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# Review title

Weight loss interventions for adults with overweight/obesity and chronic musculoskeletal pain: a mixed methods systematic review

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**Key words:** Adults; chronic; musculoskeletal pain; overweight; obese; weight loss

**Running Title:** Weight-loss for adults with overweight/obesity and chronic musculoskeletal pain

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**Conflicts of interest**: None

# Review title

Weight loss interventions for adults with overweight/obesity and chronic musculoskeletal pain: a mixed methods systematic review

## Abstract

Worldwide prevalence of adult overweight and obesity is a growing public health issue. Adults with overweight/obesity often have chronic musculoskeletal pain. Using a mixed-methods review, we aimed to quantify the effectiveness and explore the appropriateness of weight-loss interventions for this population. Electronic databases were searched for studies published between 01/01/90-01/0716. The review included 14 randomised controlled trials that reported weight and pain outcomes and three qualitative studies that explored perceptions of adults with co-existing overweight/obesity and CMP. The random-effects pooled mean weight-loss was 4.9kg (95%CI:2.9,6.8) greater for intervention vs control. The pooled mean reduction in pain was 7.3/100units (95%CI:4.1,10.5) greater for intervention vs control. Study heterogeneity was substantial for weight loss ($I^2$=95%, tau=±3.5kg) and pain change ($I^2$=67%, tau=±4.1%). Meta-regression slopes for the predictors of study quality, mean age and baseline mean weight on mean study weight reduction were shallow and not statistically significant (P>0.05). The meta-regression slope between mean pain reduction and mean weight lost was shallow, and not statistically significant, -0.09kg per unit pain score change (95%CI:-0.21,0.40,p=0.54). Meta-synthesis of qualitative findings resulted in two synthesized findings; the importance of healthcare professionals understanding the effects of pain on ability to control weight, and developing management/education programmes that address comorbidity.

Keywords: chronic musculoskeletal pain, overweight, obesity

Insert Table 1: Grade Summary of Findings here

Insert Table 2: ConQual Summary of Findings here

## Introduction

Excess weight (BMI ≥25kg/m$^2$) and chronic musculoskeletal pain (CMP) are prevalent conditions with widespread implications for the individual, health care resources and the economy.[1,2] These two conditions frequently occur simultaneously and the relationship appears to be bi-directional, adding to the complexity of managing either condition independently. Cohort, case-control studies and randomised controlled trials (RCT) assessing the effectiveness of weight loss interventions on individuals with co-existing CMP have shown that weight reduction can be achieved and is associated with lower pain scores.[3-6] However, no systematic review has been conducted to determine the effectiveness of weight loss interventions in this specific patient group or participants' perceptions of the appropriateness and sustainability of interventions to inform clinical practice.

Worldwide prevalence of overweight/obesity has risen markedly in recent decades with rates more than doubling in some developed areas; globally 1.9 billion adults are overweight, 600 million of these are obese.[7] Similarly, CMP (persistent pain, which lasts over 12 weeks or after the time that healing would have been thought to occur after trauma or surgery [8]), affects one in five adults in developed countries.[9] While back pain and osteoarthritis (OA) (particularly of the knee) account for 50% of CMP, other conditions such as rheumatoid arthritis, migraine, chronic daily headache and neck pain are also common. Both conditions can independently negatively impact on a person's health, functioning, and quality-of-life, and both conditions are a significant economic burden on the state.[10]

Although a cause-effect relationship has not been established there is growing acknowledgement of a link between obesity and CMP.[11-18] For these individuals, difficulties arise in everyday activities such as walking, climbing stairs and driving which result in a decline in independence, leading to reduction in mental health, with depression and social isolation known to affect these patient groups.[19,20] As CMP interferes with daily functioning of individuals with obesity, it can have a negative effect on weight loss.[21] Conversely, individuals with higher BMI have been shown to have increased prevalence of CMP.[22-6] The complex bi-directional relationship between CMP and overweight/obesity suggests that CMP may impede weight loss interventions, and vice versa.

In a meta-analysis of four RCTs Christensen et al.[27] showed positive effects of weight loss on pain and function. However, the review focused on pain and functional outcomes rather than weight loss itself as

an outcome measure. Additionally, the review was restricted to RCTs including participants with OA knee only. Therefore, this review was conducted to synthesise quantitative and qualitative evidence that include a wider CMP population to: 1) evaluate the effectiveness of interventions in this population for weight loss and pain and 2) gather insights of individual perceptions of the links between overweight/obesity and CMP; the effectiveness, and appropriateness of weight loss interventions, and sustainability of weight loss efforts. The findings from this review should be used to inform future interventions for the promotion of healthier lifestyles, and thus help to promote sustainable weight loss and improved management of chronic pain in adults with coexisting overweight/obesity.

## Review question/objectives

The specific review question was: Are weight loss interventions effective and appropriate for the management of adults with overweight/obesity and CMP?

The objectives of this review were to: 1) quantify the effectiveness of weight loss interventions for reducing weight and pain, in adults with overweight/obesity and CMP; 2) explore the perceptions of adults with overweight/obesity and CMP of the link between their weight and pain and their experience of the effectiveness, appropriateness and sustainability of weight loss interventions. An aggregated synthesis of qualitative and quantitative data was undertaken to derive conclusions and recommendations useful for clinical practice and policy decision making.

## Methods

This mixed methods systematic review and meta-analysis is reported in accordance with The Joanna Briggs Institute (JBI) Reviewers Manual 2014[28] The objectives, inclusion criteria and methods of analysis for this review were specified in advance and published in a protocol.[29] (PROSPERO CRD42016041828)

### Inclusion criteria

Studies that met the following criteria were included:

- experimental study designs including randomised controlled trials and quasi-experimental trials.

- adults (≥18 years) with overweight/obesity and CMP (including chronic lower back pain (CLBP), OA or rheumatoid arthritis (RA), non-specific or widespread musculoskeletal pain conditions). Diagnoses of overweight/obesity were consistent with the WHO definition (BMI ≥25<30 kg/$m^2$ overweight; BMI ≥30 kg/$m^2$ obese).[7] The protocol[29] documented that diagnosis of chronic pain should be consistent with the BPS definition (*persistent pain, which lasts over 12 weeks or after the time that healing would have been thought to occur after trauma or surgery*).[8] In this review we found that while most of the studies included participants with a diagnosis of a chronic musculoskeletal condition (predominantly OA knee), they did not specify the length of time pain had been present. National Institute for Health and Care Excellence (NICE)[30] guidelines for the management of adults with OA indicate pain as the prominent feature of this condition, therefore studies were deemed to adhere to inclusion criteria if participants were diagnosed with a specified chronic condition.
- quantitative studies that evaluated any weight management treatment programme. Interventions such as bariatric drugs (e.g. orlistat), surgery (e.g. gastric banding), and lifestyle modifications such as diet, physical activity or psychological interventions delivered as part of a multi or single component study compared with no treatment (true control) or usual care as reported by authors.
- studies reporting the following objective and subjective outcome measures - primary outcome: change in body weight; any objective validated measure (not self-reported) of adiposity (e.g. BMI, waist circumference). Secondary outcome; pain - any validated measure of pain - numeric rating scale (NRS)/ visual analogue scale (VAS).
- qualitative studies that explored the perceptions and experiences of engaging with weight loss interventions and sustaining weight loss efforts long-term.

## Search strategy and selection of studies

The search strategy aimed to find both published and unpublished studies. A three-step search strategy was used. An initial limited search of MEDLINE and CINAHL was undertaken followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms was then undertaken across all included databases (The Cochrane Library, EBSCOHOSTMedline, EBSCOHOSTCinahl, Scopus,

EBSCOHOSTPsycINFO, OvidEMBASE, Education Resources Information Centre (ERIC), Web of Science. Clinicaltrials.gov, EU Clinical Trials register, ISRCTN Registry, PROSPERO, UK Clinical Trials Gateway PQDT open, British Library EthOS, OpenGrey) from 1990-23 July 2016. This time frame was selected as overweight/obesity rates have been increasing steadily during this period.[7] Finally, the reference list of all key identified reports and articles were searched for additional studies (full search strategy provided in Supporting Information (SI)1).

Following removal of duplicates, all title abstract and subject headings were screened by the first author (LC) and a second reviewer (either CR, DM, SH, MJ, KC, JK, JO). Disagreements were resolved by consensus or a third reviewer. Full text was retrieved for all records deemed to meet all inclusion criteria.

## Assessment of methodological quality

Publications selected for critical appraisal were assessed independently by two reviewers (LC, CR) for methodological validity using standardised critical appraisal instruments from the Joanna Briggs Institute: Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) and Qualitative Assessment and Review Instrument (JBI-QARI)(SI2).[28] Where details required for critical appraisal were unclear authors were contacted for further information. Disagreements were resolved by consensus or a third reviewer (LE).

## Data extraction

**Stage 1**

Two reviewers (LC, JO) independently extracted quantitative data using the standardised data extraction tool from JBI-MAStARI[28] (SI3). The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. Where multiple reports of a primary study existed, data were extracted from the publication reporting the most comprehensive dataset associated with weight and pain.

Two reviewers (LC, KC) read each qualitative study, discussed the key themes related to the objectives of the review and agreed theme level for data extraction. Qualitative data were extracted independently

(LC, KC) using the standardised data extraction tool from JBI-QARI[28] (SI3). The data extracted included specific details about the phenomena of interest, populations, study methods and outcomes of significance to the review question and specific objectives. All studies provided verbatim data from research participants and these were extracted to illustrate each finding.

**Stage 2**

The results of each single method synthesis included in the mixed method review were extracted in numerical, tabular or textual format. For syntheses of quantitative data, this consisted of appropriate elements of the meta-analysis Forest plot. For qualitative reviews, it consisted of appropriate elements of the QARI-view table.

## Data synthesis

### Stage 1 data synthesis for each single-method synthesis

The primary statistics extracted from each study were the mean changes in weight or pain for intervention and control groups, together with the associated standard deviations of these changes. When a standard deviation (SD) of change was not reported, it was estimated from the baseline and follow-up SDs, according to the methods described in the Cochrane handbook.[31] Where a study had more than one intervention a composite of the weighted mean differences was calculated according to the methods described in the Cochrane handbook.[31]

Treatment effect sizes were pooled in a random effects meta-analysis using the Comprehensive Meta-analysis (CMA) software. All results were subject to double data entry. Pooled effects sizes (and associated 95% confidence intervals) were quantified in a weighted fashion using the inverse variance approach and a random effects model. Heterogeneity was quantified using I-squared and Tau-squared statistics. Heterogeneity sources were explored with subgroup analyses and meta-regression. Where statistical pooling was not possible the findings are presented in narrative form.

Qualitative research findings were pooled using JBI-QARI. This involved the aggregation and synthesis of findings to generate a set of statements that represented that aggregation, through assembling the findings (Level 1 findings) with an accompanying illustration and level of credibility for each finding. LC

categorised findings on the basis of similarity of concepts (Level 2 findings). Categories and descriptions were reviewed (KC) and agreed. Finally LC and KC subjected categories to a meta-synthesis in order to produce an agreed single comprehensive set of synthesised findings (Level 3 findings) that can be used as a basis for evidence-based practice.

#### Stage 2 data synthesis for mixed method synthesis

The findings of each single-method synthesis included in this review were aggregated according to the JBI Reviewers' Manual Methodology for JBI Mixed Methods Systematic Reviews[28]. This involved the configuration of the findings to generate a set of statements that represented aggregation. Quantitative findings were coded to attribute a thematic description. The resulting themes from quantitative and qualitative syntheses have been combined to produce a set of synthesised findings.

### Quality of Evidence

The overall quality of quantitative evidence for each outcome was rated according to the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach[32]. A Summary of Findings table created using GradePro is presented (Table 1). In order to establish confidence in the qualitative findings the ConQual approach outlined by Munn et al,[33] based on the principles of GRADE was used. JBI levels of credibility (U Unequivocal, C Credible, US Unsupported).[28] and dependability are presented in a ConQual table (Table 2).

## Results

Following removal of duplicates, a total of 12,388 citations were identified. Full text was retrieved for 58 potentially relevant publications and these were evaluated against the inclusion criteria by LC and CR. No further studies were found by checking reference lists. Twenty quantitative publications[4, 34-52] and two qualitative publications [53-4] were excluded at this stage. Excluded publications are listed with reasons for exclusion (SI4). Figure 1 details the study selection flowchart presented according to preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines.[55]

For the quantitative component of the review thirty publications reporting data from fourteen RCTs were included[3,56-84] (see SD6 for details).

For the qualitative component of the review five publications reporting the results of four studies were included[85-9], all five publications were critically appraised as both papers representing one study reported different themes and therefore were included separately.

## Deviations from original protocol

Two publications excluded from the per protocol analysis due to lack of clarity in the definition of CMP were critically appraised[4,42] (Foy; Jenkinson). These studies included participants who reported knee pain in the previous 4 weeks; this criterion did not meet our *a priori* criteria for chronic pain as defined by the BPS. However, as the studies involved large numbers of participants and, given the nature of the condition, chronicity was likely these studies were critically appraised for *post hoc* analysis.

Insert figure 1 Prisma Flowchart

## Methodological quality

### Quantitative studies

Fifteen publications[3,56-69] from fourteen included primary research studies, plus the two non-per protocol publications[4,42] originally excluded were critically appraised and all were included in this review. Overall quality scores ranged from 4-9 out of 10, ten publications scored ≥8. Eleven authors were approached to provide additional information regarding study methods and/or data. Four authors responded, and provided the requested data. Critical appraisal was updated for these studies.[56,59,63,64] Seven authors failed to respond and therefore questions related to risk of selection bias and detection bias were scored as unclear in these studies. Risk of selection bias was deemed high in seven studies[58,60,61,65,66,68,69] and risk of detection bias was deemed high in six studies.[42,58,66-9] Participant blinding was not achieved in any of the studies. Some authors discussed the difficulties of participant blinding inherent to rehabilitation/physical intervention studies. The results of the critical appraisal process are presented in Table 3.

Insert Table 3

### Qualitative studies

Five publications representing four studies were appraised.[85-9] One study[89] scored 3/10 and it was decided by consensus (LC, CR) to exclude this study as the methodology lacked sufficient detail to ensure dependability and credibility of findings. Methodological quality of the remaining four publications was variable, however each was deemed to be of an acceptable standard and was included in the meta-synthesis. The results of the critical appraisal process are presented in Table 4

Insert Table 4

**Description of quantitative studies**

A summary of all per protocol (n=15) and post hoc (n=2) publications is presented in Table 5.

The fourteen per protocol and two post hoc studies investigated the effectiveness of weight loss interventions in participants who were defined at baseline as overweight or obese with co-existing CMP associated with OA knee (11 studies)[3,56-65,69] OA knee or hip (2 studies)[66-7] self-reported knee pain (2 studies)[4.42] and fibromyalgia (1 study).[60]

Studies were conducted in outpatient clinics (n=7)[3,56,60,65,66,68,69], university facilities (n=4)[61-4] or in a clinical nutrition unit (n=1).[67] The remaining studies did not report the location. Studies were conducted in a wide variety of countries; most (seven) in the United States of America,[3,4,59,61-4] two in Denmark,[56,60] three in Asia,[58,65,69] one each in the UK,[42] Australia,[66] Spain,[67] and Egypt.[68] One study included only female participants[69] while one study included 90% male participants.[59] The remaining studies included more females than males (range 50-88% female). The mean age of participants ranged from 45 to 70 years with only one study including participants aged 45years. Participants in all remaining studies were older than 57 years. The mean baseline BMI across all studies ranged from 27.7-38.5 kg/m$^2$.

There were a total of 4511 participants in the sample of sixteen included studies, of which 2592 participants were from the two studies that did not meet the per protocol criteria for chronic pain. There was considerable variation in the number of participants in the studies; eight studies[56,61,64-69] had less than 100 participants, three[58-60] had >100 and <200, three [3,62-3] had >200. For the post hoc analysis Foy[4] had 2203 participants and Jenkinson[42] had 389.

The length of interventions ranged from 6 weeks to 24 months. Only two studies reported follow-up periods; in one study[56] the follow-up period of 1 year included a further 8-week period of active dietary

intervention and the results were reported in a separate publication.[57] The other study[3] reported a follow-up period of 2 years during which all participants received 6 monthly phone calls. In addition, one study[60] differed in that prior to the interventions reported therein all participants had participated in a study comparing the effect of two low energy diets, thus this study focused more on weight loss maintenance rather than initial weight loss from an intervention.

Insert Table 5 Characteristics of included studies (Quantitative)

**Description of qualitative studies**

A summary of included studies (n=4) is presented in Table 6.

All of the studies included participants with a chronic pain condition; Janke et al[85-6] included predominantly male participants with chronic pain conditions including OA, Morden et al[88] had a slightly higher proportion of female participants with chronic joint pain while Craft et al,[87] studied only female participants with fibromyalgia. Sample sizes were 13,[88] 15[87] and 30[85-6] therefore the total number of participants in the included studies was 58. Studies were conducted in the USA[85-7] and UK.[88]

All studies adopted semi-structured interviewing either in a focus group,[87] repeated individual interviews[88] or choice of group/individual interview[85-6] as the method of data collection. In addition, one study[88] included completion of a diary for one week per month for six months. Interviews in all studies were audio-recorded, video-recorded in one[87] and transcribed verbatim. Interviewer notes and diaries were added to interview data.[87-8] Data were analysed using qualitative techniques including constant comparative method and thematic analysis.

The included studies provided data regarding participants understanding of 1) the relationship between being overweight/obese and the development of CMP. 2) Factors that may influence weight management. 3) Experiences of weight management programmes. 4) Needs and preferences for weight management programmes. 5) Strategies used in self-management of weight and pain.

## Findings of the Review

### Quantitative component

The studies assessed a range of interventions administered either in isolation or in combination. Details for individual studies are reported in Table 5. The interventions included;

- Dietary intervention – healthy eating guidelines/reduced calorie intake (eight studies).[3,42,58,59,61,62,66,68]
- Dietary intervention – commercially produced meal replacement low energy diet (seven studies).[4,56,60,63,64,67,69]
- Structured exercise intervention (ten studies).[3,42,58,59,61-5,69,]
- Drugs: Orlistat (one study),[4] Mazindol (one study).[69]
- Transcutaneous electric stimulation (one study).[58]
- Pain coping skills training (one study).[3]
- Behavioural weight management (seven studies).[3,4,60-4]

Thirteen per protocol and two post hoc studies contained a dietary intervention with only one study investigating the effectiveness of structured exercise interventions in isolation.[65] All of the studies reported on the primary outcome of weight; twelve studies[4,42,56-63,66-7] reported weight change, three studies[3,64-5] reported baseline and follow-up weight, one study[68] reported change in BMI only and therefore could not be included in the meta-analysis.

**Primary outcome – Change in body weight**

The random effects pooled results across all weight loss interventions vs controls in thirteen per protocol studies[3,56-67,69] (n= 1833 participants) showed mean weight loss was 4.9kg (95% CI:2.9 to 6.8) greater for interventions; low-quality evidence (Figure 2). Heterogeneity was considerable ($I^2$ = 95%, tau = ±3.5). A sensitivity analysis was undertaken by including the studies that did not meet the per-protocol criteria[4,42] (n= 4425 participants) and this increased the mean weight loss to 5.1 kg (95% CI:3.4 to 6.8). The study investigating a weight loss intervention on participants with fibromyalgia[67] was not included in the meta-analysis as no information on weight change in kg was given. However the participants in the intervention group lost more weight than the usual care control group at six months, BMI change in the intervention group was -3.3kg/$m^{-2}$ compared with no change in the usual care control group.

Insert Figure 2

**Secondary outcome – change in pain**

Effect of weight loss interventions on pain outcomes were assessed in thirteen studies using a variety of tools. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale was used most frequently (eight studies),[3,42,56,62-4,66] two studies used Visual analogue scales[58,61] and one study each used; the Brief Pain Inventory,[65] Knee Injury and Osteoarthritis Outcome Score (KOOS),[60] Tender point examination,[7] and Lequesne Index.[68] Scores were standardized according to OMERACT recommendations[90] to allow comparison.

Pooled results from ten per protocol studies[3,56-58,60,62-6,69] (n=1658 participants) examining weight loss interventions vs usual care showed significant mean pain reduction of 7.3 units (95% CI: 4.1 to 10.5), low quality evidence in favour of intervention (Figure 3). A sensitivity analysis was undertaken by including the studies deemed non-per-protocol[4,42] (n=4250 participants). This resulted in a small decrease to 6.4 units (95%CI: 3.7 to 9.1). The meta-regression slope between mean pain reduction and mean weight lost was a shallow -0.09 kg/unit change in pain score (95%CI: -0.21 to 0.40, p=0.54). The study investigating participants with fibromyalgia[67] used tender point count to assess pain, this score could not be standardised and was therefore not included in the meta-analysis. However in this study the weight reduction group had significantly lower pain than controls, as determined by mean tender point count.

Insert Figure 3

Possible sources of heterogeneity (age, duration of study intervention, baseline BMI, sex, study quality and publication bias) were explored using meta-regression analyses. Study heterogeneity was substantial for both weight loss ($I^2$ = 95%, tau = ±3.5 kg) and pain change ($I^2$ = 67%, tau =±4.1%). The meta-regression slopes for the predictors of study quality, mean age and baseline mean weight status on study weight reduction were generally shallow and not statistically significant (P>0.05). The 95% confidence intervals for these meta-regression slopes all overlapped zero.

## Qualitative component

Meta synthesis of studies included in the review generated two synthesised findings. The synthesised findings were developed from seventeen study findings extracted from the four included studies (SI5).

Findings were grouped according to similarity of concept into seven categories. All of the findings were illustrated using direct participant quotes and therefore assigned unequivocal level of credibility. The study findings and illustrations are presented in SD5. The synthesised findings are presented below.

**Synthesised finding 1:** It is important for healthcare professionals (HCP) interacting with adults with co-existing overweight/obesity and CMP to understand the physical and psychological effects of pain that make healthy behaviour more challenging. Pain can result in eating being used as a coping strategy and may impact on self-efficacy for behaviours that promote weight loss; in particular, the impact of pain on activity levels may be a barrier to weight loss.

**Synthesised finding 2:** Healthcare professionals must acknowledge and discuss the link between weight and pain with their patients and develop management and education programmes that combine both aspects of comorbidity to promote successful outcomes in terms of weight loss and pain reduction.

**Meta-aggregation of individual syntheses**

Mixed method syntheses were conducted to answer the research question "Are weight loss interventions effective and appropriate for the management of adults with overweight/obesity and CMP?" Bayesian methods of attributing a qualitative thematic description to the quantitative findings were applied to facilitate the final meta-aggregation of the individual quantitative and qualitative syntheses[91] (SI6). Textual descriptions translated from quantitative findings were combined with the synthesised findings from the qualitative component to form the mixed methods synthesis (SI7). Meta-aggregated synthesis: Integrated interventions designed to manage both weight and specific CMP conditions are viewed positively by adults with overweight/obesity and CMP, and have been shown to be effective to achieve weight loss and pain reduction. This mixed methods synthesis was used to generate recommendations for practice.

**Discussion**

This mixed methods review aimed to develop an aggregated synthesis of quantitative and qualitative studies investigating the effectiveness and appropriateness of weight loss interventions for adults with overweight/obesity and CMP. Data from fourteen RCTs (n=1833 participants) and three qualitative studies (n=58 participants) demonstrate that integrated interventions designed to manage both weight

and specific CMP conditions are viewed positively by adults with overweight/obesity and CMP, and have been shown to be effective to achieve weight loss and pain reduction.

Quantitative analyses demonstrated that weight loss interventions compared to no treatment or usual care controls reduced body weight and pain score. Pooled data showed a reduction in body weight in favour of the intervention of 4.9 kg (CI:2.9 to 6.8). The magnitude of the effect is in keeping with recent "real world" clinical data from an NHS weight loss service.[92] A reduction in body weight of 2.5-5 kg over a period of two years is associated with a 30-60% reduction in the risk of developing diabetes, while a reduction in body weight of 5-8 kg is associated with improvement in triglyceride levels and blood lipid profile.[93] Thus, it could be argued that the reduction is clinically important. Pooled data showed a reduction in pain in favour of the intervention of 7.4 units (CI: 4.1 to 10.5)). Though no definitive meaningful clinically important difference (MCID) exists, a change of 10 points on a 100-point scale could be considered clinically important.[94] Thus, the reduction in pain may not be clinically relevant. However, given that only two of the included studies directly targeted participants pain,[3,58] it raises potential for the development of a weight loss programme to aid pain reduction in this patient population.

The review conducted by Christensen et al.[27] included 417 patients and found that a mean difference change in body weight of 6.1 kg could not predict a significant change in pain score. This finding is consistent with the findings of our review.

Several studies in this review compared more than one intervention i.e., dietary intervention, exercise intervention, behavioural intervention, pain intervention. Simple comparison between intervention arms demonstrated that when dietary and exercise components were combined, participants demonstrated greater reduction in body weight and pain scores compared to participants offered a single intervention. For example, Messier[62] reported participants in the diet and exercise group showed a mean weight loss of 0.6 kg more than the diet only group and 1.7 kg more than the exercise only group and a reduction in pain score of 1.13 (out of 20) more than the diet only group and 1.8 (out of 20) more than the exercise only group. This finding is consistent with NICE recommendations that exercise is offered to adults with OA and that weight management programmes include multiple components. Only two studies in this review incorporated a specific pain intervention[3,58]. This finding suggests that current practice views the pain aspect of comorbidity as less important than the need to address weight. Placing less emphasis on management of CMP is at odds with the qualitative findings of this review which recommend holistic

management of both conditions simultaneously. Meta-analysis and narrative analysis in this review demonstrated that adults with overweight/obesity and CMP can engage with structured weight loss interventions including exercise. However, qualitative data identified that HCP were more likely to address weight and pain as separate issues. Meta aggregation of findings recommends that: HCP working with this population demonstrate understanding of the link between weight and CMP, address issues related to comorbidity, and develop appropriately integrated management and education programmes that aim to achieve sustained weight loss and reduced pain.

The trials included in this review were mainly conducted in populations of older adults (≥57 years) with OA. Most of the studies had a high percentage of female participants and the site of OA was usually the knee. Only one trial reported the effectiveness of a weight-loss intervention on weight and pain in a population of obese adults with a different CMP condition (fibromyalgia). No completed trials investigating the effectiveness of weight loss on other types of CMP were identified. Two ongoing RCTs were found. The first of these is a combined weight and pain intervention for adults with overweight/obesity and broadly defined chronic pain.[41] The second is a trial investigating the effects of a lifestyle intervention for patients with LBP and overweight/obesity.[52] In the qualitative component of the review the CMP diagnoses of the participants also included OA knee and fibromyalgia. The study from which two papers were included[85,86] stated that in addition to participants with OA, participants with LBP were also included, however individual participants' diagnosis were not stated and therefore findings could not be attributed to any individual group.

Strengths and Limitations

The limited range of CMP groups (participants with OA and fibromyalgia) included in this review could be considered a limitation, therefore the results and recommendations for practice may be less generalisable to other pain groups. However, a strength of this review is that it builds on Christensen et al.[27] review of participants with OA. Limitations concerning the review process include the language restriction as no facility for translation was available. In addition there was a lack of response to request for further information from seven authors therefore judgements made about risk of bias and subsequent down-grading of evidence quality may not have been warranted. We also acknowledge that our explorations of moderators of response were at the study level of sample means rather than with individual participant data.[95]

## Conclusion and implications of this review

### Implications for practice and policy

The predicted increase in overweight and obesity presents a challenge and an opportunity for HCP. The results of this review and meta-analysis add to the evidence-base for managing adults with co-existing overweight/obesity and CMP. Low-quality evidence from the quantitative component and moderate quality evidence from the qualitative component suggests HCP and policy makers should emphasise the benefits of managing weight and CMP simultaneously. Interventions designed to combine management of weight and specific CMP conditions could maximise weight loss and reduce pain.

### Implications for research

To address the limitation of lack of generalisability of the results to populations other than those with OA or fibromyalgia, well-designed, high quality RCTs on the effect of combined weight loss/pain interventions are needed. Interventions including the large population of adults with CLBP would be of particular value. Studies investigating the association between changes in fat mass, inflammatory markers and pain would be beneficial in adding to understanding of the relationship between these factors. These studies will further contribute to the evidence base underpinning the management of comorbidity.

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