Predicting the progressive resistance and balance training response of community-dwelling older adults accessing aged care support services: a stepped-wedge randomised controlled trial.

KEOGH, J.W.L., HENWOOD, T., HETHERINGTON, S., GARDINER, P.A., TUCKETT, A.G., ROUSE, K. and SWINTON, P.

2022

Predicting the progressive resistance and balance training response of community-dwelling older adults accessing aged care support services: a stepped wedge randomised controlled trial

Abstract

Objectives: to quantify the variation in body composition, physical function and cognitive health changes resulting from the Muscle Up Against Disability (MUAD) resistance and balance training program and the potential for baseline characteristics to predict the magnitude of training-related response. Methods: the study represented a secondary analysis of a stepped wedge randomised controlled trial involving 245 community-dwelling adults receiving Australian government-funded aged care services who performed 26-weeks of supervised progressive resistance and balance training (PRBT). The primary outcome was proportion of response which described the number of individuals expected to make any positive change due to the intervention and not external factors. Results: for all outcomes the observed average change of the PRBT group was more favourable than the control. Analyses identified that most participants completing the PRBT program would be expected to respond positively to the intervention (86-99%) with respect to their physical performance (SPPB summary, grip strength, chair stand and isometric knee strength). A smaller proportion completing the PRBT program group would be expected to respond positively in aspects of body composition (45-60%) or cognitive function (44-84%). The strongest predictors for positive change were baseline physical function, whereby those with the poorest baseline function experienced the greatest benefits. Conclusion: this study strongly supports the promotion of PRBT as a standard component of any care plan for community dwelling older adults, especially those with low levels of physical function.

Keywords:

daily living activities; exercise therapy; physical fitness; sarcopenia; strength training.

Introduction

Australia is in an aged care crisis as a result of factors including an increased life expectancy, higher disability and complex morbidity prevalence, low health literacy, and a deficit in quality aged care workers to support care needs.[1] Community-dwelling individuals can wait up to 18 months to be awarded a government-funded Home Care Package (HCP Levels 1 – 4) due to the national queue. While waiting for government assistance, an individual's disability and disease prevalence can increase substantially, compromising their wellbeing and quality of life, with this increasing their risk of entry into residential aged care (RAC). However, RAC entry may not be granted until disability levels are significant and aligns to higher needs and a higher daily funding rate, as assessed by the Aged Care Funding Instrument (ACFI).

Aged care traditionally caters for increasing disability, with decline viewed as an inevitable outcome. Servicing this, most primary care models are focused on domestic assistance and personal care. In contrast, growing evidence supports lifelong physical activity including progressive resistance and balance training (PRBT), whereby individuals are never too old or deconditioned to improve their physical function, health and wellbeing.[2-4] Engagement in PRBT not only offers the individual better health but can decrease government spending associated with hospital presentation and stays, transitions to RAC and increasing HCP needs. [2,4] Therefore, the Australian government have promoted several reablement and restorative physical activity initiatives. However, the benefits of these programs have been sub-optimal, especially for increasing muscle mass and strength, as they lack sufficient intensity and progression and/or do not provide opportunities for ongoing participation.[5]

The Muscling Up Against Disability (MUAD) program delivered twice weekly PRBT to older Australians receiving government funded aged care support over 24 weeks.[6] The MUAD program has reported significant improvements in balance confidence[3] and physical function with a positive cost-implication when compared to normal care.[7] Whilst there is clear and consistent evidence that with appropriate PRBT, significant physical improvements follow,[8,9] little is known regarding what may characterise the greatest responders. Where substantive inter-individual variation in response exists,[10] there is potential to identify predictive characteristics and allocate targeted exercise to those most likely to benefit. Equally, this would inform future research to identify better support pathways for those who are less likely to improve with current PRBT programs e.g. those requiring additional nutritional support.

The purpose of the present study was to quantify the variability in observed PBRT-related change scores for physical function, cognitive and mental health and outcomes across the exercise period and to determine what factors may contribute to the into individual response. Using the standard biological variability observed in the control as a reference, the variation directly caused by the intervention (intervention response) could be estimated[11], and associations between observed change and baseline measures used to identify potential predictors. These analyses may help practitioners identify older adults most likely to benefit from PRBT; while also highlighting additional areas of research that might be required to assist those who are less responsive to PRBT.

Methods

Participants and overall approach

The current study comprises a secondary analysis of community-dwelling participants 65 years of age or over were recruited to the MUAD stepped wedge randomised controlled trial, with the full protocol previously described.[6] This secondary analysis focussed on variability in responses and so was restricted to the initial 24-week period following baseline assessment as illustrated in Figure 1. Recruitment of participants occurred via the Burnie Brae and St Vincent's Health Australia (SVHA) membership. Individuals were advised to this project via newsletter, website advertising and/or letters from the relevant organisations' CEOs. No power analysis was performed, as sample size was based on a calculation of exercise delivery capacity of the exercise clinics, with 300 participants considered a maximum that could be safely recruited and supervised. Participants completed baseline assessments and were then randomised by block randomisation using a sealed envelope selection method to exercise (EX) or wait-list control (CON) at a 1:2 ratio by the research manager with a computer randomised sequence.

Eligibility criteria were: a) 65 years of age and over, b) community-dwelling, c) receiving Australian government-funded aged care services, d) mobile with or without an aid, e) able to commit to the study period and follow instructions, and f) no recent history of resistance training. Exclusion criteria were: a) requiring two-person assist with transfers, standing and/or mobilising, b) medications and/or diseases with contraindications for exercise e.g. recent myocardial infarction, complete heart block, ongoing unstable angina, c) difficult behaviours, d) terminal illness, receiving palliative care and/or an imminent move to residential care, and

e) no doctor's consent to participate. All participants provided signed informed consent before participating in any aspect of the study.

The trial registration available was at Australian New Zealand Clinical Trials Registry (ACTRN12615001153505) and received ethics approval from XXX (Approval number #XXX) and Gatekeepers approval through the XXX (Approval reference HREC 15/21). The study was conducted between 2015 and 2017.

Intervention

In groups ≤10, participants completed 24 weeks of twice-weekly PRBT. Sessions were delivered in two senior centres equipped with the same exercise equipment and staffed by accredited exercise physiologists with several years experience in working with older adults with chronic disease. A minibus was provided free of charge to all participants who needed transport to and from either senior centre.

Each session commenced with a five-minute warm-up, followed by 45 minutes of PRBT and finished with a five-minute cool down involving stretches. Resistance exercises were performed on air-pressure driven, computer-integrated machines proven effective for use among older adults (HUR Australia Pty Ltd, Birkdale, QLD, Australia).[12] If pain or discomfort was reported during any exercise, technique was examined and where possible the exercise modified. If the pain or discomfort persisted, the exercise was removed from that participant's program.

Programs included: Resistance: 1) chest press; 2) seated row; 3) leg press; 4) leg curl; 5) leg extension; 7) leg abduction; 8) leg adduction; and 9) abdominal crunch performed for 3 sets of 8–12 repetitions at a moderate to high intensity (up to ~75% of the estimated 1 repetition maximum). Balance: 1) single leg stand - 2 sets aiming for 20 s on each leg; 2) tight rope walking - 2 sets of 10 steps forwards and 10 steps backwards; 3) box stepping - 5 times clockwise and 5 times anticlockwise; and 4) calf raises - 2 sets of 10. Before reaching the described full exercise protocol, all participants completed a 4-week conditioning phase at reduced resistance, intensity, sets and repetition to improve their technique and exercise tolerance. During the first two weeks of training, resistance training involved two sets of eight repetitions for each exercise at 50% of their predicted maximum capacity. During the third and fourth week, three sets of eight repetitions at 65% of predicted maximum capacity were performed. As it wasn't feasible to assess all of the participants baseline strengths at all of the exercise machines, each participants' baseline grip strength informed their exercise starting resistance, with those with below normal muscle strength given a lower, more conservative resistance. As exercise tolerance improved, resistance and balance exercise progression occurred.[6,12] This progression involved increased loads for the resistance training exercises. For the balance exercises, they were progressed with some combination of reductions in the base of support, increases in the height of the centre of mass, increased static balance durations and/or increasing the number/distance of steps of the dynamic balance tasks.

Measures

All outcome measures were completed in the senior centres where the exercise program was performed, by exercise physiologists who were not blinded to group allocation. The primary measure was the Short Physical Performance Battery (SPPB).[13,14] The components of the SPPB are hierarchical tests of standing balance, a timed 4 m walk and a timed 5-repeat chair stand test. Measures were collected as per the Guralnik et al.[13] protocol and were analysed as independent measures and as a summary score (Range 0 (worst performance) to 12 (best performance)). The SPPB is a known predictor for reduced mobility and increased hospitalisation, institutionalisation and mortality.[13,14] Gait speed was measured over 2.4 m, with the 1st m walk-in acceleration phase and the last 0.6 m deceleration phase not recorded in the gait speed time.

Secondary measures included: Height (m) and Weight (kg) were collected in a standing position, with the participants barefoot and wearing their normal clothes, and Body Mass Index (BMI kg/m^2) calculated; Lean mass and body fat were measured using bioelectrical impedance analysis (BIA) (Maltron BF-906, Maltron International Ltd, Rayleigh, UK). BIA is quick to sample, non-invasive, and is an extensively validated and accurate measure of muscle mass across all age groups.[15] Due to current guidelines, individuals with pacemakers were excluded from BIA (n = 13);[16] Muscle strength was determined from Isometric leg extension strength measured by a 0-500-kilogram strain gauge HUR Performance Recorder (HUR Labs Oy, Tampere, FI) fitted to the HUR leg extension machine and Grip Strength using an isometric Jamar dynamometer (Sammons Preston Roylan, Bolingbrook, IL).[17] The Geriatric Depression Scale – Short Form (GDS)[18] was used to quantify depressive symptoms, with participants classified as without depression (normal (0–4)), or having mild (5–8), moderate (9–11) or severe depression (12–15) based on their summary score; The Geriatric Anxiety Inventory (GAI)[19] was used to determine anxiety symptoms, with participants scoring between 0 and 8 reported as having an absence of clinical anxiety, where those with a score between 9 and 20 have suspected clinical anxiety; The Mini-Mental State Examine was used to determine cognitive function,[20] with participants classified as normal cognition (25–30) or mild (21–24), moderate (14–20) or severe (<13) cognitive impairment based on their summary score; and the EuroQoL EQ-5D-3L which assesses health-related quality of life, by providing a single index value between 1.0 (perfect health) and 0.0 (death).[21] Within the EQ-5D-3L, the participant also rated their perceived health state today on a VAS, whereby a score of 0 was the worst possible health and 100 being perfect health.

Statistical Analysis.

The analysis presented represents a secondary reporting of the data with the primary analysis reported previously.[6] All variables and analysis models selected were determined a priori. Observed change scores were calculated for all variables by subtracting baseline values from the 24-week post-intervention or post-control evaluations. Per-protocol analyses implemented with generalised additive models for location and scale[22] were used to model both the mean and the standard deviation of change scores for the intervention and control group. Variation in change scores were assumed to be the independent sum of measurement error, biological variation (caused by non-intervention related factors) and variation in intervention response (referred to as the intervention response standard deviation σ_{IR}).[11] By constructing a normal distribution centred at the observed mean change and with standard deviation σ_{IR}, the proportion of individuals expected to experience any improvement due to the intervention alone can be calculated. For each outcome, the intervention response standard deviation (σ_{IR}) was calculated as $\sqrt{SD_{Int}^2 - SD_{Con}^2}$ where the change score standard deviation of the intervention (SD_{Int}) and control (SD_{Con}) groups were obtained from the generalised additive model applying a Gaussian distribution. In the final set of models, baseline values for either BMI, grip strength (continuous predictor and bivariate: low <16 kg female, <26 kg male; high ≥16 kg female, ≥26 kg male), depression (GDS), EQ5D, walking speed (low≤0.8 m/s, high>0.8 m/s) or SPPB (low≤8, high>8) were entered as a univariable predictor of change score in univariable models. All continuous predictors were standardised by dividing values by the sample standard deviation. Cohen's f^2 effect sizes were calculated to quantify the strength of the univariate predictors, with values described as small (f^2=0.02), medium (f^2=0.15) or large (f^2=0.35).[23] All analyses were complete case analyses performed in R version 4.0.3 (R Development Core Team, 2020) and the GAMLSS package.

Results

Participants

Of the 245 participants who were randomized and completed baseline assessment, 67 of 86 (78%) participants allocated to the exercise condition completed the 24-week assessment, and 129 of 159 (81%) participants allocated to the wait-list control completed the 24-week assessment (Figure 1). For those who completed the exercise intervention, they attended a mean of 43 (90%) of the required 48 sessions. No participants indicated that the training protocol or intensity was the reason for leaving the study. A summary of the demographic characteristics of the participants is provided in Table 1.

Insert Table 1 about here

Insert Figure 1 about here

Body Composition

Relatively small mean changes for all body composition variables were identified for the intervention group and confidence intervals containing zero change (Table 2). Clear evidence was obtained that variation in observed change was greater during intervention, with proportion of response restricted to approximately half the intervention group. A single predictor (BMI) obtained a significant ($p<0.01$) negative regression coefficient and small effect size (f^2=0.06), whereas all other effects sizes were negligible indicating baseline values were not substantive predictors of observed changes scores in body composition parameters.

Insert Table 2 about here

Physical function

Consistent results were also obtained for most physical function variables, although this response was lower for walking speed (Table 3). Relatively large mean intervention improvements were obtained, with similar standard deviations for intervention and control. Collectively, the intervention response distribution was shifted from zero and narrow, resulting in proportion of response estimates close to 1 for most variables. Each of the physical function predictors returned significant regression coefficients with effect sizes ranging from small to moderate, with baseline grip strength close to a large effect size (f^2=0.33), for predicting change in grip strength. The general pattern identified was negative associations, such that greater improvements were obtained for those with lower baseline levels of physical function.

Insert Table 3 about here

Cognitive and mental health

Little changes were observed for the VAS, GDS and GAI between intervention and control for both the mean and standard deviation of change scores (Table 4). As a result, proportion of response for the outcomes were low and close to 0.5. Greater mean intervention improvements were obtained for Mini-Mental State Examination (MMSE) and EQ5D resulting in proportion of response ≥0.78. Inconsistent results were obtained for analyses of baseline predictors. Small effects (f^2≤0.08) were obtained for all physical function predictors and VAS, with lower baseline values resulting in greater improvements. No significant regression coefficients were obtained for physical function predictors and any other cognitive or mental health outcome. Medium effects (f^2=0.16) were also identified between baseline values and their subsequent change for GDS and EQ5D, with greater improvements obtained for those with reduced health at baseline.

Insert Table 4 about here

Discussion

The findings of the present study demonstrated a range of improvements that are consistent with the wider literature regarding the benefits of PRBT for older men and women.[24] Based on the analyses conducted, it would be expected that almost all participants (~90%) that completed the PRBT programme would demonstrate a positive intervention response across most physical outcomes, however, proportion of response was closer to 50% for walking speed. Lower proportion of response was also estimated for body composition and mental health outcomes where only 50-60% of participants demonstrated a positive intervention response. This tendency for more older adults to improve their physical function compared to their body composition, cognitive and mental health is also consistent with the wider exercise prescription literature.[10,25] Such responses may reflect the principle of exercise specificity, whereby resistance training is more likely to result in improved physical function in tasks sharing similar movement patterns the resistance training exercises compared to increasing their muscle hypertrophy[26], cognitive[27] and/or mental health.[28].

Perhaps of more importance, the present study explicitly demonstrated that the greatest PRBT-related response occurred in older adults with complex aged care needs who had low baseline levels of physical function. Interestingly, baseline levels of mental health or cognitive function appeared to have no significant influence on their training related response. Such results may reflect a ceiling effect for the mental health and cognitive function outcomes as inspection of the intervention group's baseline data suggests the overall group had normal levels of mental and cognitive health at baseline. The lack of effect of baseline cognitive or mental health result on the physical function response is an important result as it supports the promotion of PRBT to older adults with complex care needs, regardless of their current cognitive and mental health. This result suggests that factors outside of PRBT participation, which were common between the intervention and control group, may influence the body composition, cognitive and mental health response. Where social connection and the physical environment have been suggested previously to be predictors of exercise related physical responses,[26-28] additional research is still required to better identify these factors.

The major potential limitations of the current study may reflect the representativeness of the sample of older adults who completed the 26-week PRBT intervention to other groups of community dwelling or residential aged care older adults. In particular, while over 700 older adults were invited to participate in this project, only 245 enrolled in the study and underwent baseline testing completed, with 168 completing the exercise programme. Further, other potential limitations that may influence the study's internal or external validity include lack of blinding of the assessors, use of the per protocol analysis, free transport provided to many of the participants and some of the significant baseline differences between the completers/non-completers.

The finding in the current study that those with the lowest physical function experience the greatest benefit from PRBT is of major importance as older adults are presenting with an increased prevalence of chronic disease, disability, frailty, sarcopenia and aged care service utilisation. This finding is highly relevant for those diagnosed as being frail, based on Fried's 5 factors,[29] with many of those factors known to be modifiable by PRBT (i.e. muscle strength, mobility, activity engagement and exhaustion).[8] Previous research has demonstrated that the most physically vulnerable are more likely to enrol in interventions promising positive physical gain, but are also at the most at risk of not starting the program when compared to older adults who are less frail.[2] Combining these findings with the current study, we need to better understand the major barriers and facilitators to recruit and support older adults in their PRBT participation, with this especially important for older adults with poor physical function.[30]

Several potential routes may exist to increased PRBT participation opportunities among older Australians with compromised physical wellbeing include: 1) the Medical Benefits Scheme (MBS) that supports 5 general practitioner (GP) referred sessions to proactively address chronic disease (extended to 10 for those in RAC); 2) the My Aged Care Commonwealth Home Support Programme Allied Health and Therapy service that offers short-term and ongoing physical interventions with allied health professionals to address health needs; and 3) the Medicare funded Short-term Restorative Care programme that offers individuals 8 weeks of intensive participation in a physically benefiting intervention. Additionally: 1) the Department of Veterans Affairs supports meaningful participation for eligible service men and women, and 2) private health insurance schemes help to reduce the client out-of-pocket expenses with participation. The current study further establishes the importance of PRBT involvement for older Australians, especially for those with the lowest physical function, yet the majority of older adults still select domestic and personal care services over engagement in activities that will allow them to improve their physical function and reduce their disability. By using the above-mentioned pathways, GPs are in a powerful position to drive system change by referring fer older Australians into beneficial PRBT programmes. However, barriers such as consultation time constraints, as well as clinician and patient perceptions including fear of older adults experiencing injury and having transportation and access challenges.[31,32] still need to be addressed to increase older adult participation in PRBT.

The Australian Royal Commission into Aged Care Quality and Safety report 1) identified significant shortcomings in the sector and made 148 recommendations for improved aged care service and quality. Among these, increased access to health services, delivered by individuals and multidisciplinary teams in-person or by telehealth with GP input and referral featured prominently. To match the recommendation and move the aged care sector forward, evidence-based programmes that are safe and provide positive health outcomes for older adults (such as the MUAD programme described in this study) are required for GPs and other health providers to refer their patients/clients. Such healthcare system changes would fill an essential space in the successful reform of the current system, be consistent with aspects of the Royal Commission recommendations and better prioritise the optimisation of older adult reablement than is currently achieved by the reliance on domestic and personal care services. While such healthcare system changes may require some additional funding allocations, a number of physical well-being interventions (including the MUAD), have been shown cost-effective in the reduction in service needs, health service presentation and care needs.[7,33] In conclusion, the current programme offers a positive referral direction for GPs, specialists and other allied health professionals that align to the Royal Commission suggested modification of the aged care system and to international recommendations.[34] Most impressively, those functioning at the lowest level can achieve the largest gains, reminding us that you are never too old, too sick or too deconditioned to benefit from PRBT.

Practice impact statement: Progressive resistance and balance training is a proven but under-utilised therapy for improving function and health outcomes for older adults. As community dwelling older adults accessing aged care services with the poorest physical function achieved the greatest response, these older adults should be referred to accredited exercise professionals who will prescribe and supervise their exercise programme.

References

1. Tracey R, Briggs L. *Royal Commission into Aged Care Quality and Safety. Interim report: neglect. Vol. 1.* Canberra: Commonwealth of Australia;2019.
2. Fien S, Henwood T, Climstein M, Keogh JWL. Feasibility and benefits of group-based exercise in residential aged care adults: A pilot study for the GrACE programme. *PeerJ.* 2016;2016(5). doi:10.7717/peerj.2018.
3. Hetherington S, Henwood T, Swinton P, et al. Engineering Improved balance confidence in older adults with complex health care needs: Learning from the Muscling Up Against Disability Study. *Arch Phys Med Rehabil.* 2018;99(8):1525-1532. doi:10.1016/j.apmr.2018.03.004.
4. Hewitt J, Goodall S, Clemson L, Henwood T, Refshauge K. Progressive resistance and balance training for falls prevention in long-term residential aged care: a cluster randomized trial of the Sunbeam Program. *J Am Med Dir Assoc.* 2018;19(4):361-369. doi:10.1016/j.jamda.2017.12.014.
5. Weber M, Belala N, Clemson L, et al. Feasibility and effectiveness of intervention programmes integrating functional exercise into daily life of older adults: a systematic review. *Gerontology.* 2018;64(2):172-187. doi:10.1159/000479965.
6. Hetherington S, Swinton P, Henwood T, et al. Progressive resistance plus balance training for older Australians receiving in-home care services: cost-effectiveness analyses alongside the muscling up against disability stepped-wedge randomized control trial. *J Aging Phys Act.* 2019:1-8. Doi:10.1123/japa.2019-0085.
7. Swinton PA, Hemingway BS, Saunders B, Gualano B, Dolan E. A statistical framework to interpret individual response to intervention: paving the way for personalized nutrition and exercise prescription. Front Nutr. 2018;5:41. Doi:10.3389/fnut.2018.00041.
8. Keogh JWL, Henwood T, Gardiner P, Tuckett A, Hodgkinson B, Rouse K. Examining evidence based resistance plus balance training in community-dwelling older adults with complex health care needs: Trial protocol for the Muscling Up Against Disability project. Arch Gerontol Geriatr. 2017;68:97-105. Doi:10.1016/j.archger.2016.10.001.
9. Henwood TR, Taaffe DR. Detraining and retraining in older adults following long-term muscle power or muscle strength specific training. J Gerontol A Biol.Sci.Med.Sci. 2008;63(7):751-758. doi: 10.1093/gerona/63.7.751.
10. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994;49(2):M85-94. Doi: 10.1093/geronj/49.2.m85.
11. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. JAMA. 2011;305(1):50-58. Doi:10.1001/jama.2010.1923. doi:10.1001/jama.2010.1923
12. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010;39(4):412-423. Doi:10.1093/ageing/afq034.

13. Kyle UG, Bosaeus I, De Lorenzo AD, et al. Bioelectrical impedance analysis-part II: utilization in clinical practice. Clin Nutr. 2004;23(6):1430-1453. doi:10.1016/j.clnu.2004.09.012.

14. Schaap LA, Fox B, Henwood T, et al. Grip strength measurement: Towards a standardized approach in sarcopenia research and practice. Eur Geriatr Med. 2016;7(3):247-255. Doi:10.1016/j.eurger.2015.11.012.

15. Kurlowicz L. The Geriatric Depression Scale (GDS). Geriatric Nursing. 1999;20(4):212-213.

16. Pachana NA, Byrne GJ, Siddle H, Koloski N, Harley E, Arnold E. Development and validation of the Geriatric Anxiety Inventory. Int Psychogeriatr. 2007;19(1):103-114. Doi:10.1017/S1041610206003504.

17. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12.

18. Herdman M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res. 2011;20(10):1727-1736. doi:10.1007/s11136-011-9903-x.

19. Rigby RA, Stasinopoulos DM. Generalized additive models for location, scale and shape. J R Stat Soc C-Appl. 2005;54(3):507-554. doi:https://doi.org/10.1111/j.1467-9876.2005.00510.x.

20. Cohen JE. Statistical Power Analysis for the Behavioral Sciences. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc; 1988.

21. Jones MD, Wewege MA, Hackett DA, Keogh JWL, Hagstrom AD. Sex differences in adaptations in muscle strength and size following resistance training in older adults: A systematic review and meta-analysis. Sports Med. 2021;51(3):503-517. doi:10.1007/s40279-020-01388-4.

22. Barbalho MSM, Gentil P, Izquierdo M, Fisher J, Steele J, Raiol RA. There are no no-responders to low or high resistance training volumes among older women. Exp Gerontol. 2017;99:18-26. doi:10.1016/j.exger.2017.09.003.

23. Churchward-Venne TA, Tieland M, Verdijk LB, et al. There are no nonresponders to resistance-type exercise training in older men and women. J Am Med Dir Assoc. 2015;16(5):400-411. doi:10.1016/j.jamda.2015.01.071.

24. Robinson SM, Reginster JY, Rizzoli R, et al. Does nutrition play a role in the prevention and management of sarcopenia? Clin Nutr. 2018;37(4):1121-1132. doi:10.1016/j.clnu.2017.08.016.

25. Kimura N, Aso Y, Yabuuchi K, et al. Modifiable lifestyle factors and cognitive function in older people: a cross-sectional observational study. Front Neurol. 2019;10(401). Doi:10.3389/fneur.2019.00401.

26. Chekroud SR, Gueorguieva R, Zheutlin AB, et al. Association between physical exercise and mental health in 1·2 million individuals in the USA between 2011 and 2015: a cross-sectional study. Lancet Psychiat. 2018;5(9):739-746. Doi:10.1016/s2215-0366(18)30227-x.

27. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol.Sci.Med.Sci. 2001;56(3):M146-156. Published 2001/03/17.

28. Burton E, Farrier K, Lewin G, et al. Motivators and barriers for older people participating in resistance training: a systematic review. J Aging Phys Act. 2017;25(2):311-324. Doi:10.1123/japa.2015-0289.
29. Patel A, Kolt GS, Keogh JWL, Schofield GM. The Green Prescription and older adults: What do general practitioners see as barriers? *J Prim Health Care.* 2012;4(4):320-327. doi:10.1071/hc12320.
30. Patel A, Schofield GM, Kolt GS, Keogh JWL. General practitioners' views and experiences of counselling for physical activity through the New Zealand green prescription program. *BMC Family Practice.* 2011;12. doi:10.1186/1471-2296-12-119.

Table legends

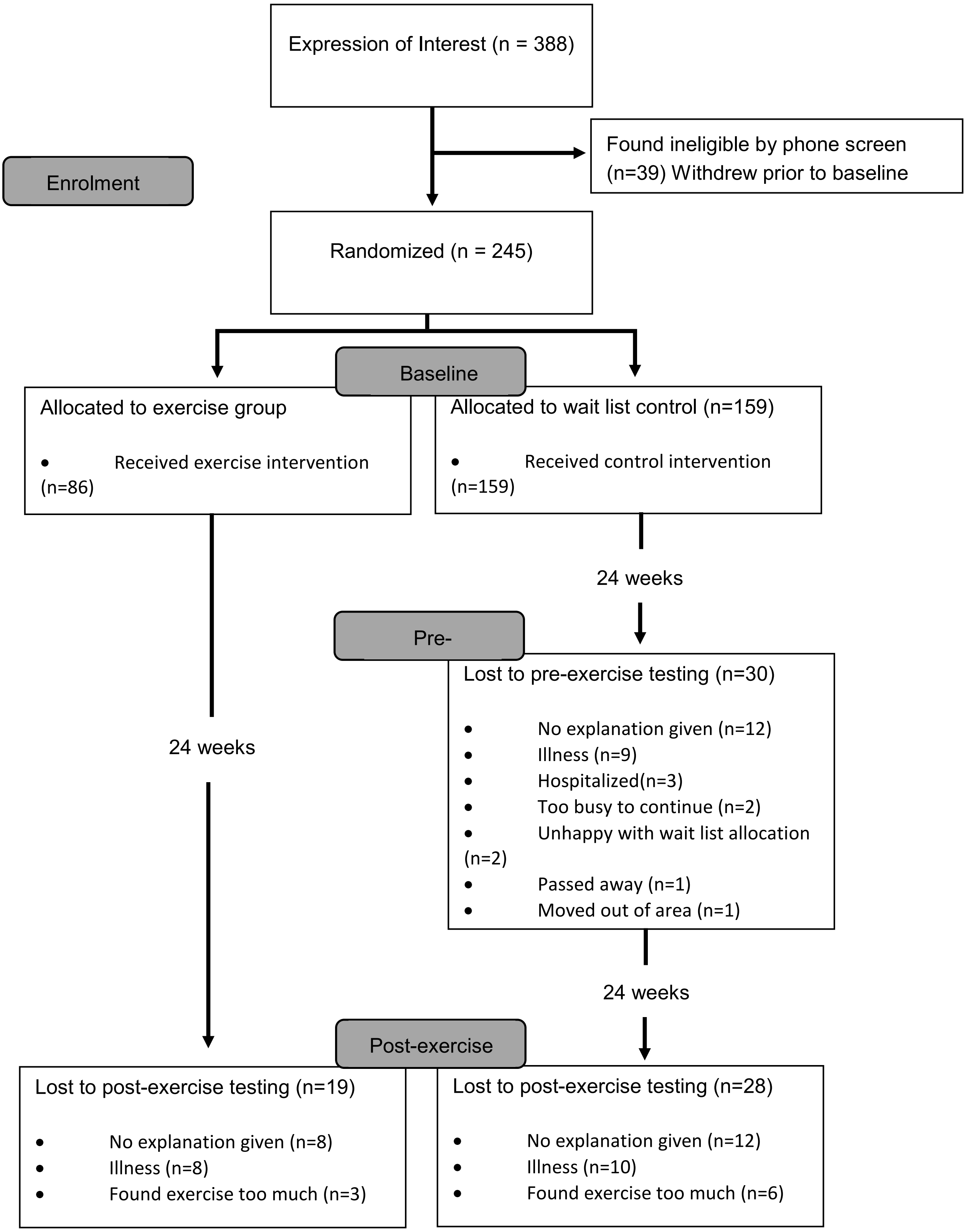
Table 1. Baseline characteristics of participants.

Table 2. Regression analyses of body composition change scores: Location, spread, proportion of response and univariate predictors.

Table 3. Regression analyses of physical function change scores: Location, spread, proportion of response and univariate predictors.

Table 4. Regression analyses of mental health and cognitive function change scores: Location, spread, proportion of response and univariate predictors.

CONSORT Flow



Observed change scores were calculated for all variables by subtracting baseline values from the 24-week post-intervention or post-control evaluations. Data were only analysed based on participants randomised allocation.

Table 1. Baseline characteristics of participants.

Measure	Exercise completers (n = 67)	Exercise Non completers (n = 19)	Control completers (n = 129)	Control Non completers (n = 30)
Age (yrs)	79.0 ± 6.0	79.6 ± 5.6	78.6 ± 6.7	80.4 ± 7.1
Gender (n, % women)	69, 80%	15, 79%	126, 79.%	23, 77%
Mass (kg)	77.7 ± 18.8	76.3 ± 23.5	74.8 ± 18.1	77.9 ± 21.1
Fat mass (kg)	32.1 ± 13.8	29.7 ± 17.6	29.8 ± 13.1	32.4 ± 15.0
Lean mass (kg)	46.6 ± 9.6	45.3 ± 9.3	44.8 ± 8.8	45.0 ± 9.4
BMI (kg/m^2)	30.0 ± 6.9	29.4 ± 9.3	29.1 ± 6.7	30.1 ± 7.5
Medications (n)	5.1 ± 3.2	5.2 ± 3.0	5.2 ± 3.1	5.1 ± 3.0
Morbidities (n)	5.0 ± 2.8	4.8 ± 2.6	5.0 ± 2.8	4.8 ± 2.6
ABC	63.7 ± 26.0	62.3 ± 25.3	64.7 ± 26.0	65.5 ± 24.3
Grip strength (kg)	22.6 ± 7.2	22.2 ± 7.8	21.3 ± 7.7	18.4 ± 6.3
Chair stand (s)	22.6 ± 16.6	37.8 ± 21.3	27.9 ± 19.6	35.0 ± 20.6
Walk speed (m/s)	0.9± 0.3	0.7 ± 0.3	0.8 ± 0.3	0.7 ± 0.2
SPPB	8.5 ± 2.6	6.3 ± 3.0	7.7 ± 2.8	6.2 ± 2.5
SPPB Balance (s)	27.3 ± 4.4	25.4 ± 6.5	25.4 ± 5.8	22.7 ± 5.6
GDS	2.8 ± 2.2	3.4 ± 2.3	3.3 ± 2.5	2.9 ± 2.1
GAI	4.1 ± 4.9	5.4 ± 6.0	4.0 ± 4.5	3.6 ± 4.2

MMSE	28.1 ± 2.2	27.6 ± 2.9	28.2 ± 2.1	27.5 ± 3.3
EQ-5D-3L	2.1 ± 1.7	2.6 ± 2.2	2.3 ± 1.5	2.5 ± 1.4
SARC-F (n, % sarcopenic)	26, 30%	11, 58%	60, 38%	18, 60%

All continuous data are presented as mean ± standard deviation. All categorical data are presented as the absolute number followed by the percentage. BMI: Body mass index. ABC: Activity-specific Balance Confidence questionnaire. SPPB: Short Physical performance Battery. GDS: Geriatric Depression Scale. GAI: Geriatric Anxiety Index. MMSE: Mini mental state examination. EQ-5D-3L: EuorQoL 5D 3L questionnaire. SARC-F: Strength, assistance with walking, rising from a chair, climbing stairs, and falls questionnaire.

Table 2. Regression analyses of body composition change scores: Location, spread, proportion of response and univariate predictors.

	Body Mass (kg)		Fat mass (kg)		Lean Mass (kg)	
Location and spread						
Mean Intervention change (95%CI)	-0.6 (-2.1 to 0.9) N = 67		-1.2 (-3.1 to 0.7) N = 67		-0.4 (-1.5 to 0.7) N = 66	
Mean Control change (95%CI)	0.1 (-1.4 to 1.6) N = 129		0.2 (-1.7 to 2.1) N = 122		-0.02 (-1.1 to 1.1) N = 122	
Intervention standard deviation (95%CI)	6.4 (5.4 to 7.5)		8.0 (6.8 to 9.5)		3.9 (4.7 to 5.5)	
Control standard deviation (95%CI)	4.3 (3.8 to 4.9)		5.8 (5.1 to 6.6)		3.5 (3.1 to 4.0)	
Proportion of response	0.56		0.60		0.45	
Predictors	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size
BMI	-1.8**	0.06	-0.1	0	-0.5	0.01
Grip Strength	-0.7	0.01	-0.8	0.01	0.2	0
Grip Strength [Low/High]	-0.2	0	-1.4	0.01	0.48	0
GDS	-0.4	0.01	-0.3	0	0.1	0
EQ5D	-0.1	0	-0.1	0	0.5	0.01
Walk Speed [Low/High]	0.5	0	-0.6	0	1.6	0.02
SPPB [Low/High]	0.3	0	0.6	0	0.8	0.01

N: Number of participants in group; BMI: Body mass index; GDS: Geriatric depression scale; EQ5D: Health-related quality of life measure; SPPB: Short physical performance battery; All continuous predicts were standardised by dividing by sample standard deviation; ** p <0.01; Effect size: Cohen's f^2.

Table 3. Regression analyses of physical function change scores: Location, spread, proportion of response and univariate predictors.

	SPPB		Isometric Knee Extension Strength (kg)		Grip Strength (kg)		Chair Stand (s)		Walk Speed (s)	
Location and spread										
Mean Intervention change (95%CI)	1.3 (0.7 to 1.8) N = 67		2.5 (2.0 to 3.0) N = 63		-0.8 (-1.9 to 0.4) N = 67		-2.1 (-5.7 to 1.5) N = 67		0.02 (-0.03 to 0.08) N = 67	
Mean Control change (95%CI)	-0.1 (-0.6 to 0.4) N = 129		0.2 (-0.3 to 0.7) N = 129		-3.1 (-4.2 to -2.1) N = 129		1.1 (-2.5 to 4.7) N = 129		-0.00 (-0.06 to 0.05) N = 128	
Intervention standard deviation (95%CI)	2.3 (1.9 to 2.7)		2.1 (1.7 to 2.4)		4.4 (3.7 to 5.2)		15.1 (12.7 to 17.8)		0.2 (0.2 to 0.3)	
Control standard deviation (95%CI)	2.2 (1.9 to 2.6)		1.6 (1.4 to 1.8)		4.2 (3.7 to 4.8)		14.8 (13.1 to 16.7)		0.1 (0.1 to 0.2)	
Proportion of response	0.98		0.97		0.99		0.86		0.57	
Predictors	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size
BMI	0.1	0	-0.1	0	0.01	0	0.1	0	0.01	0
Grip Strength	-0.2	0	-0.1	0	-2.6***	0.33	-0.2	0	0	0
Grip Strength [Low/High]	-0.53	0.01	-0.05	0	-3.4***	0.15	-0.53	0.01	0	0
GDS	0.2	0.01	-0.1	0	-0.3	0	0.2	0.01	0	0
EQ5D	0.2	0.01	0.2	0.01	0.2	0	0.2	0.01	0.02	0.02
Walk Speed [Slow/Fast]	-1.1**	0.07	-0.51	0.02	-0.89	0.01	-1.1**	0.07	-0.11***	0.07
SPPB [Low/High]	-1.6***	0.16	-0.65*	0.03	-0.61	0	-1.6***	0.16	-0.07*	0.04

N: Number of participants per group; BMI: Body mass index; GDS: Geriatric depression scale; EQ5D: Health-related quality of life measure; SPPB: Short physical performance battery; All continuous predictors were standardised by dividing by sample standard deviation; * p<0.05; ** p <0.01; *** p<0.001; Effect size: Cohen's f^2.

Table 4. Regression analyses of mental health and cognitive function change scores: Location, spread, proportion of response and univariate predictors.

	GDS		GAI		MMSE		EQ5D		EQ5D VAS	
Location and spread										
Mean Intervention change (95%CI)	-0.2 (-0.8 to 0.3) N = 67		-0.7 (-1.5 to -0.03) N = 67		0.6 (0.2 to 1.0) N = 66		-0.4 (-0.7 to -0.04) N = 67		0.34 (-4.8 to 5.6) N = 67	
Mean Control change (95%CI)	-0.4 (-0.9 to 0.1) N = 129		-0.7 (-1.5 to -0.05) N = 129		0.06 (-0.4 to 0.5) N = 123		0.1 (-0.2 to 0.5) N = 128		0.24 (-4.9 to 5.4) N = 129	
Intervention standard deviation (95%CI)	2.2 (1.8 to 2.6)		2.9 (2.5 to 3.5)		1.7 (1.5 to 2.1)		1.4 (1.2 to 1.7)		21.6 (18.2 to 25.6)	
Control standard deviation (95%CI)	1.9 (1.7 to 2.1)		3.4 (3.0 to 3.9)		1.6 (1.5 to 1.9)		1.3 (1.1 to 1.4)		20.6 (18.2 to 23.2)	
Proportion of response	0.44		0.50		0.84		0.78		0.51	
Predictors	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size	Coefficient	Effect Size
BMI	0.1	0	-0.02	0	0.13	0.01	0.04	0	-0.2; 0	0
Grip Strength	0.1	0	-0.2	0	0.030	0	-0.08	0	-6.6***	0.06
Grip Strength [Low/High]	0.1	0	-0.7	0.01	0.16	0	-0.01	0	-12.9***	0.08
GDS	-0.7***	0.16	0.05	0	0.05	0	0.02	0	2.0	0.01
EQ5D	-0.2	0.01	-0.2	0	0.07	0	-0.53***	0.16	2.9	0.02
Walk Speed [Slow/Fast]	0.46	0.01	0.66	0.01	-0.4	0.01	-0.03	0	-8.2*	0.03
SPPB [Low/High]	0.14	0	0.31	0	-0.48	0.02	-0.18	0	-9.6**	0.05

N: Number of participants per group; EQ-5D VAS: perceived health-related quality of life measure on that day; GAI: Geriatric anxiety inventory; MMSE: Mini-mental state examination; GDS: BMI: Body mass index; GDS: Geriatric depression scale; EQ5D: Health-related quality of life measure; SPPB: Short physical performance battery; All continuous predictors were standardised by dividing by sample standard deviation; * p<0.05; ** p <0.01; *** p<0.001; Effect size: Cohen's f^2.