSSON, C. and FORSSBERG, H., 1989. Rotational and translational movement features of the pelvis and thorax during adult human locomotion. *Journal of Biomechanics,* **22**(1), pp. 43-50.

STORHEIM, K. and BO, K., 2000. The effect of intensive group exercise in patients with chronic low back pain. *Advances in Physiotherapy,* **2**(3), pp. 113-123.

STORHEIM, K., BROX, J.I., HOLM, I., KOLLER, A.K. and BO, K., 2003. Intensive group training versus cognitive intervention in sub-acute low back pain: Short-term results of a single-blind randomized controlled trial. *Journal of Rehabilitation Medicine,* **35**(3), pp. 132-140.

STRAND, L.I., MOE-NILSSEN, R. and LJUNGGREN, A.E., 2002. Back Performance Scale for the Assessment of Mobility-Related Activities in People With Back Pain. *Physical Therapy,* **82**(12), pp. 1213-1223.

STRATFORD, P.W., BINKLEY, J., SOLOMON, P., FINCH, E., GILL, C. and MORELAND, J., 1996a. Defining the minimum level of Detectable Change for the Roland-Morris Questionnaire. *Physical Therapy,* **76**(4), pp. 359-365.

STRATFORD, P.W., FINCH, E., SOLOMON, P., BINKLEY, J., GILL, C. and MORELAND, J., 1996b. Using the Roland-Morris questionnaire to make decisions about individual patients. *Physiotherapy Canada,* **48**(2), pp. 107-110.

STRATFORD, P.W. and BINKLEY, J.M., 1997. Measurement properties of the RM-18. A modified version of the Roland-Morris disability scale. *Spine,* **22**(20), pp. 2416-2421.

STRATFORD, P.W., BINKLEY, J.M. and RIDDLE, D.L., 2000. Development and initial validation of the Back Pain Functional Scale. *Spine,* **25**(16), pp. 2095-2102.

STROUD, M.W., MCKNIGHT, P.E. and JENSEN, M.P., 2004. Assessment of self-reported physical activity in patients with chronic pain: Development of an abbreviated Roland-Morris disability scale. *The Journal of Pain,* **5**(5), pp. 257-263.

SULLIVAN, M.S., SHOAF, L.D. and RIDDLE, D.L., 2000. The relationship of lumbar flexion to disability in patients with low back pain. *Physical therapy,* **80**(3), pp. 240-250.

SWINKELS, A. and DOLAN, P., 1998. Regional Assessment of Joint Position Sense in the Spine. *Spine,* **23**(5), pp. 590-597.

SWINKELS, A. and DOLAN, P., 2004. Spinal position sense and disease progression in ankylosing spondylitis: a longitudinal study. *Spine,* **29**(11), pp. 1240-1245.

SYCZEWSKA, M., OBERG, T. and KARLSSON, D., 1999. Segmental movements of the spine during treadmill walking with normal speed. *Clinical Biomechanics,* **14**, pp. 384-388.

TAN, G., JENSEN, M.P., THORNBY, J.I. and SHANTI, B.F., 2004. Validation of the brief pain inventory for chronic nonmalignant pain. *The Journal of Pain,* **5**(2).

TAYLOR, N.F., GOLDIE, P.A. and EVANS, O.M., 1999. Angular movements of the pelvis and lumbar spine during self-selected and slow walking speeds. *Gait and Posture,* **9**(2), pp. 88-94.

TAYLOR, N.F., EVANS, O.M. and GOLDIE, P.A., 2003. The effect of walking faster on people with acute low back pain. *European Spine Journal,* **12**(2), pp. 166-172.

TAYLOR, N.S., GOLDIE, P. and EVANS, O., 2004. Movements of the pelvis and lumbar spine during walking in people with acute low back pain. *Physiotherapy Research International,* **9**(2), pp. 74-84.

TAYLOR, S., ELLIS, I. and GALLAGHER, M., 2002. Patient satisfaction with a new physiotherapy telephone service for back pain patients. *Physiotherapy,* **88**(11), pp. 645-657.

TAYLOR, S., FROST, H., TAYLOR, A. and BARKER, K., 2001. Reliability and responsiveness of the shuttle walking test in patients with chronic low back pain. *Physiotherapy Research International,* **6**(3), pp. 170-178.

THOMAS, L.K., HISLOP, H.J. and WATERS, R.L., 1980. Physiological Work Performance in Chronic Low Back Disability. *Physical Therapy,* **60**(4), pp. 407-411.

THOMAS, R.J., MCEWEN, J. and ASBURY, A.J., 1996. The Glasgow Pain Questionnaire: A new generic measure of pain; development and testing. *International Journal of Epidemiology,* **25**(5), pp. 1060-1067.

THOMPSON, A.G.H. and SUNOL, R., 1995. Expectations as determinants of patient satisfaction: Concepts, theory and evidence. *International journal for quality in health care,* **7**(2), pp. 127-141.

THORSTENSSON, A., NILSSON, J., CARLSON, H. and ZOMLEFER, M.R., 1984. Trunk movements in human locomotion. *Acta Physiologica Scandinavica,* **121**(1), pp. 9-22.

TITIANOVA, E.B., PITKANEN, K., PAAKKONEN, A., SIVENIUS, J. and TARKKA, I.M., 2003. Gait characteristics and functional ambulation profile in patients with chronic unilateral stroke. *American Journal of Physical Medicine and Rehabilitation,* **82**(10), pp. 778-786.

TOBIN, G.A. and BEGLEY, C.M., 2004. Methodological rigour within a qualitative framework. *Journal of advanced nursing,* **48**(4), pp. 388-396.

TREDE, F.V., 2000. Physiotherapists' approaches to low back pain education. *Physiotherapy,* **86**(8), pp. 427-433.

TULLY, E.A., FOTOOHABADI, M.R. and GALEA, M.P., 2005. Sagittal spine and lower limb movement during sit-to-stand in healthy young subjects. *Gait and Posture,* **22**, pp. 338-345.

TURSKY, B., JAMNER, L.D. and FRIEDMAN, R., 1982. The pain perception profile: A psychophysical approach to the assessment of pain report. *Behavior Therapy,* **13**(4), pp. 376-394.

UDERMANN, B.E., SPRATT, K.F., DONELSON, R.G., MAYER, J., GRAVES, J.E. and TILLOTSON, J., 2004. Can a patient educational book change behavior and reduce pain in chronic low back pain patients? *Spine Journal: Official Journal of the North American Spine Society,* **4**(4), pp. 425-435.

VAN DIEEN, J.H., SELEN, L.P. and CHOLEWICKI, J., 2003. Trunk muscle activation in low-back pain patients, an analysis of the literature. *Journal of Electromyography and Kinesiology,* **13**(4), pp. 333-351.

VAN HERP, G., ROWE, P., SALTER, P. and PAUL, J.P., 2000. Three-dimensional lumbar spinal kinematics: a study of range of movement in 100 healthy subjects aged 20 to 60+ years. *Canadian Journal of Occupational Therapy 2000,* **Dec; 39**(12), pp. 1337.

VAN TULDER, M.W., KOES, B.W., BOUTER, L.M. and METSEMAKERS, J.F.M., 1997. Management of chronic nonspecific low back pain in primary care: a descriptive study. *Spine,* **22**(1), pp. 76-82. (32 ref).

VAN UDEN, C.J. and BESSER, M.P., 2004. Test-retest reliability of temporal and spatial gait characteristics measured with an instrumented walkway system (GAITRite). *BMC Musculoskeletal Disorders,* **5**(1), pp. 13.

VERBEEK, J., SENGERS, M.J., RIEMENS, L. and HAAFKENS, J., 2004. Patient expectations of treatment for back pain. *Spine,* **29**(20), pp. 2309-2318.

VLAEYEN, J.W., KOLE-SNIJDERS, A.M., BOEREN, R.G. and VAN EEK, H., 1995. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. *Pain,* **62**(3), pp. 363-372.

VOGT, L., PFEIFER, K., PORTSCHER AND, M. and BANZER, W., 2001. Influences of nonspecific low back pain on three-dimensional lumbar spine kinematics in locomotion. *Spine,* **26**(17), pp. 1910-1919.

VOGT, L., PFEIFER, K. and BANZER, W., 2002. Comparison of angular lumbar spine and pelvis kinematics during treadmill and overground locomotion. *Clinical Biomechanics,* **17**(2), pp. 162-165.

VOGT, L., PFEIFER, K. and BANZER, W., 2003. Neuromuscular control of walking with chronic low-back pain. *Manual Therapy,* **8**(1), pp. 21-28.

VON KORFF, M., 1994. Studying the natural history of back pain. *Spine,* **19**(18 Suppl), pp. 2041-6.

VON KORFF, M., BARLOW, W., CHERKIN, D. and DEYO, R.A., 1994. Effects of practice style in managing back pain. *Annals of Internal Medicine,* **121**(3), pp. 187-195.

VON KORFF, M., ORMEL, J., KEEFE, F.J. and DWORKIN, S.F., 1992. Grading the severity of chronic pain. *Pain,* **50**, pp. 133-149.

VON KORFF, M., MOORE, J.E., LORIG, K., CHERKIN, D.C., SAUNDERS, K., GONZALEZ, V.M., LAURENT, D., RUTTER, C. and COMITE, F., 1998. A randomized trial of a lay person-led self-management group intervention for back pain patients in primary care. *Spine,* **23**(23), pp. 2608-2615.

VON KORFF, M., JENSEN, M.P. and KAROLY, P., 2000. Assessing Global Pain severity by Self-Report in Clinical and Health Services Research. *Spine,* **25**(24), pp. 3140-3151.

WADDELL, G. and MAIN, C.J., 1984. Assessment of severity in low back disorders. *Spine,* **9**(2), pp. 204-208.

WADDELL, G., 1987. 1987 Volvo award in clinical sciences. A new clinical model for the treatment of low-back pain. *Spine,* **12**(7), pp. 632-644.

WADDELL, G., SOMERVILLE, D., HEBDERSON, I. and NEWTON, M., 1992. Objective clinical evaluation of physical impairment in chronic low back pain. *Spine,* **17**(6), pp. 617-628.

WADDELL, G., NEWTON, M., HENDERSON, I., SOMERVILLE, D. and MAIN, C.J., 1993. A Fear -Avoidance Beliefs Questionnaire (FABQ) and the role of Fear-Avoidance beliefs in chronic low back pain and disability. *Pain,* **52**(2), pp. 157-168.

WADDELL, G. and MAIN, C.J., 1998. A new clinical model of low back pain and disability. *The back pain revolution.* 1st edn. London: Churchill Livingstone, pp. 223-240.

WADDELL, G., MCINTOSH, A., HUTCHUNSON, A., FEDER, G. and LEWIS, M., 1999. *Clinical guidelines for the management of acute low back pain.* London: Royal College of General Practitioners.

WADDELL, G., 2004. The back pain revolution. 2nd edn. Edinburgh: Churchill Livingstone.

WADDELL, G., 2006. Preventing incapacity in people with musculoskeletal disorders. *British medical bulletin,* **77-78**(1), pp. 55-69.

WAGNER, E.H., 1998. Chronic Disease management: What will it take to improve care for chronic illness? *Effective Clinical Practice,* **1**, pp. 2-4.

WALKER, J., HOLLOWAY, I. and SOFAER, B., 1999. In the system: the lived experience of chronic back pain from the perspectives of those seeking help from pain clinics. *Pain,* **80**, pp. 621-628.

WALL, J.C. and CROSBIE, J., 1996. Accuracy and reliability of temporal gait measurement. *Gait and Posture,* **4**, pp. 293-296.

WALL, J.C. and CROSBIE, J., 1997. Temporal Gait Analysis Using Slow Motion Video and a Personal Computer. *Physiotherapy,* **83**(3), pp. 109-115.

WALL, J.C. and SCARBROUGH, J., 1997. Use of a Multimemory Stopwatch to Measure the Temporal Gait Parameters. *Journal of Orthopaedic and Sports Physical Therapy,* **25**(4), pp. 277-281.

WALL, J.C., 1999. Walking. In: B.R. DURWARD, G. BAER and P.J. ROWE, eds, *Functional Human Movement.* Oxford: Butterworth-Heinemann, pp. 94-105.

WALSH, D.A. and RADCLIFFE, J.C., 2002. Pain beliefs and perceived disability of patients with chronic low back pain. *Pain,* **97**, pp. 23-31.

WALSH, D.A., KELLY, S.J., JOHNSON, P.S., RAJKUMAR, S. and BENNETTS, K., 2003. Performance Problems of Patients With Chronic Low Back Pain and the measurement of Patient-Centred Outcome. *Spine,* **29**(1), pp. 87-93.

WARE, J.E.,JR and SHERBOURNE, C.D., 1992. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical care,* **30**(6), pp. 473-483.

WARSI, A., LAVALLEY, M.P., WANG, P.S., AVORN, J. and SOLOMON, D.H., 2003. Arthritis self-management education programs: A meta-analysis of the effect on pain and disability. *Arthritis and Rheumatism,* **48**(8), pp. 2207-2213.

WEBB, R., BRAMMAH, T., LUNT, M., URWIN, M., ALLISON, T. and SYMMONS, D., 2003. Prevalence and predictors of intense, chronic, and disabling neck and back pain in the UK general population. *Spine,* **28**(11), pp. 1195-1202.

WEBSTER, K.E., WITTWER, J.E. and FELLER, J.A., 2005. Validity of the GAITRite walkway system for the measurement of averaged and individual step parameters of gait. *Gait and posture,* **22**(4), pp. 317-321.

WEINER, D.K., RUDY, T.E., GLICK, R.M., ROBERT BOSTON, J., LIEBER, S.J., MORROW, L.A. and TAYLOR, S., 2003. Efficacy of percutaneous electrical nerve stimulation for the treatment of chronic low back pain in older adults. *Journal of the American Geriatrics Society,* **51**(5), pp. 599-608.

WERNER, E.L., IHLEBAEK, C., SKOUEN, J.S. and LAERUM, E., 2005. Beliefs about low back pain in the Norwegian general population: are they related to pain experiences and health professionals? *Spine,* **30**(15), pp. 1770-1776.

WEST, E., BARRON, D.N. and REEVES, R., 2005. Overcoming the barriers to patient-centred care: time, tools and training. *Journal of clinical nursing,* **14**(4), pp. 435-443.

WHALLEY HAMMELL, K., 2001. Using qualitative research to inform the client-centred evidence-based practice of occupational therapy. *British Journal of Occupational Therapy,* **64**(5), pp. 228-234.

WHITE, A., 1998. Measuring Pain. *Acupuncture in Medicine,* **16**(2),

WHITTLE, M.W. and LEVINE, D., 1997. Measurement of lumbar lordosis as a component of clinical gait analysis. *Gait and Posture,* **5**(2), pp. 101-107.

WHITTLE, M.W., 2002. Gait analysis an introduction. 3rd edn. Oxford: Butterworth-Heinemann.

WILLIAMS, R.M. and MYERS, A.M., 1998. A new approach to measuring recovery in injured workers with acute low back pain: Resumption of Activities of Daily Living Scale. *Physical Therapy,* **78**(6), pp. 613-623.

WILLIAMS, S. and HARRISON, K., 1999. Physiotherapeutic interactions: a review of the power dynamic. *Arthritis Care and Research,* **4**(1), pp. 37-50.

WITTINK, H., ROGERS, W., SUKIENNIK, A. and CARR, D.B., 2003. Physical functioning: Self-report and performance measures are related but distinct. *Spine,* **28**(20), pp. 2407-2413.

WORLD HEALTH ORGANISATION, 2001. *International Classification of Functioning, Disability and Health.* Geneva: World Health Organisation.

WU, W., MEIJER, O.G., JUTTE, P.C., UEGAKE, K., LAMOTH, C.J.C., DE WOLF, G.S., VAN DIEEN, J.H., WUISMAN, P.I.J.M., KWAKKEL, G., DE VRIES, J.I.P. and BEEK, P.J., 2002. Gait in patients with pregnancy-related pain in the pelvis: an emphasis on the coordination of transverse pelvic and thoracic rotations. *Clinical Biomechanics,* **17**, pp. 678-686.

YAMADA, T. and DEMURA, S., 2005. Instruction in reliability and magnitude of evaluation parameters at each phase of a sit-to-stand movement. *Perceptual & Motor Skills,* **101**(3), pp. 695-706.

YELLAND, M.J. and SCHLUTER, P.J., 2006. Defining worthwhile and desired responses to treatment of chronic low back pain. *Pain Medicine,* **7**(1), pp. 38-45.

Appendices

1: Ethics committee approval
2: Study 1 letter of invitation
3: Study 1 information sheet
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5: Interview schedule, pilot study
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16: Brief Pain Inventory
17: Individual CV values for spatial and temporal parameters of gait
18: Control sample spinal kinematic repeatability (gait) graphs
19: Individual CV values spinal and pelvic kinematics gait
20: Individual CV values STS temporal and kinematic parameters
21: Control sample spinal kinematic repeatability (STS) graphs

pendix 1: Ethics committee approval

NHS Grampian
University of Aberdeen
Research Ethics Committees

Summerfield House
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NHS
Grampian

Mrs Kay Cooper
Robert Gordon University
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Faculty of Health & Social Care
Garthdee Road
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Date Tuesday, 17 August 2004

Enquiries to Kellie MacLeod
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REC reference number: 04/S0801/49 Please quote this number on all correspondence

Dear Mrs Cooper

Full title of study: Service redesign for chronic low back pain management in Grampian: Development of a patient-centred physiotherapy intervention which supports self-management.
REC reference number: 04/S0801/49

Thank you for your letter of 12th August 2004, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Scientific Advisor.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm ethical approval for the above research on the basis described in the application form, protocol and supporting documentation *[as revised]*.

Approval is given provided that you comply with the conditions set out in the attached document. You are advised to study the conditions carefully.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

- Patient Information Sheet, Stage 1, Version2, August 2004
- Patient Information Sheet, Stage 2 (pilot), Version 2, August 2004
- Patient Information Sheet, Stage 2, Version 2, August 2004
- GP Letter, Stage 1, Version 1, August 2004
- GP Letter Stage 2 (including Pilot)

Management approval

[Single-site studies]

The study may not commence until final management approval has been confirmed by the organisation hosting the research.

Continued

Statement of compliance *(from 1 May 2004)*
Clinical trials of medicinal products only: This Committee is recognised by the United Kingdom Ethics Committee Authority under the Medicines for Human Use (Clinical Trials) Regulations 2004, and is authorised to carry out the ethical review of clinical trials.

Yours sincerely,

Mrs Kellie MacLeod MSc
Manager & Scientific Advisor
Grampian Research Ethics Committees

Cc
R&D Department for host organisation

Enclosures *Standard approval conditions*

Appendix 2: Study 1 letter of invitation

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Mrs Kay Cooper
School of Health Sciences
Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG
Telephone: 01224 263259

Dear

I am a physiotherapist employed by NHS Grampian, currently conducting a research project along with the School of Health Sciences at the Robert Gordon University, Aberdeen. The research project concerns physiotherapy for chronic low back pain, and you are being invited to take part.

You have been chosen because you have received physiotherapy for chronic low back pain in a physiotherapy department in Grampian in the past six months. The study aims to interview patients from all over Grampian to gain an understanding of their experiences of physiotherapy and their suggestions for improvements to the service.

I would be grateful if you would read the enclosed study information sheet. After reading this, if you are interested in taking part in the study, please complete the cut-off slip below and return it in the reply-paid envelope. The researcher will then contact you by telephone to discuss the study further. If you do not wish to take part please do nothing.

Only the researcher knows that you have been approached to take part in the study, and your details remain confidential.

Thank you for reading this letter.

Yours sincerely

Mrs Kay Cooper

Please cut here

I am interested in taking part in the research study: Yes / No (Please circle)

Name____________________________________

Telephone number____________________________

I would like you to contact me on the above number at the following time (Mon – Fri) a.m. / p.m. / evening (Please circle)

If there is a particular day or specific time you do/do not wish to be contacted, please provide details here:

Letter of Invitation. Stage 1. Version1. June 2004.

Appendix 3: Study 1 information sheet

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Study Information Sheet (Study No: 04/S0801/49)

Name of Study: Patient-centred physiotherapy for chronic low back pain

Introduction

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

The purpose of the study is to develop a physiotherapy treatment for patients with chronic low back pain. Chronic low back pain is back pain that lasts longer than twelve weeks. It affects many people each year, and physiotherapists do not yet know the best way to manage it. The study aims to learn from patients who have previously received physiotherapy for this condition and to find out if treatment met their individual needs. This will be done by the researcher interviewing patients face-to-face. The knowledge gained should make it possible to develop a treatment intervention that reflects the needs of patients with chronic low back pain. Particular attention will be paid to suggestions for helping patients to manage their condition long-term.

Why have I been chosen?

You have been chosen because you have received physiotherapy for chronic low back pain in a physiotherapy department in Grampian in the past six months. The study aims to interview ten to fifteen patients from all over Grampian to gain an understanding of their experiences of physiotherapy and their suggestions for improvements to the service.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet and be asked to sign a consent form. You will be given a copy of both to keep. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you may receive at any time.

What will happen to me if I take part?

If you decided to take part, you would be interviewed by the researcher on one occasion, lasting no longer than one hour. The interview would take place in a private room in a health centre or hospital close to you. If you preferred, the researcher could visit you and conduct the interview in your home. The interview would be audio taped, in order for the researcher to listen to it at a later date. The interview would begin with a few questions about your low back pain and physiotherapy attendance. These would be things like how long you had your back pain, how it affected you, what made you go for physiotherapy, and how long your physiotherapy lasted. You would be asked your views on various aspects of the physiotherapy you received, such as what was helpful and what wasn't. You would also be asked for your views on possible new approaches to physiotherapy for chronic low back pain, being considered in this study. Following the interview, the researcher would type the conversation, from listening to the audio tape. Following the interview, the researcher would compare what you said to what other patients said in their interviews, to identify any similarities in opinion. It is possible that you may be contacted by the researcher by telephone up to six months following the interview. This would be to confirm whether the researcher's interpretation of what you said was actually what you meant. You would be reimbursed for travel costs to attend the interview.

What are the possible benefits of taking part?
This study will not benefit you directly. It is hoped that the information gained will help physiotherapists to treat future chronic low back pain patients better.

Will my taking part in this study be kept confidential?
All information which is collected about you will be kept strictly confidential. Quotations from your interview may be used by the researcher in written reports, but your real name will at no time be used. With your permission, your GP will be informed that you are taking part in the study.

What will happen to the results of the study?
The results will be published in either a physiotherapy-related journal or a journal specifically targeted at the spine or back, and presented at a professional conference. You will not be identified in any reports or publications. You will receive a summary of the findings and how the information you provided is being used.

Who is organising and funding the research?
The researcher is a physiotherapist employed by NHS Grampian, doing the study in collaboration with the Robert Gordon University. The Nursing, Midwifery and Allied Health Professions Research Training Scheme are funding the research. They are a consortium of Scottish Universities funded by NHS Scotland, the Scottish Executive and the Health Foundation.

Who has reviewed the study?
The Grampian Research Ethics Committee has approved the study.

What do I do now?
If you are interested in taking part in the research study, please return the reply slip in the envelope provided. On receipt of this, the researcher will contact you by telephone. She can answer any questions you may have. If you are still interested at this stage, a date and time for the interview will be arranged. Please remember you are free to withdraw from the study at any time.

Thank you for considering taking part in this research study. Please discuss this information with anyone you wish prior to making a decision.

Contact for further information

Mrs Kay Cooper
School of Health Sciences
Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG

Telephone: 01224 263259
e-mail: prs.cooper@rgu.ac.uk

Appendix 4: Study 1 consent form

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Study Number: 04/S0801/49

Patient Identification Number for this trial:

CONSENT FORM (Stage 1)

Title of Project: Patient-centred physiotherapy for chronic low back pain

Name of Researcher: Mrs Kay Cooper

Please initial box

1. I confirm that I have read and understand the information sheet dated June 2004 (version 1) for the above study and have had the opportunity to ask questions. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that this is part of a research project designed to develop a physiotherapy intervention for chronic low back pain, and that it may be of no benefit to me personally. I understand that the Grampian Research Ethics Committee may wish to inspect the data collected at any time as part of its research monitoring activities. ☐
4. I agree to take part in the above study. ☐

Name of Patient ______ Date ______ Signature ______

Name of Person taking consent (if different from researcher) ______ Date ______ Signature ______

Researcher ______ Date ______ Signature ______

1 for participant; 1 for researcher.

Consent form. Stage 1. Version 1. June 2004.

Appendix 5: Interview schedule, pilot study

Interviewee (PIN)______________ **Location**______________________

Date________________ **Time**______________

Interview schedule

Introduction
Thank you for agreeing to take part in this project.
I am hoping to learn about people's experiences of physiotherapy for CLBP, and would like you to give me your views as openly and honestly as you can. Any personal details remain confidential, and your name will be changed when I write up the interview and reports on it. Please remember you are free to withdraw, and can ask for the interview to be stopped at any time.
*Check interviewee consents to interview being recorded.
*Check interviewee consents to GP being informed of participation in study.
*Complete consent form.
*Check demographic details correct
*Ask if interviewee has any questions before commence interview.

I would like to start by finding out a little about your LBP and physiotherapy experience in general:

1. Can you start by telling me about your LBP and how you ended up at physiotherapy?
    - History of LBP
    - How affected now (if at all) – how has LBP been since stopped physiotherapy?
    - What made you go to physiotherapy?
    - Was this your first experience of physiotherapy?

2. Can you tell me what you were expecting from physiotherapy?
    - Explore what treatments expected – No/ type/ duration/ outcome.

3. Was the physiotherapy you received what you were expecting?
    - Explore any areas that didn't meet expectations/ in what way.

4. Overall, tell me what you thought of the physiotherapy you received for your LBP?
    - Explore whether effective or not/ level of satisfaction

5. What did you most want the physiotherapy to achieve?
    - Explore if any specific goals/aims/? functional activities.

I would like to ask a few questions on advice and explanations that you may or may not received as part of your physiotherapy.

6. Did you receive advice and explanations as part of your treatment?
   Yes: Explore what topic covered/ was it verbal or written/ was it what they needed/ was it helpful/ do they still follow the advice.
   No: Do they feel they did/ didn't need advice/ explanations. Is there anything they would have liked advice/ explanations on? If there is, what do they feel is the reason for it not being given?

7. Tell me how you would feel about the physiotherapist offering to visit your home to demonstrate practical advice?
    - e.g.posture, lifting in the home, loading washing machine, sitting in car etc.
    - Explore if feel would be relevant/ worthwhile/ would or wouldn't want physiotherapist in own home.

7b. (If positive to 7) Would you want practical demonstrations anywhere else?
- Suggest work/gym.

I would like to ask about your involvement in your physiotherapy treatment.

8. Can you tell me how involved you felt in your physiotherapy, for example in deciding on treatments to have and what the aim of treatment was?
  - Explore why/ why not involved & in what ways
  - Explore to what extent want to be involved/ want physiotherapist to be in control.

9. Did you feel your physiotherapy was guided by what you needed and by your indivivual symptoms.
  - Explore in what way was/ wasn't
  - Any examples of positive/ negative experiences?

10. Do you think anything else needs to be done by physiotherapists to make you feel involved in what happens to you?
  - Explore what/ how.

I would now like to focus on how you cope with your LBP or how you would cope with a flare-up of LBP.

11. **If LBP at present:** Tell me how you cope with your LBP at the moment?
If no LBP: Tell me how you think you would cope with a flare-up of LBP?
Explore how cope/manage
OR: Explore why feel can't/couldn't cope & how this affects them.

12. Has physiotherapy influenced how you cope/ would cope with a flare-up?
If Yes: Explore in what way/ what was useful.
If No: Explore whether anything else has influenced/ helps them.

13. Is there anything else you think physiotherapists could do to make you feel able to cope with your LBP?

14. Do you think you are likely to consult a physiotherapist again about your LBP?
If Yes: Explore why/ what circumstances would make them go.
If No: Why not (confident to self-manage? Think nothing can be done? Think waste of time?)

14b. Do you think you are likely to consult anyone else about your LBP?
Explore who/why/what would hope to achieve.

15. Some people think you should cope with your LBP on your own once you've had a course of physiotherapy, whilst others think you should be able to see a physiotherapist any time your LBP flares up. What do you think?

  - Suggest telephone helpline & whether would be of use
  - Any other support systems can think of

I would now like to ask a few questions on how your LBP was affected or still affects your day-to-day movements.

16. Does/ did your LBP affect your walking in any way?
  - Explore in what way
  - Explore whether any other day-to day activities affected (ask re sit-stand)

17. Can you tell me if physiotherapy affected these activities in any way?
  - Explore in what way did/ didn't help
  - Do they feel anything else could have been done to address them

18. How would you feel about having these activities looked at by the Physiotherapist ?

- Explore whether feel relevant/ necessary/ waste of time/ what think of pre & post measurements to "see" progress.

19. Tell me what you feel indicates whether physiotherapy has been helpful or not?

- Prompts: e.g. is it the level of pain, the ability to do some activity, or something else?

20. Is there anything else that hasn't been covered that you would like to talk about?

Summing up
Thank you for taking part. I am very grateful for the time you have given up and the information you have given, which will be very useful and interesting.
If you think of anything else that might be relevant, you can contact me (make sure have contact details). *Check if happy to be contacted at analysis stage (make sure have contact number).

Appendix 6: Interview topic guide

Patient-centered physiotherapy for chronic low back pain

Interview topic guide

Introduction

Thank you for agreeing to take part in this project.
I am hoping to learn about people's experiences of physiotherapy for CLBP, and would like you to give me your views as openly and honestly as you can. Any personal details remain confidential, and your name will be changed when I write up the interview and reports on it. Please remember you are free to withdraw, and can ask for the interview to be stopped at any time.
*Check interviewee consents to interview being recorded.
*Check interviewee consents to GP being informed of participation in study.
*Complete consent form.
*Check demographic details correct
*Ask if interviewee has any questions before interview commences.

1. Low Back Pain and physiotherapy experience

Aim: To provide background on CLBP & physiotherapy history.
Include: CLBP history & whether affected now
Physiotherapy history of this & other attendance's (if any)
How got to physiotherapy (self or GP initiated)

2. Thoughts on last physiotherapy experience

Aim: To understand expectations & level of satisfaction.
Include: What did they expect physiotherapy to involve?
What did they want to achieve by going to physiotherapy?
Did physiotherapy meet their expectations?
What did they think of their physiotherapy overall?

3. Advice and Education

Aim: To explore what they thought of advice/education received and gain suggestions for future interventions.
Include: What advice/education did they receive? (topics/mode of delivery)
Was it appropriate?
Should any other advice have been given?

4. Involvement in physiotherapy

Aim: To explore level of involvement that subjects want & what patient-centered physiotherapy is.
Include: How involved in treatment decisions were they & how involved did they want to be?
To what extent was treatment guided by their individual needs?
Does anything else need to be done to involve patients/make treatment patient-centered?

5. Self-management

Aim: To explore how subjects feel with respect to self-management of CLBP.
Include: How do/would cope with recurrence?
Has physiotherapy had an influence on coping strategies?
Are they likely to consult GP/Physiotherapist again? (reasons)
Should patients be expected to cope on their own after physiotherapy?
Could any support mechanisms be put in place?

Summing up

Thank you for taking part. I am very grateful for the time you have given up and the information you have given, which will be very useful and interesting.
If you think of anything else that might be relevant, you can contact me (make sure have contact details). *Check if happy to be contacted at analysis stage (make sure have contact number).

Appendix 7: Interview schedule, main study

Interviewee (PIN)_____________ **Location**______________________

Date_______________ **Time**_____________

Interview schedule

Introduction

Thank you for agreeing to take part in this project.

I am hoping to learn about people's experiences of physiotherapy for CLBP, and would like you to give me your views as openly and honestly as you can. Any personal details remain confidential, and your name will be changed when I write up the interview and reports on it.

Please remember you are free to withdraw, and can ask for the interview to be stopped at any time.

*Check interviewee consents to interview being recorded.

*Check interviewee consents to GP being informed of participation in study.

*Complete consent form.

*Check demographic details correct

*Ask if interviewee has any questions before commence interview.

I would like to start by finding out a little about your LBP and physiotherapy experience in general:

1. Can you start by telling me about your LBP and how you ended up at physiotherapy?
    - History of LBP
    - How affected now (if at all) – how has LBP been since stopped physiotherapy?
    - What made you go to physiotherapy?
    - Was this your first experience of physiotherapy?

2. Can you tell me what you were expecting from physiotherapy?
    - Explore what treatments expected – No/ type/ duration/ outcome.

3. Was the physiotherapy you received what you were expecting?
    - Explore any areas that didn't meet expectations/ in what way.

4. Overall, tell me what you thought of the physiotherapy you received for your LBP?
    - Explore whether effective or not/ level of satisfaction

5. What did you most want the physiotherapy to achieve?

- Explore if any specific goals/aims/? functional activities.

I would like to ask a few questions on advice and explanations that you may or may not received as part of your physiotherapy.

6. Did you receive advice and explanations as part of your treatment?
    Yes: Explore what topic covered/ was it verbal or written/ was it what they needed/ was it helpful/ do they still follow the advice.
    No: Do they feel they did/ didn't need advice/ explanations. Is there anything they would have liked advice/ explanations on? If there is, what do they feel is the reason for it not being given?

I would like to ask about your involvement in your physiotherapy treatment.

7. Can you tell me how involved you felt in your physiotherapy, for example in deciding on treatments to have and what the aim of treatment was?
    - Explore why/ why not involved & in what ways
    - Explore to what extent want to be involved/ want physiotherapist to be in control.

8. Did you feel your physiotherapy was guided by what you needed and by your indivivual symptoms.
    - Explore in what way was/ wasn't
    - Any examples of positive/ negative experiences?

9. Do you think anything else needs to be done by physiotherapists to make you feel involved in what happens to you?
    - Explore what/ how.

I would now like to focus on how you cope with your LBP or how you would cope with a flare-up of LBP.

10. **If LBP at present:** Tell me how you cope with your LBP at the moment?
    If no LBP: Tell me how you think you would cope with a flare-up of LBP?
    Explore how cope/manage
    OR: Explore why feel can't/couldn't cope & how this affects them.

11. Has physiotherapy influenced how you cope/ would cope with a flare-up?
    If Yes: Explore in what way/ what was useful.
    If No: Explore whether anything else has influenced/ helps them.

12. Is there anything else you think physiotherapists could do to make you feel able to cope with your LBP?

13. Do you think you are likely to consult a physiotherapist again about your LBP?
    If Yes: Explore why/ what circumstances would make them go.
    If No: Why not (confident to self-manage? Think nothing can be done? Think waste of time?)

13b. Do you think you are likely to consult anyone else about your LBP?
Explore who/why/what would hope to achieve.

14. Some people think you should cope with your LBP on your own once you've had a course of physiotherapy, whilst others think you should be able to see a physiotherapist any time your LBP flares up. What do you think?

    - Suggest telephone helpline & whether would be of use
    - Any other support systems can think of

15. Tell me what you feel indicates whether physiotherapy has been helpful or not?
- Prompts: e.g. is it the level of pain, the ability to do some activity, or something else?

16. Is there anything else that hasn't been covered that you would like to talk about?

Summing up

Thank you for taking part. I am very grateful for the time you have given up and the information you have given, which will be very useful and interesting.

If you think of anything else that might be relevant, you can contact me (make sure have contact details). *Check if happy to be contacted at analysis stage (make sure have contact number).

Appendix 8: Study 2 information sheet

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Patient information sheet (Study number 04/S0801/49)

Patient-centred physiotherapy for chronic low back pain

Introduction

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

The purpose of the study is to develop methods of measuring walking and spinal movement in patients with chronic low back pain. Chronic low back pain is back pain that lasts longer than twelve weeks. It affects many people each year, and physiotherapists do not yet know the best way to manage it. To show which treatments are best, it is important for physiotherapists to be able to measure patients' symptoms and their effects. Measurements can be compared before and after treatment to show what effect the treatment has had. There are several measurements in use, but not all are satisfactory. Simple measurements of walking and movement of the spine during walking and standing up may be appropriate measures to use. To decide, it is necessary to find out how chronic low back pain affects walking and standing up. This is part of a wider study that aims to develop a physiotherapy treatment for patients with chronic low back pain. The measurements developed will be used to measure how effective the new physiotherapy treatment is.

Why have I been chosen?

You have been chosen because you have been referred to physiotherapy with chronic low back pain. The study is being conducted throughout Grampian, and aims to have fifty-four patients taking part.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet and be asked to sign a consent form. You will be given a copy of both forms to keep. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of physiotherapy you receive.

What will happen to me if I take part?

If you decided to take part you would have your walking and standing up measured by the researcher. This would take place in the Human performance laboratory, Garthdee Campus, Robert Gordon University. You would be asked to dress in shorts (these can be provided), and would have your top rolled/folded up to reveal your low back. Some body measurements would be taken (such as weight, height and leg length), and then some small, lightweight reflective markers would be attached to your skin with hypoallergenic double-sided tape at various points on your legs and back. You would be asked to walk at your normal pace, several times across the room, whilst infrared cameras detect the markers on your body and convert them into a 3-D image of you on a computer screen. You would also be asked to rise from a chair several times. You would be able to rest at any time during this process. In addition to the measurements you would be asked to fill in questionnaires about your symptoms and how they affect you. The whole procedure, including the questionnaires, would take no longer than one hour. You would be reimbursed for travel costs to attend the measurement session.

What are the possible benefits of taking part?
This study will not benefit you directly. It is hoped that the knowledge gained will improve measurement of chronic low back pain patients. The measurements would be used in a further research study to show the effectiveness of a newly developed physiotherapy treatment for chronic low back pain.

Will my taking part in the study be kept confidential?
All information that is collected about you during the course of the research will be kept strictly confidential. Any information about you which leaves the hospital/health centre will have your name and address removed so that you cannot be recognised from it. With your permission, your GP will be informed that you are taking part in this study.

What will happen to the results of the research study?
The results will be published in either a physiotherapy-related journal or a journal specifically targeted at the spine or back, and presented at a professional conference. You will not be identified in any reports or publications. You will receive a summary of the findings and how the information you provided is being used.

Who is organising and funding the research?
The researcher is a physiotherapist employed by NHS Grampian, doing the study in collaboration with the Robert Gordon University. The Nursing, Midwifery and Allied Health Professions Research Training Scheme are funding the research. They are a consortium of Scottish Universities funded by NHS Scotland, the Scottish Executive and the Health Foundation.

Who has reviewed the study?
The Grampian Research Ethics Committee has approved the study.

What do I do now?
The researcher will contact you in a few days. She can answer any questions you may have. If you are still interested at this stage, a date and time for the measurement session will be arranged. Please remember you are free to withdraw from the study at any time.

Thank you for considering taking part in this research study. Please discuss this information with anyone you wish prior to making a decision.

Contact for further information
Mrs Kay Cooper
School of Health Sciences
The Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG
Telephone: 01224 262677
e-mail: prs.cooper@rgu.ac.uk

Appendix 9: Study2 letter of invitation

THE ROBERT GORDON UNIVERSITY
ABERDEEN

NHS
Grampian

Mrs Kay Cooper
School of Health Sciences
The Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG
Telephone: 01224 262677

Dear Sir/Madam,

I am a physiotherapist employed by NHS Grampian, currently conducting a research project along with the School of Health Sciences at the Robert Gordon University, Aberdeen. The research project concerns the measurement of patients with chronic low back pain, and you are being invited to take part.

You have been chosen because you are receiving treatment for chronic low back pain. The study aims to develop methods of measuring walking and spinal movement in patients with chronic low back pain.

I would be grateful if you would read the enclosed study information sheet. After reading this, if you are interested in taking part in the study, please complete the cut-off slip below and return it in the reply-paid envelope. The researcher will then contact you by telephone to discuss the study further. If you do not wish to take part please do nothing.

Thank you for reading this letter.

Yours sincerely

Mrs Kay Cooper

Please cut here

I am interested in taking part in the research study: Yes / No (Please circle)

Name________________________________

Telephone number________________________

I would like you to contact me on the above number at the following time (Mon – Fri) a.m. / p.m. / evening (Please circle)

If there is a particular day or specific time you do/do not wish to be contacted, please provide details here:

Appendix 10: Study 2 information sheet
(controls)

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Volunteer information sheet (Study number 04/S0801/49)

Title
Normal lumbar spinal movement during walking and sit to stand.

Introduction
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

The purpose of this study is to describe movement of the lower spine during walking and sit to stand in a group of healthy subjects with no significant history of low back pain. The information gained will then be used to compare with the movement of the lower spine in subjects with low back pain. It is thought that measurement of spinal movement during walking and sit to stand may be important in the assessment of low back pain patients. To help establish this, it is important to first investigate differences between those with and without low back pain. This will determine which aspects of the measurements are most relevant.

Why have I been chosen?

You have been chosen because you are aged 18-64, do not have significant low back pain, and can walk and rise from a chair independently.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet and be asked to sign a consent form. You will be given a copy of both forms to keep. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you decided to take part you would attend the Human Performance Laboratory, Garthdee Campus, Robert Gordon University on one occasion. You would be asked to dress in shorts (these can be provided), and would have your top rolled/folded up to reveal your low back. Some body measurements would be taken (such as weight, height and leg length), and then some small, lightweight reflective markers would be attached to your skin with hypoallergenic double-sided tape at various points on your legs and back. You would be asked to walk at your normal pace, several times across the room, whilst infrared cameras detected the markers on your body and converted them into a 3-D image of you on a computer screen. You would then be asked to rise from a chair three times at your usual, comfortable speed, whilst the cameras again detected the markers. You would be able to rest at any time during this process.

What are the possible benefits of taking part?

This study will not benefit you directly. It is hoped that the knowledge gained will improve measurement of low back pain patients.

Will my taking part in the study be kept confidential?

All information that is collected about you during the course of the research will be kept strictly confidential.

What will happen to the results of the research study?
The results will be published in either a physiotherapy-related journal or a journal specifically targeted at the spine or back, and presented at a professional conference. You will not be identified in any reports or publications. You will receive a summary of the findings and how the information you provided is being used.

Who is organising and funding the research?
The researcher is a Physiotherapist employed by NHS Grampian, conducting the research in association with the Robert Gordon University. The Nursing, Midwifery and Allied Health Professions Research Training Scheme are funding the research; they are a consortium of Scottish Universities funded by NHS Scotland, the Scottish Executive and the Health Foundation.

Who has reviewed the study?
The Grampian Local Research Ethics Committee and The Robert Gordon University School of Health Sciences ethics committee has approved the study.

What do I do now?
The researcher can answer any questions you may have. If you are interested in taking part, a date and time for the measurement session will be arranged. Please remember you are free to withdraw from the study at any time.

Thank you for considering taking part in this research study. Please discuss this information with anyone you wish prior to making a decision.

Contact for further information
Mrs Kay Cooper
School of Health Sciences
The Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG
Telephone: 01224 262677
e-mail: prs.cooper@rgu.ac.uk

Appendix 11: Study 2 consent form

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Study Number: 04/S0801/49

Subject Identification Number for this trial:

CONSENT FORM

Title of Project: Patient-centred physiotherapy for chronic low back pain

Name of Researcher: Mrs Kay Cooper

Please initial box

1. I confirm that I have read and understand the information sheet dated .... (version ....) for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that this is part of a research project designed to promote knowledge of walking and spinal movement in chronic low back pain patients, and that it may be of no benefit to me personally. I understand that the R&D office of NHS Grampian may wish to inspect the data collected at any time as part of its research monitoring activities. ☐

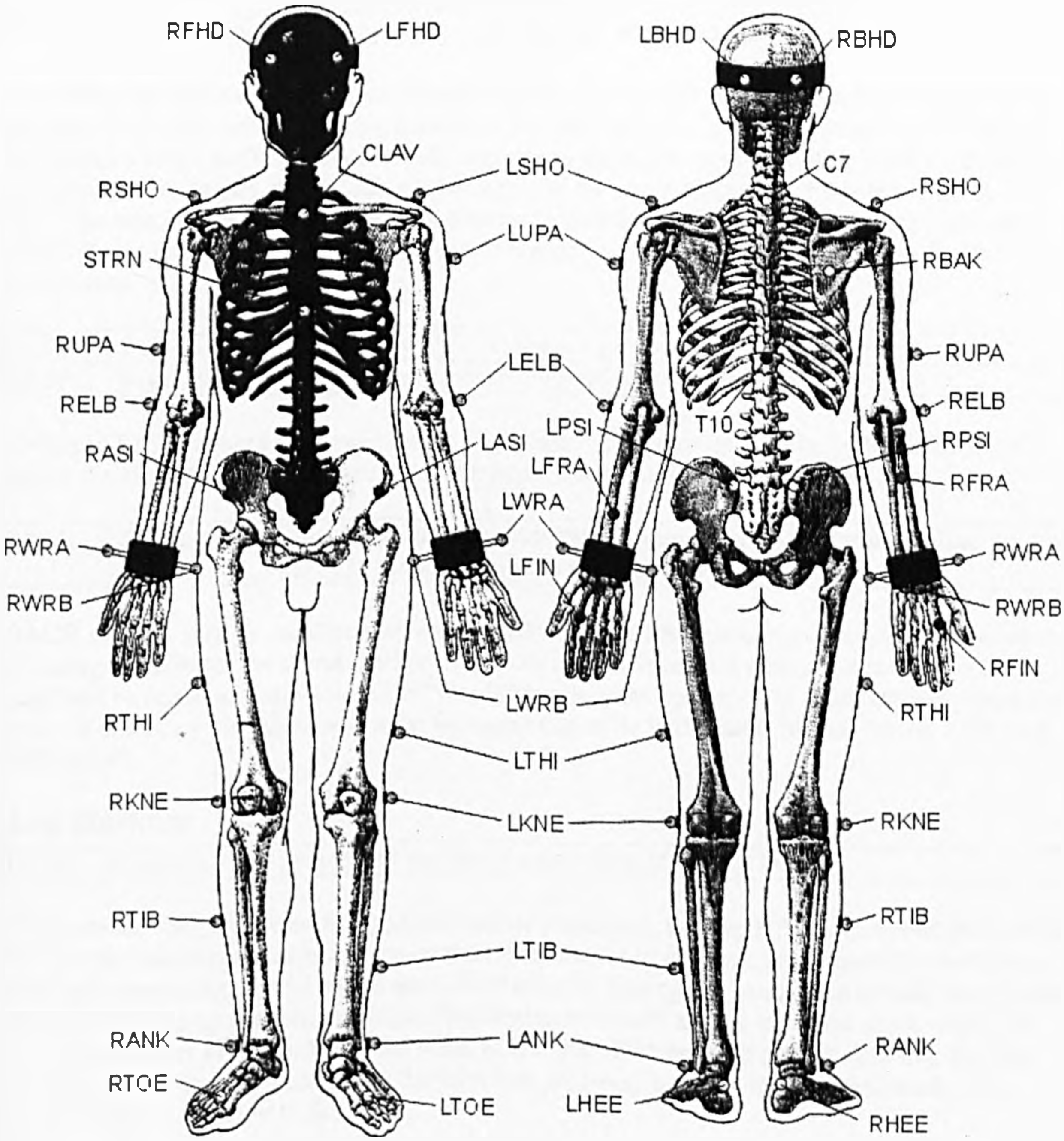
4. I agree to take part in the above study. ☐

Name of Volunteer	Date	Signature
Name of Person taking consent (if different from researcher)	Date	Signature
Researcher	Date	Signature

1 for volunteer, 1 for researcher

Appendix 12: Vicon Plug-in-Gait marker placement

Plug-in-Gait Marker Placement



The following describes in detail where the Plug-in-Gait markers should be placed on the subject. Where left side markers only are listed, the positioning is identical for the right side.

Lower Body

Pelvis

LASI	Left ASIS	Placed directly over the left anterior superior iliac spine
RASI	Right ASIS	Placed directly over the right anterior superior iliac spine

The above markers may need to be placed medially to the ASIS to get the marker to the correct position due to the curvature of the abdomen. In some patients, especially those who are obese, the markers either can't be placed exactly anterior to the ASIS, or are invisible in this position to cameras. In these cases, move each marker laterally by an equal amount, along the ASIS-ASIS axis. The true inter-ASIS Distance must then be recorded and entered on the subject parameters form. These markers, together with the sacral marker or LPSI and RPSI markers, define the pelvic axes.

LPSI	Left PSIS	Placed directly over the left posterior superior iliac spine
RPSI	Right PSIS	Placed directly over the right posterior superior iliac spine

LPSI and RPSI markers are placed on the slight bony prominences that can be felt immediately below the dimples (sacro-iliac joints), at the point where the spine joins the pelvis.

SACR	Sacral wand marker	Placed on the skin mid-way between the posterior superior iliac spines (PSIS). An alternative to LPSI and RPSI.

SACR may be used as an alternative to the LPSI and RPSI markers to overcome the problem of losing visibility of the sacral marker (if this occurs), the standard marker kit contains a base plate and selection of short "sticks" or "wands" to allow the marker to be extended away from the body, if necessary.. In this case it must be positioned to lie in the plane formed by the ASIS and PSIS points.

Leg Markers

LKNE	Left knee	Placed on the lateral epicondyle of the left knee

To locate the "precise" point for the knee marker placement, passively flex and extend the knee a little while watching the skin surface on the lateral aspect of the knee joint. Identify where knee joint axis passes through the lateral side of the knee by finding the lateral skin surface that comes closest to remaining fixed in the thigh. This landmark should also be the point about which the lower leg appears to rotate. Mark this point with a pen. With an adult patient standing, this pen mark should be about 1.5 cm above the joint line, mid-way between the front and back of the joint. Attach the marker at this point.

LTHI	Left thigh	Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand, although the height is not critical.

The thigh markers are used to calculate the knee flexion axis location and orientation. Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand, although the height is not critical. The antero-posterior placement of the marker is critical for correct alignment of the knee flexion axis. Try to keep the thigh marker off the belly of the muscle, but place the thigh marker at least two marker diameters proximal of the knee marker. Adjust the position of the marker so that it is aligned in the plane that contains the hip and knee joint centers and the knee flexion/extension axis. There is also another method that uses a mirror to align this marker, allowing the operator to better judge the positioning.

LANK	Left ankle	Placed on the lateral malleolus along an imaginary line that passes through the transmalleolar axis
LTIB	Left tibial wand marker	Similar to the thigh markers, these are placed over the lower 1/3 of the shank to determine the alignment of the ankle flexion axis

The tibial marker should lie in the plane that contains the knee and ankle joint centers and the ankle flexion/extension axis. In a normal subject the ankle joint axis, between the medial and lateral malleoli, is externally rotated by between 5 and 15 degrees with respect to the knee flexion axis. The placements of the shank markers should reflect this.

Foot Markers

LTOE	Left toe	Placed over the second metatarsal head, on the mid-foot side of the equinus break between fore-foot and mid-foot
LHEE	Left heel	Placed on the calcaneous at the same height above the plantar surface of the foot as the toe marker

Appendix 13: Information sheet intrarater reliability study

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Title

Test-retest reliability of Vicon measurement system marker placement.

Introduction

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

The purpose of this study is to assess the accuracy of the researcher in attaching skin markers for use with the Vicon measurement system. Vicon is a three-dimensional optical motion analysis system. It consists of several infrared cameras, located around a ten-metre walkway, which detect lightweight reflective markers attached to the skin. Using Vicon to measure spinal movement during walking and standing up may be useful as a measure of treatment outcome in patients with chronic low back pain. The researcher intends to use Vicon to measure the spinal movement of patients with low back pain. However, before doing this, it is important to assess the accuracy with which the researcher can use this system.

Why have I been chosen?

You have been chosen because you are aged 18-64, do not have significant low back pain, and can walk independently.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet and be asked to sign a consent form. You will be given a copy of both forms to keep. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you decided to take part you would attend the Human Performance Laboratory, Garthdee Campus, Robert Gordon University on two separate occasions, at least twenty-four hours apart. On each occasion, you would be asked to dress in shorts (these can be provided), and would have your top rolled/folded up to reveal your low back. Some body measurements would be taken (such as weight, height and leg length), and then some small, lightweight reflective markers would be attached to your skin with hypoallergenic double-sided tape at various points on your legs and back. You would be asked to walk at your normal pace, several times across the room, whilst infrared cameras detect the markers on your body and convert them into a 3-D image of you on a computer screen. You would be able to rest at any time during this process. You would be reimbursed for travel costs to attend the measurement session.

What are the possible benefits of taking part?
This study will not benefit you directly. It is hoped that the knowledge gained will improve measurement of chronic low back pain patients.

Will my taking part in the study be kept confidential?
All information that is collected about you during the course of the research will be kept strictly confidential.

Who is organising and funding the research?
The researcher is a Physiotherapist employed by NHS Grampian, conducting the research in association with the Robert Gordon University. The Nursing, Midwifery and Allied Health Professions Research Training Scheme are funding the research. They are a consortium of Scottish Universities funded by NHS Scotland, the Scottish Executive and the Health Foundation.

Who has reviewed the study?
The School of Health Sciences ethics committee has approved the study.

What do I do now?
The researcher can answer any questions you may have. If you are interested in taking part, a date and time for the first measurement session will be arranged. Please remember you are free to withdraw from the study at any time.

Thank you for considering taking part in this research study. Please discuss this information with anyone you wish prior to making a decision.

Contact for further information
Kay Cooper
School of Health Sciences
Robert Gordon University
Garthdee Road
Aberdeen
AB10 7QG

Telephone: 01224 262677
e-mail: prs.cooper@rgu.ac.uk

Appendix 14: Roland Morris Low Back Pain Disability Questionnaire

THE
ROBERT GORDON
UNIVERSITY
ABERDEEN

NHS
Grampian

Patient-centred physiotherapy for chronic low back pain

Study No: 04/S0801/49

PIN: ___________ **DATE: ___________**

Roland-Morris Low Back Pain Disability Questionnaire

Instructions
When your back hurts, you may find it difficult to do some of the things you normally do. This list contains some sentences that people have used to describe themselves when they have back pain. When you read them, you may find that some stand out because they describe you *today.* As you read the list, think of yourself *today*. When you read a sentence that describes you today, put a tick against it. If the sentence does not describe you then leave the space blank and go on to the next one. Remember; only tick the sentence if you are sure that it describes you today.

1. I stay at home most of the time because of my back ___
2. I change position frequently to try and get my back comfortable ___
3. I walk more slowly than usual because of my back ___
4. Because of my back I am not doing any of the jobs that I usually do around the house ___
5. Because of my back, I use a handrail to get upstairs ___
6. Because of my back, I lie down to rest more often ___
7. Because of my back, I have to hold on to something to get out of an easy chair ___
8. because of my back, I try to get other people to do things for me ___
9. I get dressed more slowly than usual because of my back ___

Please Turn Over

10. I only stand up for short periods of time because of my back ___

11. Because of my back, I try not to bend or kneel down ___

12. I find it difficult to get out of a chair because of my back ___

13. My back is painful almost all the time ___

14. I find it difficult to turn over in bed because of my back ___

15. My appetite is not very good because of my back pain ___

16. I have trouble putting on my socks (or stockings) because of the pain in my back ___

17. I only walk short distances because of my back pain ___

18. I sleep less well because of my back ___

19. Because of my back pain I get dressed with help from someone else ___

20. I sit down most of the day because of my back ___

21. I avoid heavy jobs around the house because of my back ___

22. Because of my back pain I am more irritable and bad tempered with people than usual ___

23. Because of my back, I go upstairs more slowly than usual ___

24. I stay in bed most of the time because of my back ___

THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER

November 12, 2004

Kay Cooper
Robert Gordon University
School of Health Sciences, Faculty of Health and Social Care
Garthdee Road
Aberdeen
United Kingdom AB42 1GB

Dear Mrs. Cooper:

I am pleased that you have considered using the Brief Pain Inventory© (BPI) in your upcoming study. The study description you provided seems to be congruent with the intended use of the BPI. You may reproduce the BPI but your copyright use is limited only to this specific study. In addition, the following should appear in your reproduced copy.

Copyright 1991 Charles S. Cleeland, Ph.D.
Pain Research Group
Used by permission.

Additional information can be obtained by visiting our website:
www.mdanderson.org/departments/prg.

I look forward to having a summary of your results.

Sincerely,

Charles S. Cleeland, Ph.D.
McCullough Professor of Cancer Research
Chairman, Department of Symptom Research
Division of Internal Medicine

CSC: gmm

Cc: Tito R. Mendoza, Ph.D.

CARING • INTEGRITY • DISCOVERY
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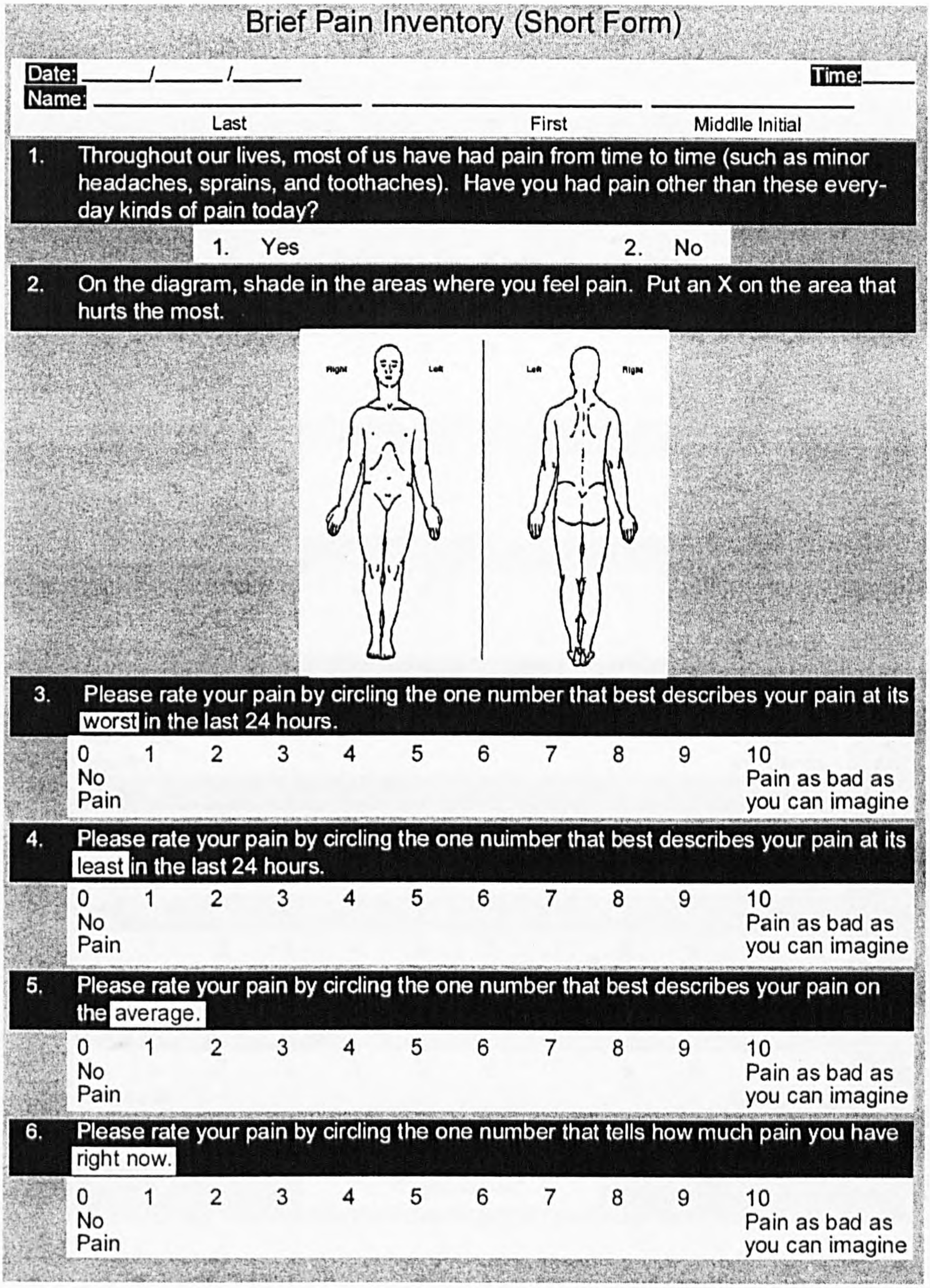
A Comprehensive Cancer Center designated by the National Cancer Institute
located in the Texas Medical Center

Appendix 16: Brief Pain Inventory



Brief Pain Inventory (Short Form)

Date: _____/_____/_____ **Time:**_____

Name: ________________ ________________ ________________

Last First Middle Initial

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these every-day kinds of pain today?

1. Yes 2. No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.

Right Left Left Right

3. Please rate your pain by circling the one number that best describes your pain at its **worst** in the last 24 hours.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

4. Please rate your pain by circling the one nuimber that best describes your pain at its **least** in the last 24 hours.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

5. Please rate your pain by circling the one number that best describes your pain on the **average.**

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

6. Please rate your pain by circling the one number that tells how much pain you have **right now.**

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please circle the one percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Relief										Complete Relief

9. Circle the one number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

B. Mood

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

C. Walking Ability

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

D. Normal Work (includes both work outside the home and housework)

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

E. Relations with other people

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

F. Sleep

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

G. Enjoyment of life

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

Appendix 17: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, normal speed; control sample (n=20)

Parameter	Unit of measurement	1	2	3	4	5	6	7	8	9	10
Cadence	steps/min	0.78	1.67	3.57	0.44	0.81	0.53	5.31	2.85	4.03	2.50
Left stride time	seconds	0.89	1.41	3.91	0.40	1.75	0.83	6.10	2.68	3.54	2.54
Right stride time	seconds	2.98	1.94	3.46	0.60	1.59	0.63	4.20	3.27	4.64	2.56
Left step time	seconds	4.45	0.93	10.43	1.41	4.58	2.71	9.66	3.99	1.61	4.86
Right step time	seconds	1.37	5.39	3.69	1.72	2.61	2.63	1.60	3.11	6.38	1.11
Left SS	percent	2.97	2.44	2.13	0.00	0.00	6.03	2.37	0.00	5.67	3.23
Right SS	percent	3.58	0.00	8.80	1.43	0.00	2.44	8.92	4.22	4.88	24.17
Double Support	percent	14.62	4.20	2.46	3.61	5.43	19.92	18.83	12.30	5.37	3.89
Left stance (foot off)	percent	3.82	0.97	3.30	1.14	3.38	3.59	4.78	2.54	2.42	6.65
Right stance (foot off)	percent	1.53	0.71	1.19	0.37	1.03	4.43	3.16	0.97	2.70	1.83
Left stride length	metres	5.80	3.81	2.44	1.46	1.96	3.25	1.88	1.75	2.16	2.31
Right stride length	metres	5.50	4.30	1.88	1.18	0.93	3.52	4.23	0.94	4.04	1.93
Left step length	metres	3.21	4.71	1.76	0.97	0.84	4.35	2.71	2.13	1.94	2.70
Right step length	metres	5.69	4.95	3.56	1.86	1.37	2.81	5.14	0.35	3.31	2.22
Speed	Metres/second	5.45	4.75	6.04	1.63	0.92	3.94	8.87	1.32	6.19	2.48

Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, normal speed; control sample (n=20)

Parameter	Unit of measurement	11	12	13	14	15	16	17	18	19	20
Cadence	steps/min	2.23	0.99	0.81	0.99	0.78	4.18	1.12	4.52	0.24	3.87
Left stride time	seconds	2.00	1.88	1.12	1.21	1.32	5.20	1.20	3.53	0.61	4.48
Right stride time	seconds	2.34	2.33	1.48	0.76	0.50	3.30	1.48	4.50	0.32	3.03
Left step time	seconds	3.47	1.65	3.26	2.03	2.57	8.33	1.76	2.40	5.54	2.42
Right step time	seconds	1.21	2.18	3.27	1.41	3.28	2.25	2.48	4.11	4.39	7.29
Left SS	percent	2.73	4.32	9.27	1.06	2.59	5.40	2.17	2.65	4.17	13.55
Right SS	percent	3.65	6.44	4.68	25.52	0.00	10.56	2.11	2.17	1.86	7.01
Double Support	percent	1.42	14.57	5.39	2.29	5.35	9.19	5.25	12.39	4.52	16.95
Left stance (foot off)	percent	2.85	3.69	2.64	0.95	2.09	3.71	1.20	3.14	1.43	4.73
Right stance (foot off)	percent	1.52	2.39	4.13	0.21	2.51	0.91	0.94	1.49	3.02	6.92
Left stride length	metres	0.81	1.49	1.74	0.60	3.37	4.74	3.31	3.85	5.28	1.43
Right stride length	metres	0.87	1.74	1.37	1.27	3.77	2.37	2.78	3.61	4.97	1.43
Left step length	metres	2.93	1.85	1.50	1.61	2.14	4.71	3.04	3.07	7.69	2.18
Right step length	metres	1.91	1.20	1.80	1.40	5.31	4.50	2.77	3.11	3.30	0.79
Speed	Metres/second	2.17	2.74	0.98	2.04	3.82	7.02	2.98	2.36	5.38	4.38

Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, fast speed; control sample (n=20)

Parameter	**Unit of measurement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cadence	steps/min	2.23	1.67	3.15	2.00	1.45	2.09	10.22	2.95	2.12	1.99
Left stride time	seconds	3.71	1.41	3.01	1.53	2.30	1.70	11.22	3.44	3.12	0.38
Right stride time	seconds	0.60	1.94	3.34	2.45	0.98	2.40	10.41	2.72	1.39	3.74
Left step time	seconds	9.87	0.93	3.20	5.02	6.92	3.01	14.42	4.20	5.09	7.00
Right step time	seconds	2.04	5.39	2.37	7.56	2.25	5.99	10.58	1.90	3.01	8.06
Left SS	percent	1.47	2.44	2.84	10.79	2.71	7.53	7.92	2.44	8.54	9.33
Right SS	percent	3.76	0.00	3.64	0.00	4.55	0.00	9.61	2.47	2.44	3.26
Double Support	percent	3.72	4.20	10.18	23.92	0.00	7.37	15.41	9.22	33.33	13.40
Left stance (foot off)	percent	3.88	0.97	1.92	1.03	2.91	1.19	1.12	1.54	3.67	0.95
Right stance (foot off)	percent	1.42	0.71	0.94	8.31	2.60	3.59	1.53	2.60	6.76	3.98
Left stride length	metres	2.68	3.81	0.64	1.28	0.08	2.87	7.33	1.13	1.29	3.39
Right stride length	metres	4.35	4.30	0.40	0.37	0.52	2.23	7.88	1.29	1.29	3.02
Left step length	metres	3.87	4.71	0.65	1.41	1.01	4.79	6.99	1.56	1.45	1.88
Right step length	metres	2.36	4.95	0.84	2.85	0.48	1.31	7.76	1.15	1.38	2.80
Speed	Metres/second	2.38	4.75	2.93	1.55	1.55	4.73	17.05	4.44	2.38	2.77

Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, fast speed; control sample (n=20)

Parameter	Unit of measurement	11	12	13	14	15	16	17	18	19	20
Cadence	steps/min	4.58	4.00	3.18	2.65	2.09	2.30	1.49	2.08	1.50	0.59
Left stride time	seconds	3.53	3.36	5.79	1.98	3.77	2.79	0.34	1.70	1.70	0.50
Right stride time	seconds	5.68	4.57	2.38	3.18	2.73	1.94	2.50	2.84	1.86	1.53
Left step time	seconds	3.56	5.19	15.16	8.08	11.26	4.52	0.91	1.44	8.69	5.01
Right step time	seconds	5.47	5.97	4.03	7.72	11.34	1.08	6.16	1.36	10.33	5.28
Left SS	percent	6.29	0.00	6.01	6.78	16.66	2.22	4.00	4.20	3.15	6.52
Right SS	percent	6.57	5.07	8.72	11.50	5.94	7.53	41.81	3.53	8.66	7.06
Double Support	percent	5.59	16.26	28.47	3.95	19.92	10.83	17.44	22.06	20.14	25.32
Left stance (foot off)	percent	1.50	2.34	7.71	6.25	8.53	1.56	3.07	2.26	6.60	5.18
Right stance (foot off)	percent	1.67	2.58	2.83	6.34	8.73	4.73	2.47	5.03	1.17	3.16
Left stride length	metres	2.12	2.87	2.42	1.73	2.24	3.67	6.57	0.22	0.81	1.58
Right stride length	metres	2.47	2.36	4.31	2.19	3.94	3.09	6.70	1.99	0.97	1.34
Left step length	metres	1.40	2.24	2.17	3.63	8.28	3.97	5.91	1.18	2.94	2.85
Right step length	metres	3.22	3.64	2.59	4.05	5.78	3.46	7.15	1.49	0.99	1.94
Speed	Metres/second	5.43	6.39	3.13	2.13	1.36	5.75	6.60	1.48	1.67	1.52

Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, normal speed; CLBP sample (n=17)

Parameter	**Unit of measurement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cadence	steps/min	3.10	11.72	0.44	10.26	3.31	1.60	1.25	1.93	2.14	1.66
Left stride time	seconds	2.66	11.05	0.75	2.59	4.91	2.37	1.53	2.22	3.44	1.92
Right stride time	seconds	3.77	11.52	0.37	3.66	2.34	0.64	1.02	1.89	0.94	1.70
Left step time	seconds	13.96	8.59	2.55	5.86	5.28	5.54	0.99	3.73	5.09	2.26
Right step time	seconds	7.46	14.70	1.85	4.20	5.54	1.82	2.18	2.28	4.16	3.20
Left SS	percent	10.89	0.35	2.63	8.71	6.14	3.17	4.55	5.25	4.68	6.59
Right SS	percent	6.67	7.74	3.47	3.44	6.86	2.08	2.64	3.98	4.82	2.87
Double Support	percent	9.17	4.24	9.60	12.85	5.59	3.66	1.62	16.45	6.08	20.51
Left stance (foot off)	percent	4.61	4.72	3.48	1.53	3.02	1.58	2.09	2.17	3.10	2.87
Right stance (foot off)	percent	6.51	0.41	1.14	5.68	3.34	0.65	2.15	4.32	3.02	5.55
Left stride length	metres	2.29	9.10	3.09	1.89	0.47	3.31	1.89	2.37	8.78	2.30
Right stride length	metres	1.70	9.31	1.11	2.23	0.87	1.52	2.21	1.94	9.02	2.81
Left step length	metres	3.87	10.36	5.34	0.70	1.87	5.57	3.18	3.52	7.98	1.67
Right step length	metres	5.89	8.50	4.58	4.66	1.43	1.24	2.31	1.38	10.00	3.38
Speed	Metres/second	4.62	21.61	1.35	3.80	2.10	1.77	3.67	3.61	9.13	3.99

Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, normal speed; CLBP sample (n=17)

Parameter	**Unit of measurement**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Cadence	steps/min	1.88	1.04	3.42	0.18	3.42	2.36	2.44
Left stride time	seconds	2.33	0.61	3.83	0.26	2.83	1.51	2.81
Right stride time	seconds	1.89	2.15	3.20	0.12	3.79	3.03	2.08
Left step time	seconds	8.20	2.91	4.16	2.71	6.72	2.46	7.17
Right step time	seconds	6.77	7.39	3.56	1.98	13.10	0.92	2.27
Left SS	percent	14.22	3.32	4.22	3.71	9.66	1.77	11.44
Right SS	percent	0.55	4.26	3.41	2.06	5.52	2.97	5.78
Double Support	percent	20.58	5.93	6.02	8.31	12.59	2.99	26.88
Left stance (foot off)	percent	1.86	1.16	2.13	1.37	3.19	2.62	3.79
Right stance (foot off)	percent	8.28	2.48	3.10	1.82	6.83	0.16	9.02
Left stride length	metres	5.24	1.42	4.13	1.61	4.08	1.76	3.14
Right stride length	metres	5.59	1.56	4.30	1.61	3.44	2.49	4.25
Left step length	metres	6.14	2.57	4.68	2.31	7.43	1.81	2.76
Right step length	metres	4.89	0.84	3.64	2.00	2.69	3.73	4.00
Speed	Metres/second	8.28	1.19	7.59	2.60	7.23	2.47	6.54

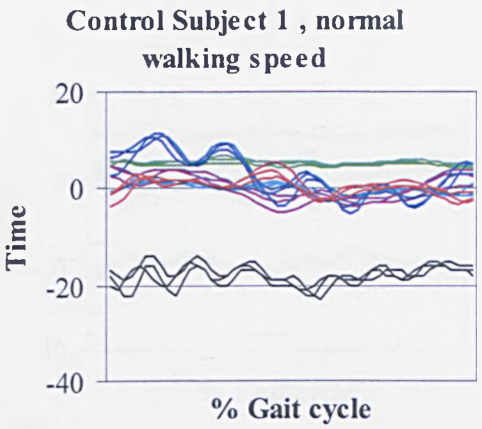
Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, fast speed; CLBP sample (n=17)

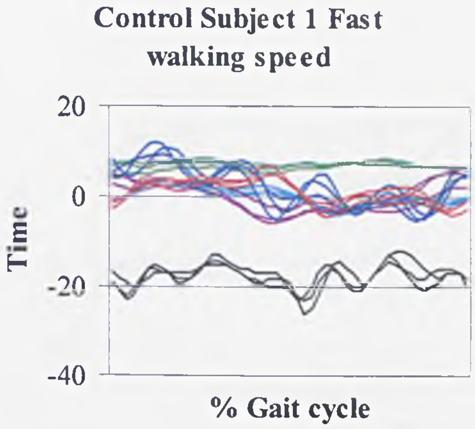
Parameter	**Unit of measurement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cadence	steps/min	0.67	0.79	1.05	2.29	1.39	2.89	2.37	0.44	3.09	2.38
Left stride time	seconds	0.78	0.52	1.19	1.88	1.79	3.02	2.39	0.99	2.96	1.73
Right stride time	seconds	0.46	1.19	1.11	2.97	1.32	2.71	2.12	1.04	3.23	3.57
Left step time	seconds	2.05	2.38	3.23	5.98	6.45	1.47	1.41	5.45	3.22	2.87
Right step time	seconds	1.68	1.92	2.04	4.12	4.36	4.55	3.67	3.90	3.67	1.36
Left SS	percent	5.97	2.11	1.91	14.06	1.80	2.61	1.64	5.68	1.28	2.62
Right SS	percent	2.05	4.09	1.09	0.81	4.25	1.01	2.20	2.02	1.19	3.06
Double Support	percent	16.04	8.40	12.24	18.83	12.33	6.76	7.67	5.88	6.98	15.74
Left stance (foot off)	percent	1.45	1.90	4.29	0.76	2.68	0.79	1.13	2.46	2.36	2.70
Right stance (foot off)	percent	4.26	1.21	2.18	7.93	0.83	1.99	1.01	3.37	1.67	2.72
Left stride length	metres	3.30	1.24	3.86	3.37	0.56	1.13	3.65	3.59	1.40	2.15
Right stride length	metres	3.46	1.20	2.60	2.41	0.45	1.27	3.57	3.07	1.51	3.31
Left step length	metres	2.79	1.54	6.41	1.37	3.06	0.75	3.72	3.96	1.62	3.11
Right step length	metres	4.24	1.80	1.29	6.58	1.75	1.84	3.72	2.51	1.74	2.71
Speed	Metres/second	2.90	2.10	3.50	4.39	1.25	41.29	4.80	3.03	3.34	0.13

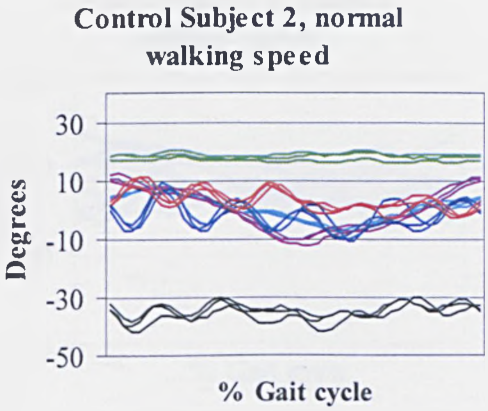
Appendix 17 continued: Individual Coefficient of Variation (CV) values for Spatial and temporal parameters, fast speed; CLBP sample (n=17)

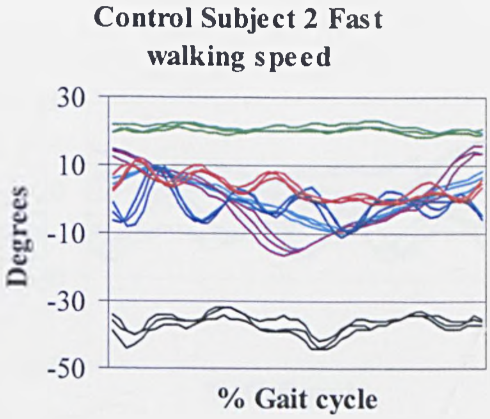
Parameter	**Unit of measurement**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Cadence	steps/min	0.74	1.66	3.04	1.46	0.98	2.37	0.58
Left stride time	seconds	1.30	0.91	3.84	0.95	1.47	3.05	0.35
Right stride time	seconds	0.00	3.11	2.21	2.21	0.55	2.21	1.10
Left step time	seconds	3.85	3.27	1.99	0.97	3.92	9.28	17.30
Right step time	seconds	3.46	10.65	7.33	1.86	1.31	8.10	13.97
Left SS	percent	5.13	2.35	5.24	1.96	3.00	2.21	2.18
Right SS	percent	4.38	5.50	1.53	3.80	3.57	7.93	24.04
Double Support	percent	0.21	3.97	18.25	3.30	9.33	25.47	28.21
Left stance (foot off)	percent	2.13	1.69	0.82	2.09	2.64	6.27	11.67
Right stance (foot off)	percent	1.38	5.03	5.65	0.54	1.42	3.48	0.81
Left stride length	metres	1.54	6.15	1.33	2.49	1.44	0.56	0.48
Right stride length	metres	0.68	7.05	1.49	3.32	1.23	0.94	1.43
Left step length	metres	2.28	4.43	3.12	2.42	2.00	1.53	28.30
Right step length	metres	0.01	9.23	2.54	6.79	1.10	0.80	18.72
Speed	Metres/second	1.95	5.01	2.84	5.07	1.65	1.81	1.76

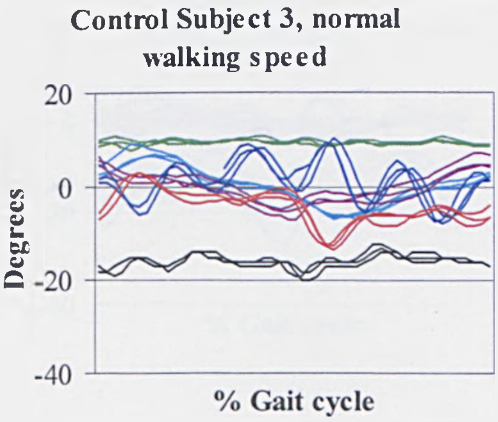
Appendix 18: Control sample spinal kinematic repeatability (gait) graphs

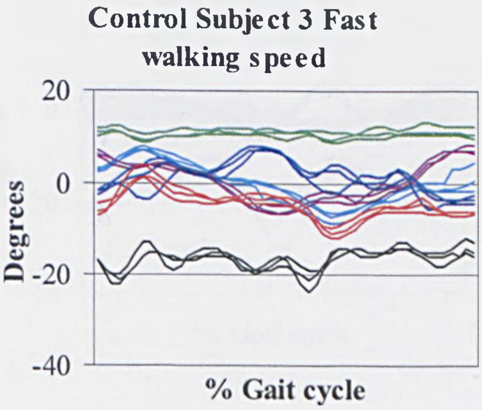

Control Subject 1 , normal walking speed


Control Subject 1 Fast walking speed


Control Subject 2, normal walking speed

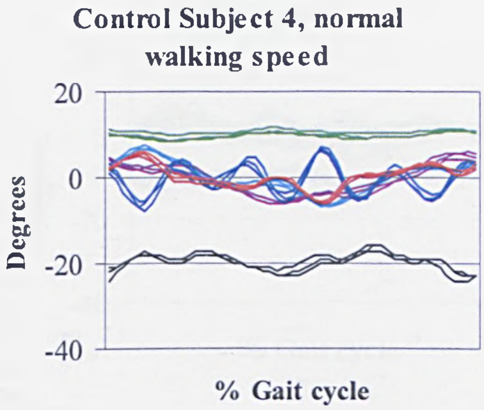

Control Subject 2 Fast walking speed

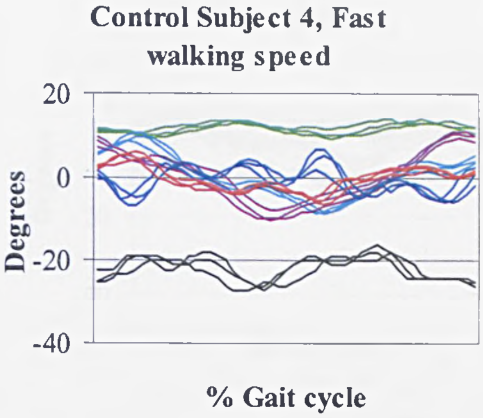

Control Subject 3, normal walking speed

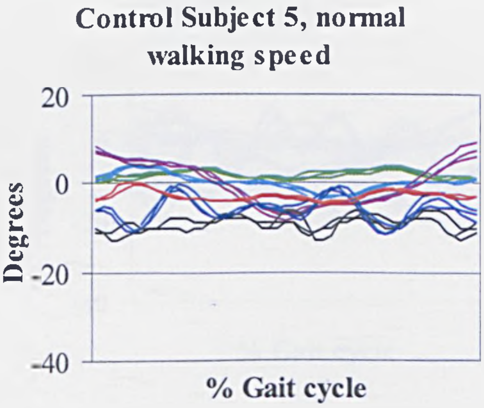

Control Subject 3 Fast walking speed

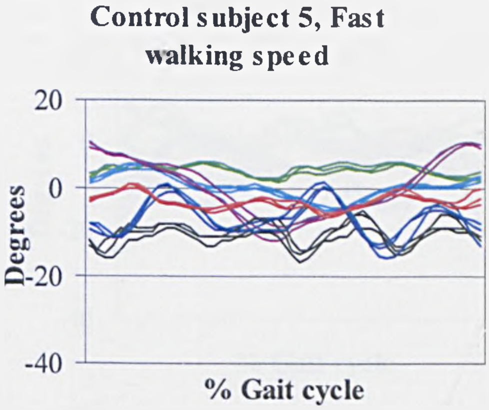
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

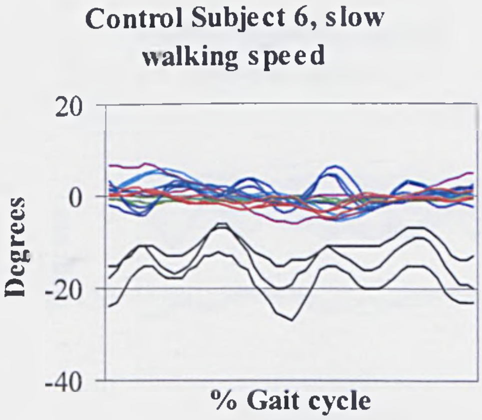
Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs

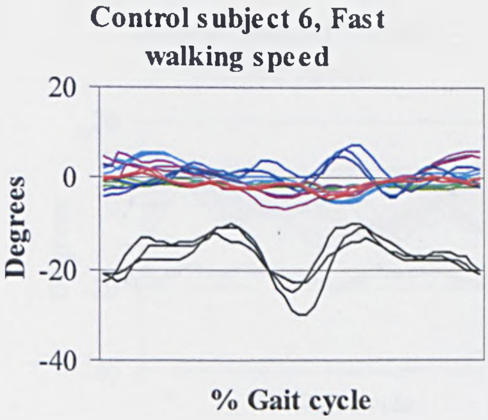

Control Subject 4, normal walking speed


Control Subject 4, Fast walking speed


Control Subject 5, normal walking speed

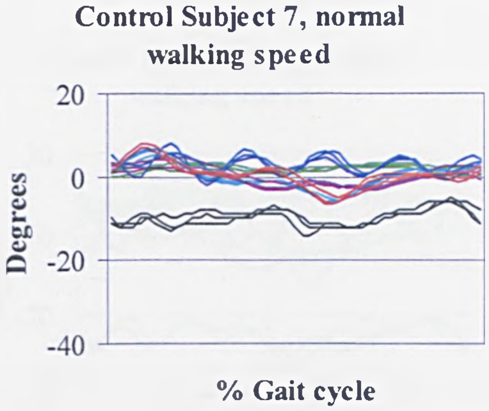

Control subject 5, Fast walking speed

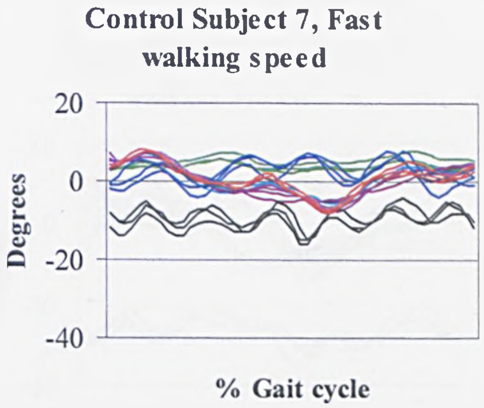

Control Subject 6, slow walking speed

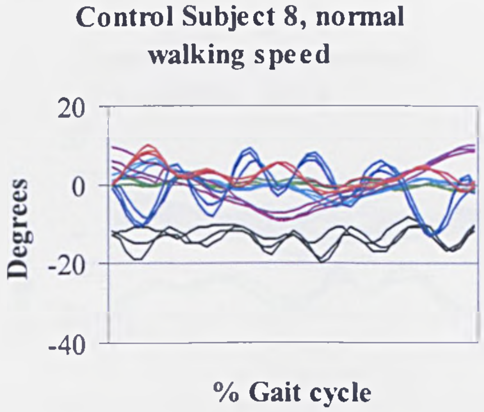

Control subject 6, Fast walking speed

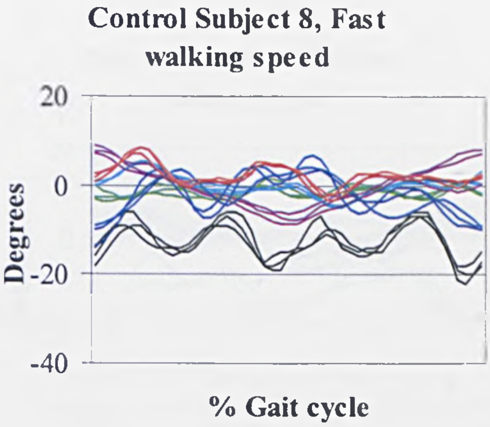
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

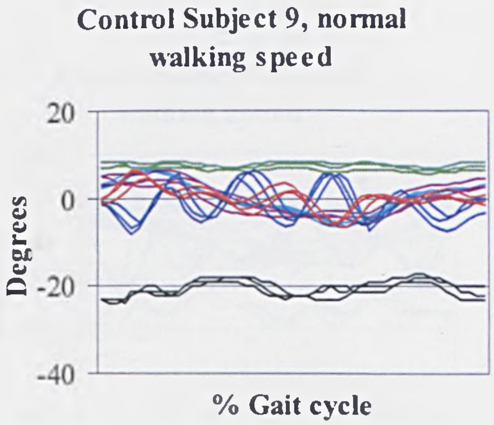
Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs

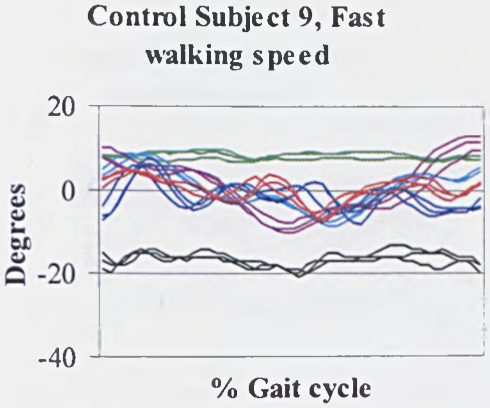

Control Subject 7, normal walking speed


Control Subject 7, Fast walking speed


Control Subject 8, normal walking speed


Control Subject 8, Fast walking speed

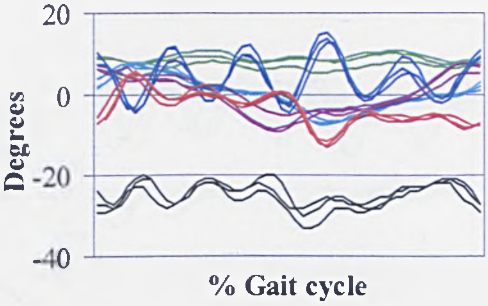

Control Subject 9, normal walking speed


Control Subject 9, Fast walking speed

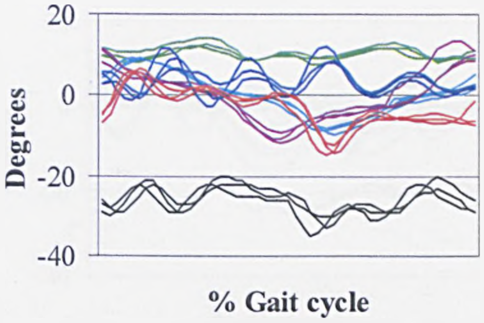
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs

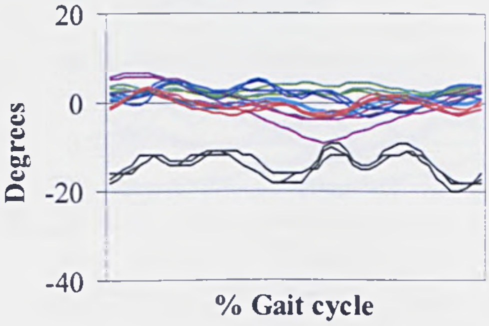
Control Subject 10, normal walking speed



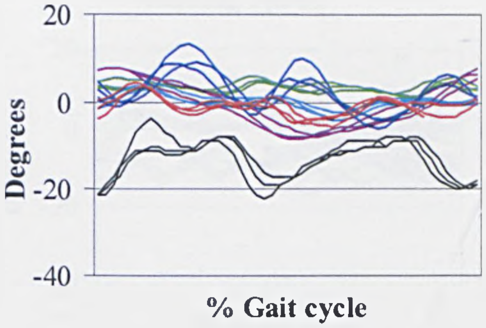
Control Subject 10, Fast walking speed



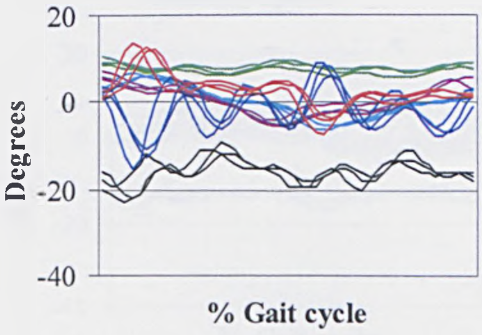
Control Subject 11, normal walking speed



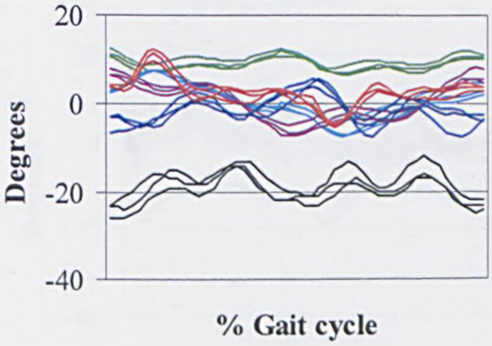
Control Subject 11, Fast walking speed



Control Subject 12, slow walking speed



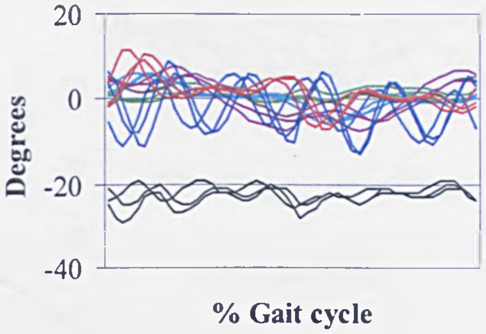
Control Subject 12, Fast walking speed



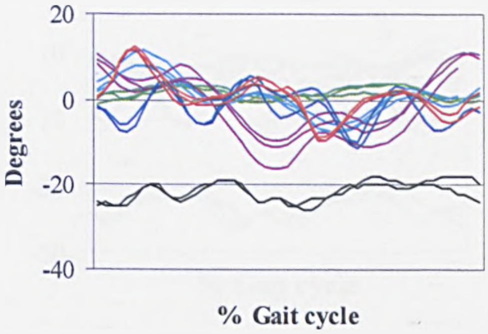
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs

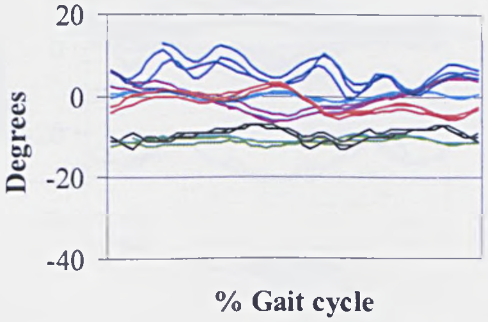
Control Subject 13, normal walking speed



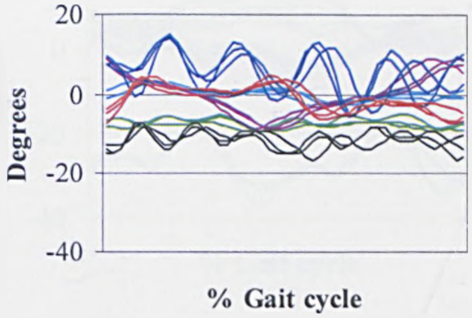
Control Subject 13, Fast walking speed



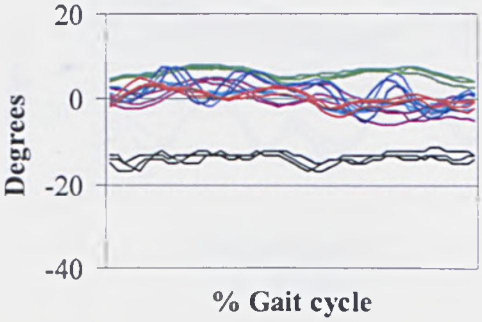
Control Subject 14, normal walking speed



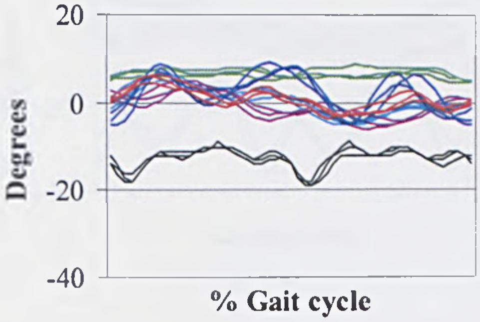
Control Subject 14 Fast walking speed



Control Subject 15, slow walking speed



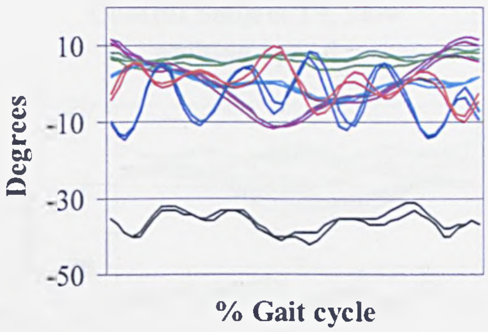
Control Subject 15, Fast walking speed



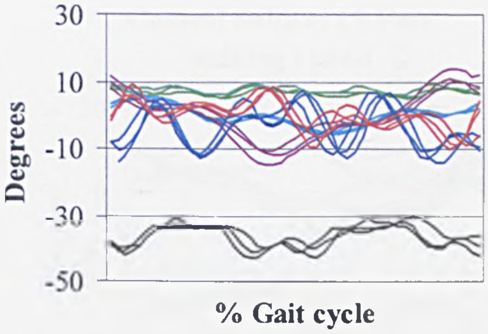
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs

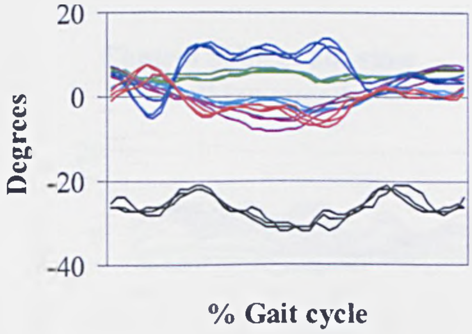
Control Subject 16, slow walking speed



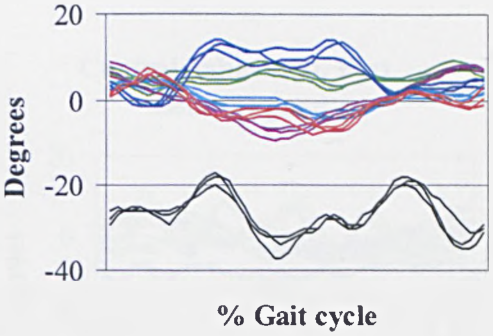
Control Subject 16, Fast walking speed



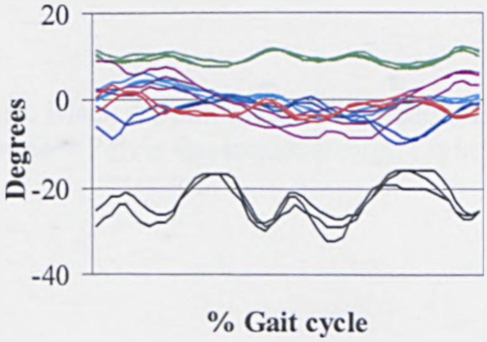
Control Subject 17, slow walking speed



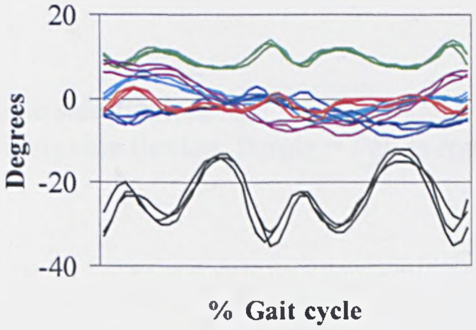
Control Subject 17 Fast walking speed



Control Subject 18, normal walking speed

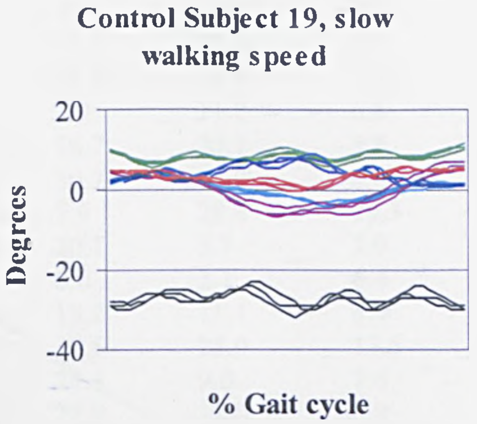


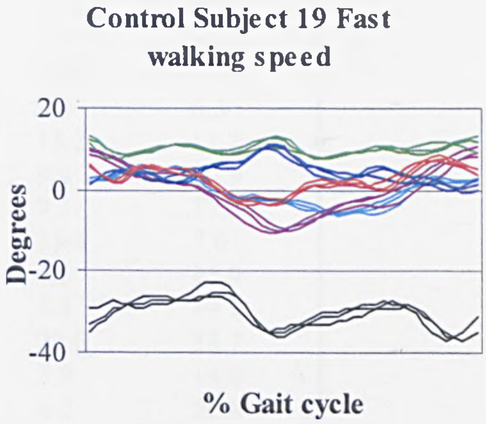
Control Subject 18 Fast walking speed

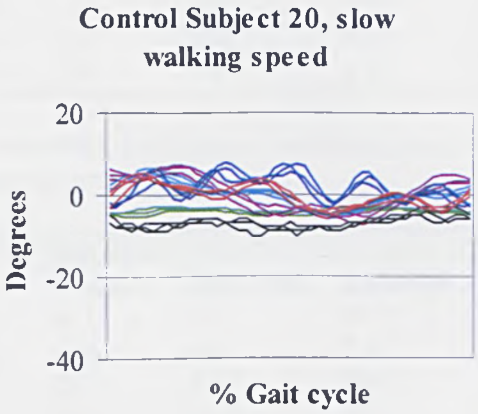


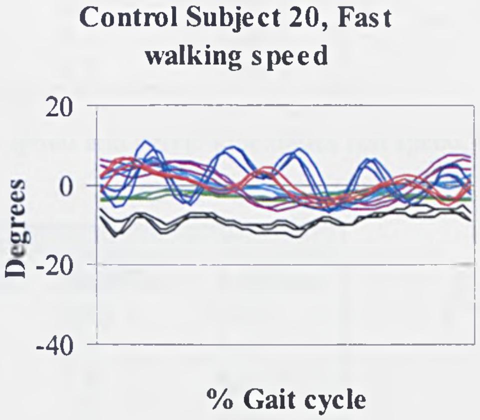
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion. Purple = Pelvis rotation

Appendix 18 continued: Control sample spinal kinematic repeatability (gait) graphs


Control Subject 19, slow walking speed


Control Subject 19 Fast walking speed


Control Subject 20, slow walking speed


Control Subject 20, Fast walking speed

Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = Spine rotation, Green = Pelvis flexion/extension, Light blue = Pelvis side flexion, Purple = Pelvis rotation

Appendix 19: Individual Coefficient of Variation values (CV) for spinal and pelvic kinematics normal speed, control sample (n=20)

	Spine			Pelvis		
	Flex/Ext	**Side Flex**	**Rotation**	**Flex/Ext**	**Side Flex**	**Rotation**
1	20.8	10.0	26.9	33.5	19.0	25.4
2	11.1	15.2	5.4	17.9	1.7	10.3
3	20.8	12.4	4.6	19.4	10.2	21.9
4	7.9	11.2	6.6	23.3	2.4	6.3
5	16.7	20.7	3.8	15.6	13.2	11.7
6	30.7	14.9	6.0	28.5	9.9	60.9
7	7.9	28.6	19.3	15.7	9.1	17.2
8	20.1	5.7	7.9	5.0	35.4	7.6
9	0.0	2.1	6.4	17.4	4.5	16.9
10	19.2	11.1	8.9	2.5	5.4	19.1
11	12.5	25.0	17.5	7.5	22.0	38.7
12	24.4	9.0	7.6	10.2	7.9	14.0
13	22.9	12.0	6.9	15.1	4.2	20.8
14	10.2	10.3	2.6	18.9	6.7	13.3
15	20.0	6.6	2.0	23.8	5.2	11.2
16	7.4	5.1	9.6	16.3	7.3	3.0
17	0.0	3.8	14.4	17.2	14.9	21.3
18	8.1	7.1	13.3	4.8	21.4	27.9
19	15.1	14.8	10.5	5.6	6.1	15.8
20	20.0	7.9	2.4	31.3	6.7	14.3

Individual Coefficient of Variation values (CV) for spinal and pelvic kinematics fast speed, control sample (n=20)

	Spine			Pelvis		
	Flex/Ext	**Side Flex**	**Rotation**	**Flex/Ext**	**Side Flex**	**Rotation**
1	24.1	9.7	23.7	55.5	14.8	29.5
2	10.8	4.6	3.9	16.6	1.1	6.0
3	22.2	2.7	14.4	10.8	7.8	8.2
4	16.4	21.6	6.7	7.5	6.3	11.0
5	11.1	15.5	16.3	5.4	9.3	8.3
6	26.7	8.7	12.6	29.4	1.1	22.5
7	5.4	19.6	2.7	26.2	5.4	24.2
8	18.9	15.8	12.2	12.8	4.0	13.7
9	24.1	8.2	15.9	39.3	3.5	13.5
10	25.5	32.6	5.8	25.0	3.7	16.3
11	14.2	23.8	9.4	15.4	20.6	4.1
12	4.9	10.7	6.9	5.6	11.4	16.6
13	0.0	5.8	3.4	6.8	6.9	14.6
14	6.0	8.4	9.9	32.0	9.4	3.3
15	0.0	4.2	13.3	28.0	7.0	19.1
16	14.8	9.7	15.6	8.2	5.9	16.2
17	23.3	6.8	21.8	18.4	14.8	13.4
18	11.2	25.4	13.9	6.5	11.2	20.1
19	8.3	7.8	10.1	16.8	4.8	4.8
20	24.1	10.3	18.3	12.4	3.0	4.5

Appendix 19 continued: Individual Coefficient of Variation values (CV) for spinal and pelvic kinematics normal speed, chronic low back pain sample (n=20)

	Spine			Pelvis		
	Flex/Ext	Side Flex	Rotation	Flex/Ext	Side Flex	Rotation
1	0.0	11.4	12.8	28.9	11.8	11.5
2	24.1	23.6	18.1	10.4	11.3	29.6
3	13.5	13.9	24.5	7.8	16.6	7.5
4	10.8	8.0	25.2	8.3	14.5	9.5
5	19.9	15.4	3.9	9.3	12.8	1.9
6	0.0	17.7	1.8	17.0	26.9	9.8
7	9.1	15.2	9.6	11.9	11.0	22.0
8	6.0	35.6	12.2	21.9	10.7	19.4
9	17.6	8.5	4.2	7.4	2.5	24.9
10	35.3	15.4	1.8	5.8	3.4	8.6
11	8.7	16.2	8.1	23.7	26.1	17.8
12	0.0	14.2	12.0	5.2	16.4	10.0
13	28.9	23.0	11.7	6.2	14.8	3.6
14	8.7	10.3	3.2	17.1	27.2	22.6
15	16.7	15.0	15.3	33.1	11.1	15.0
16	12.5	8.6	2.1	16.2	4.6	9.9
17	7.9	18.8	18.7	17.5	14.8	14.1

Individual Coefficient of Variation values (CV) for spinal and pelvic kinematics fast speed, chronic low back pain sample (n=20)

	Spine			Pelvis		
	Flex/Ext	Side Flex	Rotation	Flex/Ext	Side Flex	Rotation
1	28.9	10.1	13.1	6.2	9.9	19.8
2	20.4	7.1	7.7	20.6	4.8	0.8
3	13.9	5.8	5.8	7.7	4.3	1.6
4	13.9	6.8	10.7	8.3	14.5	12.8
5	14.3	4.1	7.0	9.4	6.9	7.5
6	5.4	10.9	4.8	11.3	18.7	1.0
7	9.1	6.1	9.6	30.4	2.2	12.9
8	6.0	16.9	3.2	3.4	4.9	8.3
9	16.7	20.4	10.5	25.8	1.5	6.4
10	17.3	10.5	9.4	13.8	6.8	8.3
11	11.9	11.9	3.6	24.1	13.6	6.8
12	6.2	8.8	11.3	13.0	11.2	28.7
13	27.7	16.1	14.9	18.1	27.9	7.1
14	4.9	12.2	1.9	7.8	3.1	5.8
15	34.6	0.6	10.5	12.9	5.5	1.7
16	11.5	7.7	23.2	24.9	15.6	4.8
17	15.7	4.6	7.7	5.1	23.5	14.6

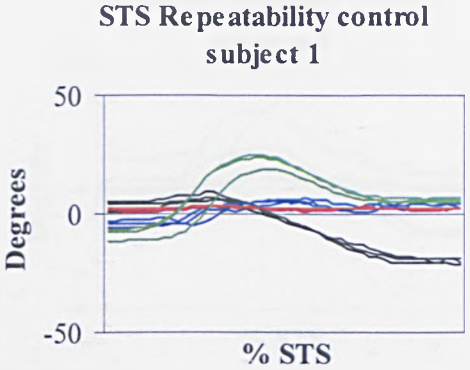
Appendix 20: Individual Coefficient of Variation values (CV), STS temporal and kinematic parameters, control sample

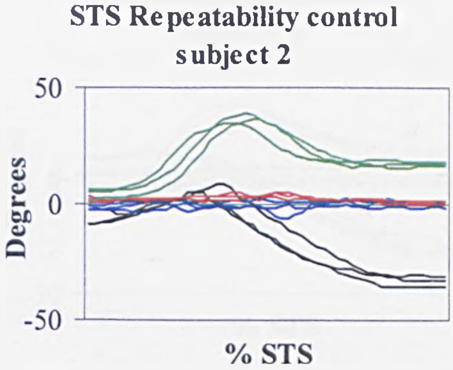
	Timing	Spine Flex/Ext	Side Flex	Rot	Pelvis Flex/Ext
1	5.5	5.52	9.47	30.61	4.2
2	4.7	8.39	35.14	32.97	8.2
3	15.4	5.76	19.02	11.62	4.7
4	1.1	7.64	10.15	18.56	8.5
5	9.0	5.44	5.26	3.30	12.8
6	20.7	54.39	22.91	5.12	1.5
7	3.3	8.32	49.57	25.36	3.7
8	25.3	4.92	16.70	30.19	6.0
9	16.2	3.70	9.41	25.36	6.6
10	N/A	4.72	16.58	22.78	6.6
11	38.1	1.42	17.54	3.14	3.7
12	10.7	9.43	30.81	55.01	1.5
13	10.4	6.58	10.71	14.84	5.8
14	13.0	9.12	5.37	18.74	10.0
15	19.9	N/A	N/A	N/A	N/A
16	18.5	N/A	N/A	N/A	N/A
17	20.7	N/A	N/A	N/A	N/A
18	7.0	N/A	N/A	N/A	N/A

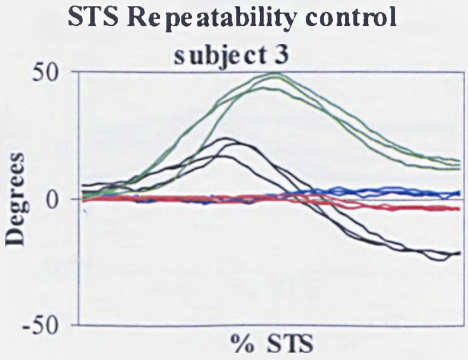
Individual Coefficient of Variation values (CV), STS temporal and kinematic parameters, chronic low back pain sample

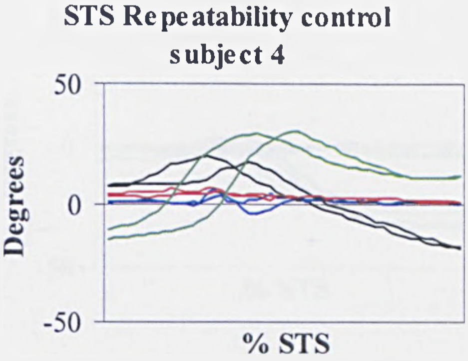
	Timing	Spine Flex/Ext	Side Flex	Rot	Pelvis Flex/Ext
1	4.46	2.8	20.0	16.6	0.2
2	12.80	2.1	21.5	6.7	4.0
3	4.16	1.8	18.7	27.8	9.7
4	15.81	4.0	9.6	23.0	8.7
5	18.89	6.2	5.5	11.1	7.2
6	17.87	13.0	29.9	4.9	5.9
7	18.89	6.7	9.6	19.4	5.5
8	13.96	3.2	9.8	41.9	5.6
9	2.82	12.8	9.7	47.8	10.8
10	25.89	6.3	43.5	24.4	7.2
11	10.45	0.0	22.5	37.6	5.6
12	6.75	4.9	11.7	17.5	6.3
13	13.60	4.3	13.1	17.2	6.0
14	10.21	6.9	4.5	38.2	5.0
15	8.94	N/A	N/A	N/A	N/A
16	38.95	N/A	N/A	N/A	N/A

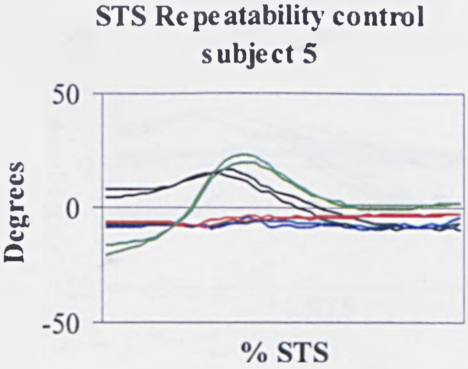
Appendix 21: Control sample spinal kinematic repeatability (STS) graphs

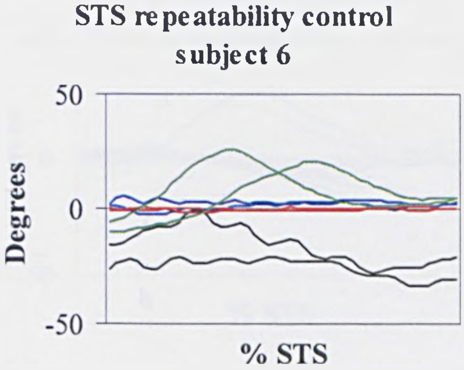

STS Repeatability control subject 1


STS Repeatability control subject 2


STS Repeatability control subject 3

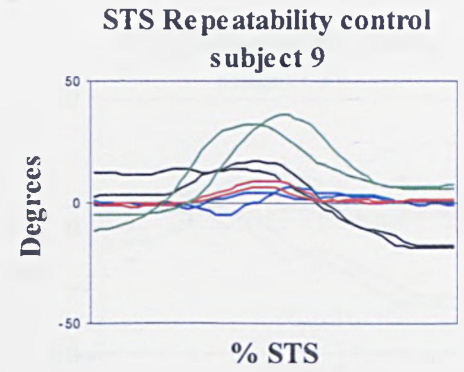

STS Repeatability control subject 4

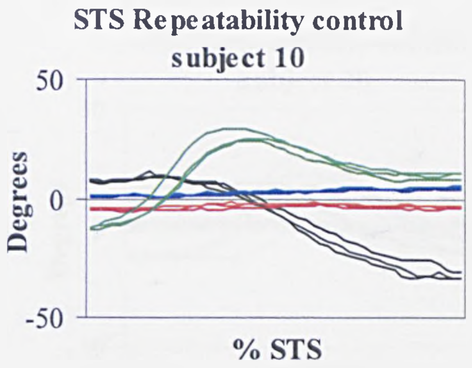

STS Repeatability control subject 5

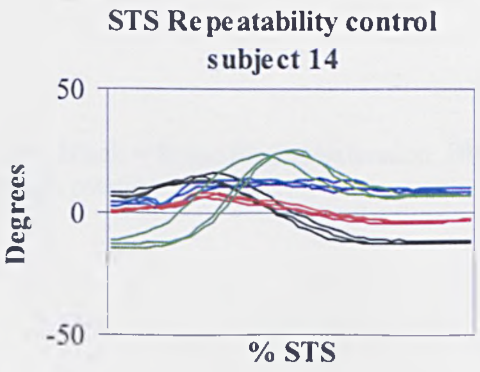

STS repeatability control subject 6

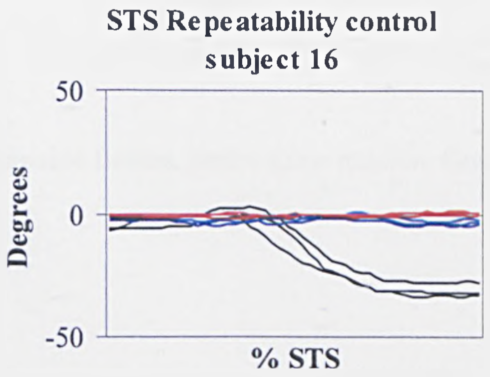
Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = spine rotation, Green = pelvis rotation

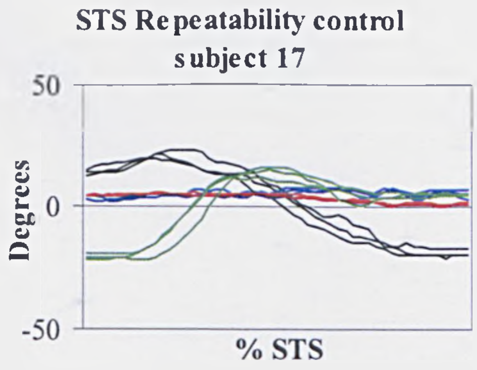
Appendix 21continued: Control sample spinal kinematic repeatability (STS) graphs

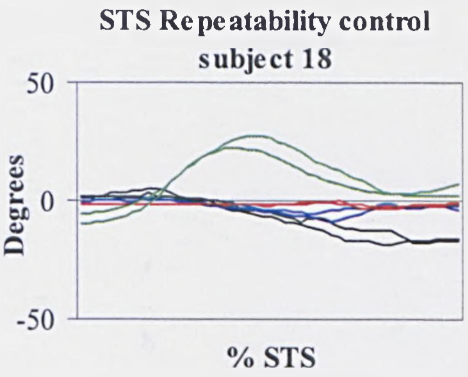

STS Repeatability control subject 9


STS Repeatability control subject 10


STS Repeatability control subject 14

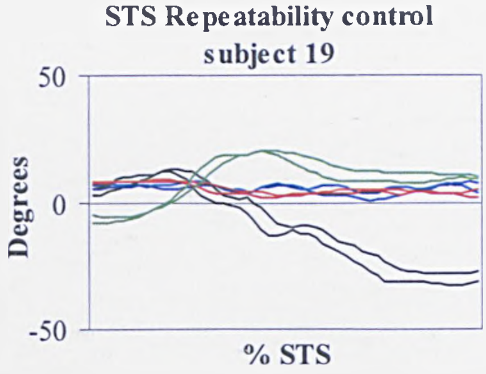

STS Repeatability control subject 16

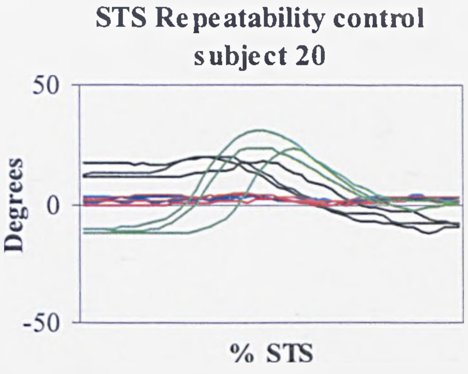

STS Repeatability control subject 17


STS Repeatability control subject 18

Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = spine rotation, Green = pelvis rotation

Appendix 21continued: Control sample spinal kinematic repeatability (STS) graphs





Key: Black = Spine flexion/extension, Blue = Spine side flexion, Red = spine rotation, Green = pelvis rotation