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ORIGINAL RESEARCH

A Randomized Controlled Feasibility Trial Evaluating a Resistance Training Intervention With Frail Older Adults in Residential Care: The Keeping Active in Residential Elderly Trial

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Frailty is associated with negative health outcomes, disability, and mortality. Physical activity is an effective intervention to improve functional health status. However, the effect of resistance training on multidimensional health in frail older adults remains unclear. This randomized controlled trial was conducted in a U.K. residential care home to assess feasibility with limited efficacy testing on health and functional outcomes and to inform a future definitive randomized controlled trial. Eleven frail older adults (>65 years) completed a 6-week machine-based resistance training protocol three times a week. Uptake and retention were greater than 80%. The measures and intervention were found to be acceptable and practicable. The analyses indicated large improvements in functional capacity, frailty, and strength in the intervention group compared with the controls. These findings support the feasibility of a definitive randomized controlled trial and reinforce the value of resistance training in this population. This trial was registered with ClinicalTrials.gov: NCT03141879.

Keywords: care home residents, frailty, multidimensional health, physical function, strengthening exercise

Frailty is a clinically significant multidimensional syndrome associated with adverse outcomes such as falls, hospitalization, disability, and mortality among older adults (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013; Fried et al., 2001; Xue, 2011). It is characterized by diminished strength, mobility, and functional capacity and increases an individual's vulnerability to external stressors, including infection or trauma (Hewitt et al., 2019; Morley et al., 2013). Despite no universally accepted definition of frailty (Fried et al., 2001; Theou et al., 2015), it is of increasing importance as the world's older population continues to grow (United Nations Department of Economic and Social Affairs Population Division, 2019) and a rising proportion are spending prolonged periods in ill health. Evidence suggests that their health span (the period of life spent in good health) is not keeping pace with their life span (Whittaker et al., 2019).

Sustained ill health and loss of function in older age are not predetermined, and frailty is not an inevitable consequence of aging. Frailty is a manageable condition (Morley et al., 2013) and has consistently been shown to be responsive to physical activity intervention. Being physically active is vitally important to optimize healthy aging and improve function (Bherer, Erickson, & Liu-Ambrose, 2013; Lazarus & Harridge, 2018). Furthermore, preserving balance and muscle and bone strength is integral to maintaining quality of life by reducing both the fear and the risk of falls, fractures, and frailty (Davies, Atherton, McBride, & Calderwood, 2019; Fragala et al., 2019; Skelton & Mavroeidi, 2018). Robust evidence supports the beneficial effects of resistance training to improve muscle strength and function, and its ability to mitigate age-related declines in neuromuscular function, rate of force development, bone mineral density, and associated metabolic dysregulation (Fragala et al., 2019; McLeod, Stokes, & Phillips, 2019).

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However, despite the mounting evidence that resistance training interventions are effective for combatting age-related physical decline, older adults in residential care are an often overlooked group. This is potentially due to higher frailty levels, reduced physical independence and functional ability, and the perceived difficulty of providing a feasible regimen of training for individuals with a range of comorbidities and limitations. Additional barriers may include the ability to tolerate testing and training, health and injury risks, adherence levels, and declines in cognitive function and health status (Ferrucci et al., 2004). Research also suggests that frail older adults may themselves be reticent to engage in physical activity due to fear of falling, comorbidities, injury risk, overexertion, and changes to habitual routines (Finnegan, Bruce, Lamb, & Griffiths, 2015; Franco et al., 2015).

Approaches to physical activity interventions in residential care have included multicomponent exercise (Arrieta et al., 2018; Cadore et al., 2014; Lazowski et al., 1999), functional exercise (Peri et al., 2008), and combined resistance and weight-bearing exercise (Fien, Henwood, Climstein, & Keogh, 2016). The most commonly utilized exercise protocol is multicomponent training, with the inclusion of resistance, balance, aerobic, and flexibility activity (Theou et al., 2011), and current guidelines suggest this may be the best strategy to improve gait, balance, and strength and to reduce the risk of falls (Fragala et al., 2019). However, the generalizability of these recommendations to address wider health consequences of frail older adults is still to be established. Studies that reported positive changes in physical function included stepping reaction time and timed walking test (Lord et al., 2003); enhanced functional outcomes, muscle strength, and power (Cadore et al., 2014); and significant improvement in strength, gait speed, and lower limb function (Bastone Ade & Jacob Filho, 2004). Exercise interventions with progressive resistance training as the primary focus are less common in residential care settings and have tended to focus primarily on physical performance outcomes, for example, strength, walking speed, balance, and functional capacity (Hassan et al., 2016; Serra-Rexach et al., 2011).

Delivering strengthening exercise programs as a group-based activity might also be important in a residential care home setting. For example, one study conducting a group multicomponent exercise intervention with community-dwelling frail older adults reported a reversal of frailty and improvements in cognitive, emotional, and social-networking measures (Tarazona-Santabalbina et al., 2016). This underlines the positive impact that social support and group processes can have on the engagement with, and maintenance of, physical activity behavior (Shvedko, Whittaker, Thompson, & Greig, 2018; Smith, Banting, Eime, O'Sullivan, & Van Uffelen, 2017). What is not yet clear is the impact of resistance training in a group setting on multidimensional health and well-being and physical function in frail older adults in residential care. Consequently, research to assess the feasibility and impact of this is timely and urgent.

Aims and Objectives

The primary aim of this study was to assess the feasibility of a definitive, randomized controlled trial (RCT) using a resistance training intervention with frail older adults in residential care. The secondary aim was to perform limited efficacy testing on measures of multidimensional health from pre- to postintervention compared with the wait-list control. These are intended as the primary dependent variables in the future definitive RCT and include physiological, psychological, cognitive, and emotional health measures, and functional capacity.

The specific objectives arising from these aims were to (a) evaluate the experiences of the intended recipients, well-being team, and care staff (acceptability); (b) determine actual interest, use, and adherence levels to the resistance training intervention (demand); (c) evaluate the level of organizational change required, including perceived fit into the existing culture and structure (integration and adaptation); (d) determine the practicality of the resistance training intervention with frail older adults in residential care (practicality); (e) evaluate the suitability and relevance of the selected measures of multidimensional health and wellness (implementation and expansion); and (f) examine changes pre- to postintervention compared with the wait-list control in measures of multidimensional health using mean differences, effect size, and meaningful change (limited-efficacy testing). The feasibility aims and objectives were based on the research design framework proposed by Bowen et al. (2009). As this was a feasibility study, there were no directional hypotheses.

This research has been reported in line with CONSORT 2010 guidelines for reporting randomized pilot and feasibility trials (Eldridge et al., 2016), Consensus on Exercise Reporting Template (Slade, Dionne, Underwood, & Buchbinder, 2016) and Standard Protocol Items: Recommendations for Interventional Trials Schematic Participant Timeline (Chan et al., 2013). The CONSORT 2010 checklist is included as Supplementary Material (available online).

Method

Participants

The trial site was a care home in Birmingham, United Kingdom, initially approached due to management support of healthy aging and research initiatives, a dedicated well-being team, and a strong sense of community. The initial recruitment of the participants was made by either a direct approach from a staff member, introduction to a member of the research team, or by voluntary attendance at a short introductory talk given by the principal investigator and researcher in the care home (February 2019). Participants were screened against the following eligibility criteria: (a) resident in the care home; (b) age ≥65 years; (c) having at least three of the five Fried Frailty Phenotype Criteria (adapted from Fried et al., 2001); (d) no severe sensory impairments that would profoundly impact their ability to participate; (e) the ability to speak and read the English language; (f) not currently taking part in any other clinical trial that could potentially affect the results of this study; and (g) having a predicted life expectancy greater than the length of the trial.

Recruitment

All potential participants were offered a summary sheet about the study (a two-page flyer based on the participant information sheet content). The summary sheet detailed the "who, what, when, where, and why" of the study, including potential benefits and risks of taking part, research team contact details, and confidentiality and data protection. The summary sheet was produced on the advice of the well-being team, who suggested that lengthy documentation may be off-putting for some residents, particularly those with any cognitive or sight impairment. All potential participants who expressed further interest in the study were given the full comprehensive Participant Information Sheet, in line with the published protocol (Doody, Lord, & Whittaker, 2019). Potential participants had 10 days to consider whether they would like to participate and were encouraged to meet with a member of the research team to discuss any queries. Following any further explanation, interested potential participants were provided with an informed consent form. The trial design was inclusive, including those who may have lacked the capacity to provide informed consent, and documentation was in place for personal or nominated consultees. All participants had capacity and provided written informed consent before trial commencement and verbal consent before the start of their interview. All were free to withdraw from the study at any time.

Sample Size

A convenience sample of approximately 48 participants was suggested by Doody et al. (2019) in the published protocol. The actual sample size for this trial was adjusted following recruitment advice from the care home staff and was in line with recommendations (Hertzog, 2008; O'Cathain et al., 2015). Specific guidance for mixed methods randomized feasibility trials is limited. Hertzog (2008) proposed that samples of 10–15 per group may be adequate, depending on the nature of the decision based on the estimate, and that even a few cases will be informative for decisions regarding acceptability, practicality, and implementation. Sample sizes for qualitative feasibility trials are also typically small, between 5 and 20 individuals (O'Cathain et al., 2015). An additional week (labeled as Week –3 on Table 1) was allocated for consent and eligibility screening prior to the baseline assessments to allow for broader recruitment. Following the initial level of interest generated by the introductory talk at the care home and discussions with the well-being team, the researcher aimed for a sample of 20 participants.

Trial Design

Ethical approval for this study was provided by the London Harrow Research Ethics Committee, REC: 17/LO/1316 Protocol: RG_17-108 IRAS: 219616. The full study protocol has been published

Table 1 Study Timeline

Week	Monday	Tuesday	Wednesday	Thursday	Friday
Week -3	Recruitment	Recruitment	Recruitment	Recruitment	Recruitment
Week -2	Consent and eligibility screen	Consent and eligibility screen	Consent and eligibility screen	Consent and eligibility screen	Consent and eligibility screen
Week -1	Baseline assessments	Baseline assessments	Baseline assessments	Baseline assessments	Baseline assessments
Week 0	Baseline assessments	Baseline assessments	Baseline assessments	Baseline assessments	Baseline assessments
Week 1	Exercise session: 1	Rest	Exercise session: 2	Rest	Exercise session: 3
Week 2	Exercise session: 4	Rest	Exercise session: 5	Rest	Exercise session: 6
Week 3	Exercise session: 7	Rest	Exercise session: 8	Rest	Exercise session: 9
Week 4	Exercise session: 10	Rest	Exercise session: 11	Rest	Exercise session: 12
Week 5	Exercise session: 13	Rest	Exercise session: 14	Rest	Exercise session: 15
Week 6	Exercise session: 16	Rest	Exercise session: 17	Rest	Exercise session: 18
Week 7	Postintervention assessments	Postintervention assessments	Postintervention assessments	Postintervention assessments	Postintervention assessments
Week 8	Postintervention assessments	Postintervention assessments	Postintervention assessments	Postintervention assessments	Postintervention assessments
Weeks 9–14	Wait-list control exercise sessions Monday–Wednesday–Friday				
Weeks 13–14	Follow-up assessments: Intervention group	Follow-up assessments: Intervention group	Follow-up assessments: Intervention group	Follow-up assessments: Intervention group	Follow-up assessments: Intervention group
Weeks 15–16	Follow-up assessments: Wait-list control group	Follow-up assessments: Wait-list control group	Follow-up assessments: Wait-list control group	Follow-up assessments: Wait-list control group	Follow-up assessments: Wait-list control group

elsewhere (Doody et al., 2019). Trial registration: ClinicalTrials.gov: NCT03141879. Registered 5 May 2017.

The trial was conducted between February 2019 and July 2019. The study timeline is shown in Table 1 and represents the overall study duration.

All study participants completed the initial screening (Week –2) and baseline measures (Weeks –1 and 0) prior to confirmation of group allocation. The 6-week resistance-training program was scheduled for Weeks 1–6 for the intervention group, and Weeks 9–14 for the wait-list control group. Both groups completed postintervention testing in Weeks 7–8, with follow-up testing scheduled for Weeks 13–14 and Weeks 15–16 for the intervention and wait-list control group, respectively. This staggered approach ensured that follow-up testing was completed 6 weeks after the end of the group exercise sessions. The participants were advised to avoid strenuous physical activity or resistance training for at least 24 hr prior to any measures of strength or functional capacity, or blood samples. Due to the comprehensive test battery, and to avoid participant fatigue, assessments were scheduled over multiple days/visits (Table 2).

Randomization. The principal investigator conducted the randomization and allocation independent of the identification, consent, screening, and baseline assessments. The researcher enrolled participants; conducted eligibility screening and baseline testing; and informed participants of their group allocation. Permuted block randomization (1:1) was used to randomize the participants. Randomization was conducted using a computer-generated random number generator (www.randomizer.org). Group allocation was not revealed until after the consent, eligibility screening, and baseline measures had been completed, ensuring allocation concealment and minimizing selection bias. Due to the nature of the intervention and the researcher's dual role (intervention delivery and tester), further blinding was not possible. The trial participants, care staff, and well-being team members were also aware of the group allocation. All postintervention and follow-up testing were completed unblinded by the researcher. Minimization of conscious bias was upheld by strict adherence to standardized test protocols, timing of tests, and consistency of encouragement across all assessments.

Important changes to trial design after the protocol was published. The published protocol (Doody et al., 2019) advised the use of a concurrent control group design for the feasibility trial and utilization of a wait-list control group within the subsequent future RCT. After discussion with the care home management, this was amended to a wait-list control to ensure that all participants would have access to potential beneficial effects of the intervention, as well as nullifying the negative psychological impact of being interested in exercise for better health and then being randomized to no treatment. Both groups had continued access to regular on-site well-being activities independent from this study. Utilization of the wait-list control group allowed more insight into the acceptability and implementation of the proposed RCT. Due to the small size and the proposed number of covariates (frailty score and age), block randomization was adopted rather than the stratified-block method in the published protocol. Stratified-block randomization would be a consideration for a future RCT to control for baseline covariate imbalance, reduce bias in statistical analysis, and increase the power of the study.

Measures

Feasibility outcomes. The primary aim of the study was to assess the feasibility of conducting a definitive RCT. The feasibility outcome measures are defined in Table 3 and address all key focus areas for feasibility trials (Bowen et al., 2009). All semistructured interviews and focus groups were conducted by the researcher, who had previous experience of interviewing and facilitating group discussions. The researcher had established professional

Table 2 Participant Timeline (Schedule of Enrollment, Interventions, and Assessments Based on Standard Protocol Items Recommendations for Interventional Trials [2013])

	Study period													
	Enrollment	Baseline		Intervention	Postintervention			Intervention (wait-list control)	Follow-up (intervention group)			Follow-up (wait-list control)		
		B1	B2		P1	P2	P3		F1	F2	F3	F1	F2	F3
Timepoint (weeks)	−2	−1	0	1–6	7	8	8	9–14	13	14	14	15	16	16
Enrollment														
Eligibility screen	×													
Informed consent	×													
Fried Frailty Phenotype	×				×				×			×		
SMMSE	×				×				×			×		
Allocation			×											
Study groups														
Intervention				×										
Wait-list control								×						
Assessments														
SPPB		×				×				×			×	
GDS		×			×				×			×		
ISEL-12		×			×				×			×		
Sociodemographics		×												
MNA		×				×				×			×	
Leg strength/RFD			×		×					×			×	
HADS			×			×				×			×	
PSS			×			×				×			×	
Katz ADL			×			×				×			×	
Blood measures			×		×						×			×
Semistructured interviews							×							
Focus groups (staff)														×

Note. SMMSE = Standardized Mini-Mental State Examination; SPPB = Short Physical Performance Battery; GDS = Geriatric Depression Scale; ISEL = Interpersonal Support Evaluation List; MNA = Mini Nutritional Assessment; RFD = rate of force development; HADS = Hospital Anxiety and Depression Scale; PSS = Perceived Stress Scale; ADL = Activities of Daily Living.

Table 3 Feasibility Trial Outcomes, Objectives, and Assessments

Area of focus	Objectives	Assessment or measure
1. Acceptability	• To assess screening and eligibility criteria • To evaluate recruitment, retention, and adherence rates • To evaluate participant experience, feedback, and perceived appropriateness • To investigate the views and opinions of management, care, and support staff	• Participant uptake analysis • Semistructured interviews with participants • Focus groups with well-being team staff, care staff, and management
2. Demand	• To determine level of interest, actual use, and adherence • To investigate staff opinion of trial suitability and proposed, definitive RCT	• Analysis of uptake rates • Exercise intervention adherence rates • Focus groups with well-being team staff, care staff, and management
3. Implementation	• To determine factors affecting ease, difficulty, or quality of implementation in this setting • To evaluate the applicability of the selected measures of multidimensional health and wellness • To determine any logistical issues which may require consideration or amendment prior to RCT	• Semistructured interviews with study participants • Focus groups with well-being team staff, care staff, and management
4. Practicality	• To determine time-cost, burden, and benefit for researcher, participants, staff, and broader support team • To evaluate any practical constraints around required resources, time, or commitment • To assess the quality and suitability of the intervention in this setting	• Semistructured interviews with study participants • Focus groups with well-being team staff, care staff, and management
5. Integration	• To assess integration into the existing culture, protocols, and procedures within the care home • To investigate perceived fit and longer-term sustainability in this setting	• Focus groups with well-being team staff, care staff, and management
6. Adaptation	• To evaluate the requirement for any modification or amendments to the existing intervention	• Focus groups with well-being team staff, care staff, and management • Semistructured interviews with study participants
7. Expansion	• To investigate any potential disruption and positive or negative effects on the environment, organization, or culture from potential program expansion • To assess any budget and/or resource requirements for further expansion	• Focus groups with well-being team staff, care staff, and management • Semistructured interviews with study participants
8. Limited-efficacy testing	• To examine the potential positive meaningful impact of a moderately intensive 6-week resistance-training intervention on markers of multidimensional health in frail, older adults • To assess the efficacy of the intervention on the health and functional variables (identified as primary dependent variables of a proposed future RCT)	• Analysis of the health and functional variables • Analysis of uptake and adherence rates • Analysis of the level of satisfaction with the interventions through interviews and focus groups

Note. RCT = randomized controlled trial.

relationships with all participants and staff throughout the study. The interviews took place either in the communal lounge area outside of scheduled activities or in participants' rooms to ensure a quiet, private space. Two separate focus groups were conducted in a private room. Audio was digitally recorded using an IBM ThinkPad X1 Laptop (Lenovo, China), Voice Recorder App (Microsoft 2018), and iGOKU USB Microphone (iGOKU, China). The researcher also kept comprehensive written field notes and a reflexive diary. Full details of the data collection are given in the trial protocol (Doody et al., 2019).

Health and functional outcomes. Measures of multidimensional health are outlined in Table 2, Participants Timeline, and in the trial protocol (Doody et al., 2019). These measures were categorized into physiological, psychological, cognitive, and emotional health measures; social support; and functional capacity. The physiological measures were inflammatory cytokines, C-reactive protein, cortisol, and dehydroepiandrosterone sulfate from blood serum. The psychological and emotional measures were composed from the Geriatric Depression Scale (Yesavage et al., 1983), the Hospital Anxiety Depression Scale (Zigmond & Snaith, 1983), and the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983). The cognitive assessment comprised the Standardized Mini Mental State Examination (SMMSE; Molloy, Alemayehu, & Roberts, 1991), and social support was measured through the Interpersonal Support Evaluation List-12 (Cohen, Mermelstein, Kamarck, & Hoberman, 1985). Finally, functional capacity was assessed using the Activities of Daily Living scale (Katz, Downs, Cash, & Grotz, 1970), the Short Physical Performance Battery (Guralnik et al., 1994), and leg strength. The Fried Frailty Phenotype (Fried et al., 2001) and SMMSE (Molloy et al., 1991) were also used as part of eligibility screening (Table 2). Quantitative data for each participant were recorded on an individual case report form.

Important changes to health and functional outcome assessments after the protocol was published. The original protocol (Doody et al., 2019) specified the assessment of leg strength and power output, and one-repetition maximum (1RM) testing (Sheppard & Triplett, 2016, p. 453). The 1RM would be subsequently used for the assignment of training loads. This testing methodology was amended due to the consideration of safety, appropriateness, relevance, and validity (Conlon, Haff, Tufano, & Newton, 2018; Zourdos et al., 2016). While maximal strength testing per se is safe and acceptable for older adults (Alcazar, Guadalupe-Grau, Garcia-Garcia, Ara, & Alegre, 2018), the researcher used professional judgment to select a maximal isometric strength testing protocol for the lower limbs only, including knee extensors, knee flexors, hip adductors, and hip abductors. This

was justified on the basis that Moir (2012) proposed that isometric tests require little movement skill, are relatively easy to administer, and provide additional rate-of-force development data. Rate of force development has shown direct association with the ability to contract muscles rapidly and maximally, related to fall risks (Fragala et al., 2019). Furthermore, guidelines advise that maximal strength testing may be contraindicative for adults with severe osteoporosis (American College of Sports Medicine, 2018) but acknowledge that no specific criteria are recommended.

Isometric maximal strength testing was performed using the Performance Recorder Software Suite User Manual test protocol (August 13, 2010) and HUR Rehab Line Equipment Measurement Instructions, and was in-line with previous research using HUR equipment (Borg, Laxåback, & Björkgren, 2008; Mård et al., 2008). The Performance Recorder is a reliable tool to assess isometric strength and to monitor change in strength over time (Neil et al., 2013). Subsequent discussions with the equipment manufacturers confirmed that the 1RM test data would be reliable as an outcome measure, but not appropriate for accurate training load prescription (Newton, Cormie, & Cardinale, 2011).

Attendance and adherence. Attendance was reported as a percentage of attended exercise sessions. The adherence to exercise prescription was measured and reported as the percentage of total repetitions completed at the prescribed load. The exercise adherence data (including attendance, exercises performed, sets, repetitions, and loads) were automatically recorded by the SmartTouch software, incorporated into the exercise machines, and verified by the researcher. Any technical issues that compromised accurate record-keeping using SmartTouch (HUR Ltd., Finland), including Wi-Fi connectivity or log-in and recognition problems, were reported and noted alongside attendance records to ensure data reliability.

Resistance Training Intervention

Equipment. The resistance-training intervention utilized specialized, pneumatic, strength-training equipment with SmartTouch web-based software and radio-frequency identification user log-in systems with smart cards from the premium line of HUR SmartTouch (4th Generation; HUR Ltd., Kokkola, Finland). The ergonomically designed machines were specially designed for use in active-aging programs. The touch screens on each machine displayed the participants' names on log-in and sign-out, the overall program, sets, repetitions, and load.

All machines were set up and used according to the manufacturer's guidelines. The range of motion limiters, seat heights, and lever arm lengths were set, stored on individual radio-frequency identification cards, and checked prior to each session. The participants were encouraged to work through the full range of joint movement (unless limited by pain or specific joint or medical problems) and with proper technique, including handgrip, body and limb positioning, breathing patterns, range of movement, and speed. The researcher assisted with transferring the participants from machines to any assisted walking devices; manually modified the load, if required; offered feedback; and assisted with any technology issues, that is, card recognition or Wi-Fi connectivity. Participants with sight, hearing, or movement limitations were supported with individual attention, as needed. All radio-frequency identification cards were kept in a card storage box next to the machine compressor unit and only accessed by the researcher or the participant.

Five separate, free-standing machines were used: leg press, leg extension/leg curl, chest press, hip abduction/adduction, and optimal rhomboid. The leg extension/leg curl and hip abduction/adduction machines had dual functionality, and the exercise program prescription included all seven exercises. All machines (except for hip abduction/adduction) had unilateral and bilateral capability. The exercise equipment was installed in the main meeting room (lounge) at the care home, with adequate space between machines to allow direct access from walking frames and wheelchairs.

Delivery. All exercise sessions were supervised by the researcher, who was a qualified strength and conditioning coach with over 25 years of experience. Program-specific training with HUR equipment (including isometric strength testing with Performance Recorder and HUR Labs Performance Recorder PC software [HUR Ltd., Finland]) was undertaken prior to program commencement, with additional support available throughout the trial duration.

The sessions were run as a group-based activity, with a total of five participants attending each time. The participants wore their usual day clothes. While no specific or structured motivation strategies were used, the researcher and care home staff were supportive and encouraging throughout the intervention. The participants were actively encouraged to attend all scheduled assessment and exercise sessions. This could include a verbal reminder of the day/time of the session and/or physical assistance in moving to the lounge. While adherence was keenly promoted, the participants were assured that attendance and engagement were voluntary.

Important changes to equipment and delivery after the protocol was published. The published protocol (Doody et al., 2019) proposed using six separate machines for all participants. However, current recommendations advise that the inclusion of specific exercises, and the volume of exercise per session, needs to be tailored to individual fitness and physical function (Fragala et al., 2019; Ribeiro, Nunes, & Schoenfeld, 2020). In alignment with this, the researcher used professional judgment to make modifications, as required. This intervention was subsequently amended to include only five machines (seven exercises) by exclusion of the abdominal crunch machine, directly based on guidelines for any clinical diagnosis for osteoporosis or frailty (American College of Sports Medicine, 2018) and extensive strength and conditioning and biomechanics literature (McGill, 2006, 2010, 2015; Verkhoshansky & Siff, 2009) discouraging repetitive loaded spinal flexion patterns in deconditioned or weak individuals. Specific guidance for individuals with osteoporosis (Skelton & Mavroeidi, 2018) further recommends spine-sparing exercises and an avoidance of repetitive, weighted, loaded flexion patterns.

The proposed intervention (Doody et al., 2019) was a group exercise circuit, but was subsequently modified to allow individual progression through the training prescription, if required, in line with U.K. CMO's recommendations (Davies et al., 2019).

Exercise prescription. The resistance training intervention was based on published recommendations for strength training for older adults, including, but not limited to, ACSM Guidelines for Exercise Testing and Prescription (American College of Sports Medicine, 2018), NSCA Program Design for Resistance Training (2016), U.K. CMO 2019 Physical Activity Guidelines for Older Adults (Davies et al., 2019), and NSCA Resistance Training for Older Adults (Fragala et al., 2019). These included detailed guidance on the number and frequency of sessions, structure, duration, loading, sets, repetitions, total volume load, rest intervals, and progression.

The sessions were performed three times per week for 6 weeks, on Monday, Wednesday, and Friday mornings (09:30–10:30),

allowing a minimum of a 48-hr recovery between sessions. All participants were scheduled to attend 18 sessions in total throughout the 6-week intervention. Once established, the total session duration was 35–40 min, including the warm-up and cooldown. The initial sessions (Week 1) were slightly longer in duration (45–50 min) due to participant unfamiliarity with the warm-up exercises, machines and log-in systems, individual machine setup, and establishing appropriate individual starting loads.

The short warm-up routine (approximately 5 min) was completed immediately prior to the resistance training program, either sitting or standing, depending on the individual participant. It included a range of low-intensity, simple movement patterns primarily aimed at increasing blood flow, joint fluid viscosity, and range of movement, including shoulder rolls, reaches, punching patterns, marching on the spot, and calf raises. The sequencing of the exercises was not strictly standardized, but did follow a basic progressive format, with a focus on movement quality, posture, and technique. The warm-up time was also a time for social interaction and feedback between the researcher and the participants. Post exercise session, the participants were encouraged to perform approximately 5 min of light stretching and mobility patterns similar to the warm-up. All exercise sessions were supervised by the researcher, ensuring high levels of fidelity around consistency of delivery, coaching technical guidance, motivation, and observation. The intervention was delivered as planned, and the program prescription is shown in Table 4.

Although the exercise selection was standardized, there was flexibility to individualize this design by order or movement pattern. The order could be influenced by practical issues of transferring between machines (requiring additional time and/or assistance from the researcher), use by another group member, or individual preference. Any consistent preferences or sequencing were recorded.

The starting loads for each participant were confirmed during the first exercise session and as part of the initial familiarization. As all participants were beginners with no prior experience of resistance training, the initial loading was conservative and designed to improve confidence, orientation, and skill acquisition, with a secondary focus on progressive overload (Conlon et al., 2018). The OMNI resistance exercise scale (Gearhart, Lagally, Riechman, Andrews, & Robertson, 2009) and "reps in reserve" (Helms, Cronin, Storey, & Zourdos, 2016) were used to describe the appropriate loading and progression. While not a key criterion of the study, load progression was achieved by programmed microadjustments on each machine: when more than 14 repetitions of a given exercise could be completed with good form, the load was automatically increased by 5% for upper limbs and 10% for lower limbs on the subsequent training session (Sheppard & Triplett, 2016). All loads were modifiable manually by the participant or researcher intrasession, if required, and immediate feedback was given on the machine screen to confirm whether the volume load (Reps × Sets × Load) had been achieved. The participants were encouraged to hit their targets and gradually increase loading, but the focus was on movement quality, consistency, and overall session enjoyment.

All participants were asked to follow the resistance training program as prescribed and not make any substantial changes to any other physical activity for the duration of the intervention. There were no other nonexercise components in the study, that is, lifestyle coaching or specific education.

Important changes to exercise prescription after the protocol was published. The original protocol (Doody et al., 2019) suggested three to four sessions per week, totaling 21 sessions over 6 weeks, with an alternating pattern of three sessions one week and four sessions the next. Following discussions with the well-being team, this was not considered feasible: the lounge area was often used for other routine activities, including religious services on Sundays, and a changing schedule would be disruptive to both staff and residents. It was also advised that a regular routine at a consistent timeslot would be more acceptable, minimize interference with other activities, and increase the likely adherence and successful implementation.

The original protocol (Doody et al., 2019) proposed that the prescription of training loads for the intervention would be based on the percentages of 1RM tests on each machine. This is a traditional and accepted tool within strength and conditioning, but is not without flaws (Sheppard & Triplett, 2016), and is a considerable time requirement. Deconditioned and inexperienced participants in any resistance training program will benefit from an orientation phase with a progressive increase in training volume load (Sets × Reps × Load) allowing time for musculotendinous adaptations before 1RM testing. 1RM testing for beginners with little/no experience of resistance training on each exercise may not be accurate and representative of actual strength levels. Initial increases in strength are often attributed to improvements in coordination and skill, rather than strength alone (Newton et al., 2011). Older adults may have existing health conditions including arthritis and joint pain or mild cognitive impairment and may

Table 4 Program Prescription Including Sets, Reps, Interset Recovery Interval, and Intensity (Load)

Exercise	Sets	Reps	Interset recovery (s)	Speed of movement	Load
Optimal rhomboid	2	12	120	Concentric: as rapidly as possible while maintaining sound technique Eccentric: controlled (1–2 s)	Progression from "light-moderate" intensity (RPE 5–6) to "moderate-hard" (RPE 7–8) (Equivalent OMNI-RES 4–6 progressing to 6–8, with 2–4 RIR)
Hip adduction	2	12	120		
Hip abduction	2	12	120		
Chest press	2	12	120		
Leg extension	2	12	120		
Leg curl	2	12	120		
Leg press	2	12	120		

Note. RPE = rating of perceived exertion; reps = repetitions; OMNI-RES = OMNI-resistance exercise scale; RIR = repetitions in reserve.

require a more subjective feedback approach. The training loads were subsequently prescribed based on professional expertise and the participants' subjective feedback.

The exercise prescription in the original protocol (Doody et al., 2019) proposed "2 sets of 5 reps at 80% 1RM (Repetition Maximum)." This was modified to "2 sets of 12 reps at Rating of Perceived Exertion (RPE) light/moderate intensity" in line with current guidelines (Fragala et al., 2019). All exercises, sets, loads, and repetitions were modifiable intrasession to allow for daily fluctuation and subjective feedback (Sheppard & Triplett, 2016; Verkhoshansky & Siff, 2009).

Data Analysis

All quantitative data from individual case report forms were inputted into IBM SPSS Statistics for Windows (version 25.0; IBM Corp., Armonk, NY). The qualitative data from interviews and focus groups were transcribed verbatim into Microsoft Word and uploaded into NVivo (version 12, QSR International Pty Ltd.) for thematic analysis. The researcher's reflective journal and additional field notes were also uploaded as supporting data.

Feasibility outcome measures. Thematic analysis (Braun & Clarke, 2006) was used to identify, analyze, organize, and communicate themes in the qualitative data. The researcher reviewed the audio recordings and field notes after each interview and documented additional reflections in a reflexive diary. After transcribing the interviews, the researcher read and reread the transcripts alongside the supporting field notes and journal entries to ensure immersion in the data. Initial themes (codes) were developed deductively based on the feasibility outcomes, key areas of interest, and interview questions and were used to build a coding framework in NVivo (version 12). Subthemes were subsequently refined and developed inductively from an analysis of theme frequencies, patterns, and occurrences in the data set. The researcher documented any initial observations to clarify coding decisions, keep track of evolving ideas and theories, and improve trustworthiness of the data by providing an audit trial (Nowell, Norris, White, & Moules, 2017). Reviewing and refinement of themes, including any recoding and renaming, were completed by the authors before the final write-up and analysis.

Attendance and adherence data were analyzed for both groups for the duration of their respective 6-week exercise intervention (Weeks 1–6 and 9–14, as detailed in Table 1) to provide further insight into feasibility, demand, and acceptability with this population.

Health and functional outcome measures. Limited efficacy testing was completed on all measures. Descriptive statistics were used to report participant characteristics, recruitment, adherence, and participation rates. Intention-to-treat analysis was applied for all variables where participant data were missing due to missing assessments or dropping out of the study: the last measure taken was carried forward. The intervention effect was calculated using the mean difference (95% confidence intervals) pre- to postintervention. The effect size evaluation was performed using Hedges' g and interpreted as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$) based on Cohen (1988). The analysis was pre- to postintervention compared with the wait-list control. In line with recommendations from Schober, Bossers, and Schwarte (2018), an evaluation of minimally clinically relevant changes and smallest meaningful change (Perera, Mody, Woodman, & Studenski, 2006) was also reported if reliable thresholds were available.

Results

Participants

Of those who were contacted ($n = 18$), 15 consented to eligibility screening, giving an uptake of 83.3% (Figure 1 CONSORT diagram). Four were excluded for not meeting the Fried Frailty criteria. All the eligible participants randomized to the study ($n = 11$) completed the full baseline assessments. Six participants (54.5%) were allocated to the intervention group, and five (45.5%) to the wait-list control group. One participant in the intervention group was unable to join the training intervention due to unrelated health complications and changes in medication, but did not wish to withdraw. This participant remained positive that they would be able to rejoin in due course and completed the post- and follow-up assessments. Subsequently, all data were included in the intention-to-treat analysis. All participants (100%) were assessed for every feasibility and health and functional outcome.

The participants were mainly female (63%), with a mean age of 86.09 (7.18); the age range was 73–95 years. All participants were White and British. Most participants had secondary or degree/diploma education (64%), had been a resident at the care home for 54.00 (55.65, range: 5–156) months, and reported, on average, 2.36 (1.36) medical conditions. The Fried Frailty score was 3.27 (±0.47), with the SPBB scores ranging from one to eight, indicating the presence of frailty and functional limitations. The Katz Activities of Daily Living score was 5.18 (0.98), indicating partial dependency. The calculated gait speed from the SPBB walking test was 0.48 (0.21) m/s, suggesting an increased likelihood of poor health and function, but the SMMSE score of 27.00 (4.17) indicated normal cognitive function. The baseline descriptive characteristics are summarized by group in Table 5. This also shows no significant sociodemographic or screening measure score differences between the intervention and control group, although cognitive function was marginally higher in the intervention group.

The primary outcomes were concerned with feasibility; the quantitative feasibility statistics are shown in Table 6. Overall uptake and retention were over 80%. Attendance and adherence, in the intervention but not the control group, were consistent with previous findings (Martin & Sinden, 2001) and exceeded 80% in all cases. Table 7 presents a breakdown of adherence by participant, detailing total repetitions, repetitions at prescribed load, and those meeting the adherence criteria. Most striking are the differences in the adherence criteria: in the intervention group, excluding intention-to-treat analysis, completion in all cases was over 95% and met the adherence criteria, while the control group recorded less than 50% in all cases, with none meeting the criteria. All participants engaged in interviews except one person from the control group, due to illness. The interview duration ranged from 8 to 37 min. Care home management and well-being staff focus groups were both 36 min in duration.

Feasibility Outcomes

The qualitative findings from the focus groups and interviews established several themes for each of the feasibility issues examined. These are outlined in Figure 2 for illustrative purposes.

Acceptability. Two themes were identified: "Appropriateness of Intervention" and "Participant Experience." As regards "Appropriateness of Intervention," the discussions were focused on the suitability of the equipment and exercise prescription, the relevance

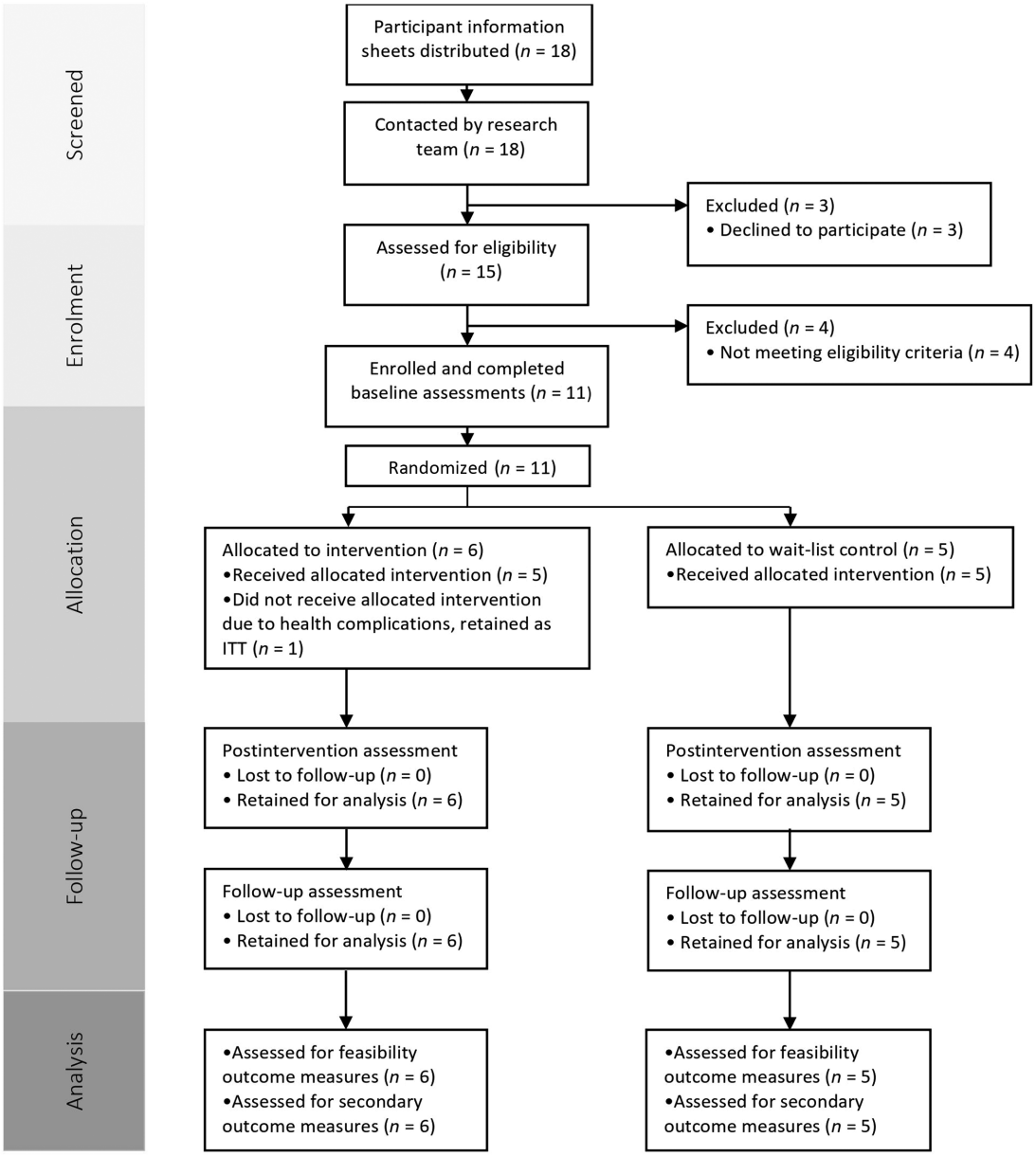

Figure 1 — Consolidated Standards of Reporting Trials (CONSORT 2010) participant flow diagram. *Note*. The figure is based on the CONSORT extension for pilot and feasibility trials flow diagram (Eldridge et al., 2016). ITT = intention to treat.

of the assessments, and engagement with the research team. The staff explained that, despite some initial reservations, it had fitted in well, with high levels of engagement and interest. Limited capacity to support more residents, particularly those with cognitive impairment, was reported as the only negative feature. The comments from most participants were that the exercise prescription was "reasonable," "manageable," and "beneficial." One participant, commenting on the suitability, said, "I've just been quite happy doing the exercises and coming along. I've felt it's not been too hard, too onerous, too exacting. I can quite easily cope with it and I've found it quite pleasant" (Mary, participant, wait-list control). Opinions about the assessments, including the overall number, requirement for multiple reassessments, and some of the questionnaires, were more divergent. For example, while some participants spoke of enjoying the detail and "thought-provoking" nature of the questions, others said that they were "pretty useless," "a bit out of this world," and lacking relevance.

The participants spoke positively about the practical relevance of the functional capacity tests, considered it to be "pretty obvious" that the physical tests were going to be useful, and, despite it being a novel experience, took a keen interest in the strength measures. The participants talked candidly about the new challenges: "getting on those machines . . . . grrr . . . and testing to your limits . . . phew, you know, and that's coz I'm not used to it, you see" (William, participant, wait-list control).

In terms of "Participant Experience," most participants described their experience of the intervention as having been physically, mentally, and socially beneficial and recognized that doing more exercise positively impacted their general health. The participants spoke about improvements in leg strength, balance,

Table 5 Baseline Sociodemographic, Anthropometric, and Health-Related Characteristics of Sample

	Mean (*SD*)/*n* (%)		
Variable	**Intervention (*n* = 6)**	**Wait-list control (*n* = 5)**	***p***
Age (years)	85.83 (7.83)	86.40 (7.20)	.90
Range (years)	73–93	79–95	
Gender			
Female	3 (50.0)	4 (80.0)	.30
BMI (kg/m^2)	25.22 (4.87)	27.83 (1.75)	.29
Medical conditions	3.00 (1.55)	1.60 (0.55)	.09
Education			
Primary	1 (16.7)	3 (60.0)	.27
Secondary	4 (66.7)	2 (40.0)	
Degree/diploma	1 (16.7)	0 (0)	
Education years	10.67 (1.03)	9.40 (0.89)	.06
Occupation			
Manual	2 (33.3)	2 (40.0)	.82
Marital status			
Never	1 (16.7)	2 (40.0)	.33
Married	2 (33.3)	0 (0.0)	
Separated/divorced	0 (0.0)	1 (20.0)	
Widowed	3 (50.0)	2 (40.0)	
Length of stay (months)	46.7 (57.5)	62.8 (58.6)	.66
Fried frailty score	3.33 (0.52)	3.20 (0.45)	.66
SPPB score	5.83 (1.94)	3.60 (3.13)	.18
SPPB gait speed (m/s)	0.55 (0.20)	0.39 (0.21)	.23
Katz ADL	5.50 (0.84)	4.80 (1.10)	.26
SMMSE	29.17 (1.17)	24.40 (5.13)	.05*

Note. ADL = Activities of Daily Living; BMI = body mass index; SMMSE = Standardized Mini-Mental State Examination; SPPB = Short Physical Performance Battery. *$p \le .05$, **$p \le .01$, ***$p \le .001$, differences indicated by independent *t* tests, or chi-squared for categorical variables.

Table 6 Overall Feasibility Statistics

Statistic	Group	%
Study uptake	Both	83.3
Retention rate	Both	100.0
Session attendance[a]		
All allocated participants (*n* = 6)	Intervention	82.4
Excluding ITT participant (*n* = 5)	Intervention	98.9
All allocated participants (*n* = 5)	Wait-list control	34.4
Session adherence[b]		
All allocated participants (*n* = 6)	Intervention	83.05
Excluding ITT participant (*n* = 5)	Intervention	99.66
All allocated participants (*n* = 5)	Wait-list control	24.68

Note. ITT = intention to treat; reps = repetitions.
[a]Number of scheduled sessions attended, reported as a percentage of total available sessions. Intervention group = 18 total sessions (6 weeks, 3 days per week); control group = 12 total sessions (six scheduled sessions cancelled by facility due to room timetable clashes and norovirus outbreak containment procedures). [b]Adherence to intervention exercise prescription (calculated as percentage of total reps completed at prescribed load).

and movement confidence. Feedback to the staff from one participant's family had been that of astonishment, such were the improvements in walking speed and capacity on a family holiday. Commenting on their experience, one participant explained,

> My balance. My walking. I do have a three-wheeler walker but even so when I first starting using it, I was zigzag on the corridor but now . . . and I can speed up my walking a little bit. Mentally it's given me the confidence to do things that I couldn't. (Betty, participant, intervention)

The participants placed value on regular social interaction, involvement, and purpose. They spoke about enjoying talking to the researchers, the mental and physical stimulus of the intervention, and the opportunity to connect with fellow residents. One participant stated that "I think it has helped bring the five of us out that are residents in the home . . . . I think it's helped us relax and be able to communicate" (Betty, participant, intervention).

Demand. The feasibility outcome of Demand generated two themes of "Attendance and Adherence" and "Interest and Reasons for Involvement." Regarding "Attendance and Adherence," the participants suggested that 3 days a week was "not excessive" and "just about right." One participant with full attendance noted, "Well, I think this is the sort of thing, once you start you've got to keep it going. To be most effective" (James, participant, intervention). The staff members expressed surprise at the commitment and adherence of the participants and explained that this was contrary to their initial expectations. Reflecting on why attendance had exceeded expectations, the staff were candid about the need for routine, structure, consistency, and encouragement when working with older adults in residential care. The recorded

Table 7 Session Adherence by Participant

Participant ID	Group	Adjusted reps	Actual reps completed (% of total prescription)	Prescribed reps completed (% of total prescription)	Adherence criteria met (Y/N)
01	Intervention	2,972	98.28	98.28	Y
09	Intervention	3,097	102.41	100.00	Y
10	Intervention	3,565	117.89	100.00	Y
14	Intervention[a]	0	0.00	0.00	N
15	Intervention	3,099	102.48	100.00	Y
17	Intervention	3,911	129.33	100.00	Y
05	Wait-list control	290	9.59	9.59	N
06	Wait-list control	366	12.10	12.10	N
07	Wait-list control	1,116	36.90	36.90	N
11	Wait-list control	1,462	48.35	48.35	N
13	Wait-list control	498	16.47	16.47	N

Note. Adjusted reps includes all optimally and overperformed reps only, as reported by the SmartTouch software, and in line with the progressive loading prescription. Any reps at less than prescribed load were not included. Adherence criteria is detailed in the published protocol (Doody et al., 2019). ITT = intention to treat; reps = repetitions; Y= yes; N = no.
[a]ITT participant.

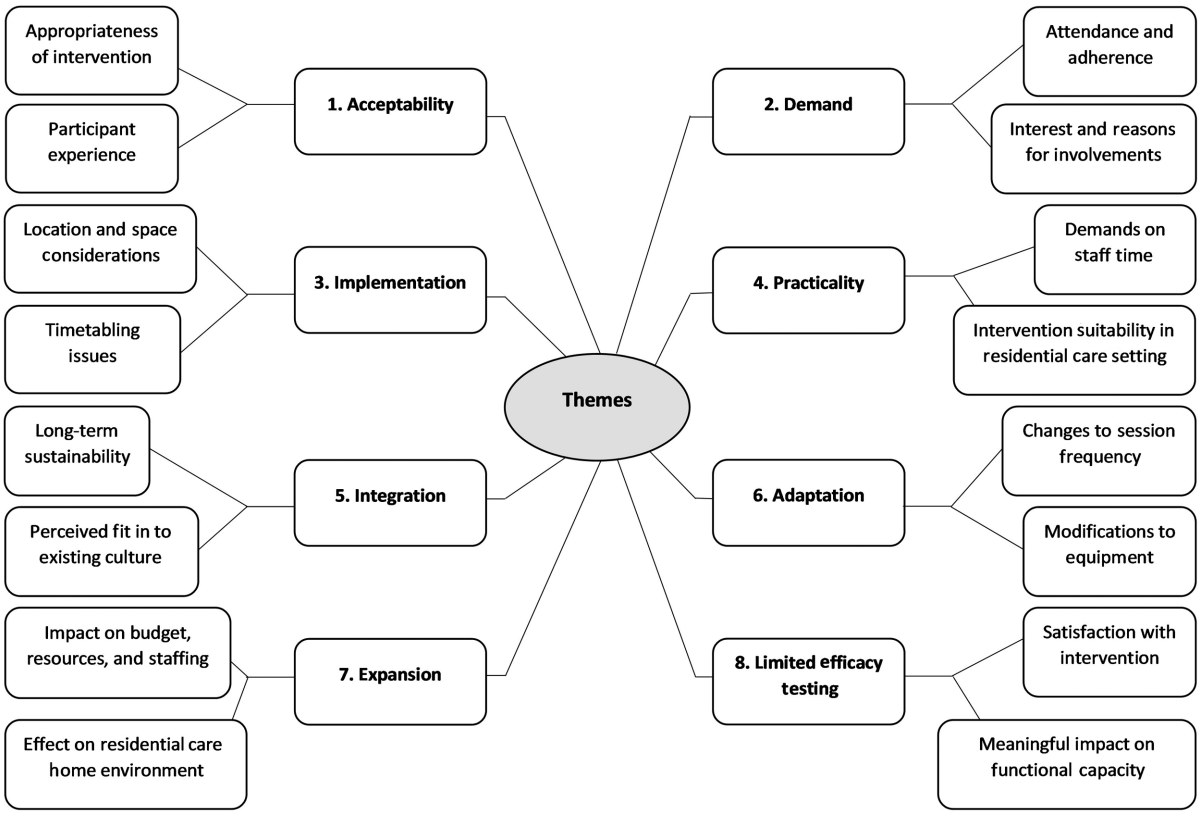

Figure 2 — Thematic coding structure map. *Note*. Mind-map (NVivo, version 12) illustrating the feasibility outcomes and subsequent themes identified from the thematic analysis of the interviews and focus group discussions.

levels of attendance and adherence were notably lower in the wait-list control group. The staff suggested that individual levels of motivation, group cohesion, and physical proximity to the exercise equipment may have made a difference.

"Interest and Reasons for Involvement" was identified as a theme, with several participants enthusiastically embracing the opportunity to take part. The participants spoke about enjoying the physical challenge, mental stimulation, self-reflection, and opportunity to benchmark their functional ability. For example, one participant said, with laughter,

> I know I'm 80 and things do wear out but what's the point? If you've got the help to do something to improve your health both physically and mentally, and it's free, then why not benefit ... make use of it? (Betty, participant, intervention)

The staff discussed a "can-do attitude" toward research in the residential care home and were upbeat about the physical activity intervention and potential impact. The participants spoke about "being useful," "helpful," creating more knowledge, and a feeling that others may benefit from the findings: "Does it mean that I'm helping people? Now, if I'm helping anybody, good, tick me off please, and I'll step into that one quite freely" (Joyce, participant, wait-list control).

Implementation. Two themes were developed here: "Location and Space Considerations" and "Timetabling Issues." Regarding "Timetabling Issues," the staff and participants felt that working within and respecting the existing daily routines of the care home had minimized any negative impact and meant that the intervention "fitted in" well. "Location and Social Space Considerations" was a more contentious theme. Some staff members felt strongly that installing and using the exercise equipment in the lounge area was detrimental:

> It restricts a lot of space and loads of people don't like it which then creates actually more negative feeling about it rather than creating a positive "oh, I would get involved" ... they don't want it in their space, it's getting in the way ... in an ideal world I don't think anyone would want it there permanently. (Jessica, staff member)

Others maintained that any negative issues were minor, with the benefits outweighing any perceived disadvantage. One staff member, for example, expressed an opinion that high visibility and accessibility had been advantageous:

> I think a lot of it has been to do due with the fact that it is so visible. It's kept it in their thoughts ... "oh, yes we're doing that" ... and then other people have asked them questions and they like the fact that they can say, "I'm involved in this that and the other" ... and doing this ... so helps to generate it because they've got a talking point whereas if it's away in a cupboard people aren't going to say, "what's that all about?" because they don't see it. (Linda, staff member)

Practicality. For practicality, "Demands on Staff Time" and "Intervention Suitability in Residential Care Setting" themes emerged. "Demands on Staff Time" was a theme for both the staff and participants. Overall, the staff felt positively about their time input and how it had changed over the project duration: more help was needed in the early stages, including assistance with local knowledge, promotion, and recruitment, whereas the latter stages required less direct involvement. The need to request additional help from the staff to access the equipment, for example, was a concern for some less able participants: "I was a bit concerned that two people had to lift me off that one machine, well helped with a lift up. I don't like to involve the staff, you see" (William, participant, wait-list control).

In terms of "Intervention Suitability in Residential Care Setting," it became clear that there were important practical considerations around scheduling and space demands. The staff pointed out that minimizing changes to preexisting schedules and creating a routine would be important for any future research. The demands on space in residential care homes were recognized as a practical issue of "impact" and "restriction," and the experienced care staff saw this is a potential barrier: "They [care homes] weren't designed with certain things in mind as care has progressed on so it's not just a problem in that room in this instance, it's a general problem" (Linda, staff member).

Integration. Regarding integration, two themes were explored: "Perceived Fit of Exercise into Existing Culture" and "Long-Term Sustainability." For "Perceived Fit into Existing Culture," the staff noted that exercise was already an accepted, regular, and popular feature on the well-being timetable in the form of a seated "Music and Movement" class. However, it was discussed that, although this was "fantastic" for frail and wheelchair-bound people, the training intervention had been a "real outlet," and a good fit for those who wanted to participate in more challenging exercise options.

Under "Long-Term Sustainability," the staff remarked that there was additional demand for the equipment above and beyond the feasibility trial and that even residents who were not involved in the trial had expressed interest. One staff member felt strongly that it was viable and would provide an opportunity to reinforce education surrounding long-term quality of life:

> I have seen frail people become a lot better. And I think that the education ... just because you're old, isn't an excuse for poor quality of life, because you can get better. You can improve your quality of life, until you die. (Lauren, staff member)

Most study participants were also supportive of long-term possibilities: "I think it's been a great idea and I only hope that they'll keep the equipment, quite frankly." (Arthur, participant, intervention)

Adaptation. Two key themes were established here: "Changes to Session Frequency" and "Modifications to Equipment." While the staff and participants were open to considering changes to the frequency of sessions, there was overall support for the original format (three times per week). Some staff members talked positively about increasing the availability of sessions so long as this could be maintained within a regular structure and routine: "I think that people really like routine here and if you can build it into a routine, you could even get it more frequently really" (Jessica, staff member).

Under "Modifications to Equipment," most staff comments were positive and included praise for the specific design functions for older people, ability to individualize loading and progression, and ease of installation. Feedback from the participants was more nuanced: some participants felt it lacked broader accessibility and had presented challenges, including physically "getting on" to the machines.

Several participants were, however, undaunted by any additional physical demands. As one particularly upbeat interviewee laughingly explained,

> Well, out of 4 machines there was one where ... well I called it "The Beast" ... because you had to put your legs under these rollers, and I did find that difficult, but we laughed about it and I was helped. (Betty, participant, intervention)

Expansion. Two key themes emerged from the feasibility outcome of expansion: "Impact on Budget, Resources and Staffing" and "Effect on Residential Care Home Environment." The staff felt that any further expansion would be a "huge commitment and cost" and were concerned about "cost effectiveness" and whether use would be sustained long term. The staff explained that the equipment alone would not be enough, and having a specialist, a trained and motivating individual on-site with an ability to understand older people "makes a difference":

> I don't think you could put it in a room aside from anything else. I think you've got to build something else in. So, whether you have a person who oversees the whole lot and spurs people on, it's encouragement, I think, really. I think you've got to have that particular person who's motivating enough to do it. (Susan, staff member)

"Effect on Residential Care Home Environment" was identified as an issue for further expansion, especially in care facilities that were not purpose built, with the equipment viewed as "taking up a lot of space." However, there were differing perspectives within the staff:

> I find there to be a big benefit with exercise so I would outweigh the benefit with the fact that it is in the room because I know the benefit of exercise, I put a lot of stock into it. Yes, I would be quite happy to have it stay there regardless of the fact that it is in the way or not, but I understand that it might not be ideal, but I think it's good. (Lauren, staff member)

Limited efficacy testing. Two key themes were established here: "Meaningful Impact on Functional Capacity" and "Satisfaction with Intervention." In terms of "Meaningful Impact on Functional Capacity," it became clear that improvements in strength, walking speed, and balance were recognized and valued by both the staff and participants. The participants described feeling "much firmer on my feet," healthier, and strong enough to get out of chairs without using their arms:

> Well, overall, I found it very beneficial physically and also mentally because I've been diagnosed with vascular dementia and having various buttons to press, when and whatever, I have found it very beneficial. But physically I am doing things that I haven't been able to do, for you know. (Betty, participant, intervention)

However, some participants were more reserved with their judgments and felt that it had not "made a great deal of difference," "achieved a limited objective," and that while it had "built things up somewhat," it was too soon to assess the impact.

In relation to "Satisfaction with Intervention," both the staff and participants felt that, overall, the intervention had been a positive experience: the staff spoke about it as having been "a great success," "better than we anticipated," and "really good." It was suggested that it had been a "social interaction" and facilitated a "joining together of the group." One staff member commented on the social aspect of the group intervention: "I think it's good to keep this generation of people as busy as possible because it fights loneliness and fights all sorts of other things, so I think that it has been really positive time" (Lauren, staff member). The participants talked in terms of having been "very happy "and "pleased," and "enjoying" the intervention: "Yes, I'm just sorry that it's come to an end and just hope and pray that these machines can be here a bit longer. Sorry to see them go whenever" (Betty, participant, intervention). And another reflected that "in a way, it's given us a little bit more purpose in living. It feels as though perhaps you might be, you can still be a little bit useful, even though you are old" (Mary, participant, wait-list control).

Health and Functional Outcomes

Analyses of pre- to postintervention compared with the wait-list control indicated significant differences in some variables; however, due to the feasibility nature of this study, the mean differences, 95% confidence interval, and effect sizes are also presented (Table 8). Changes that are most notable are shown in Table 8. These included differences in some measures of strength and functional capacity: peak torque measures for the right knee extension and hip abduction, and the Fried Frailty walk time, walk test speed, and total score. Changes over time in some measures of functional capacity also indicated clinically important change (Kwon et al., 2009): the mean difference in the Short Physical Performance Battery gait speed (0.24 m/s) and Short Physical Performance Battery total score (1.50).

The measures showing improvement, as described above, are shown in Figures 3–7. The follow-up time point is also shown for the sake of completeness. The variables that did not seem to differ in any way between the groups over time were cytokines and stress hormones and the psychological/emotional (Geriatric Depression Scale, Hospital Anxiety Depression Scale, Perceived Stress Scale), cognitive (SMMSE), and social support measures (Interpersonal Support Evaluation List).

Harms

There were no reported adverse events during the feasibility trial.

Discussion

This study has shown that a resistance training intervention designed to improve the multidimensional health and functional capacity of frail older adults in residential care is feasible. The results of this trial support the development of a definitive RCT and provide relevant feedback in terms of acceptability, demand, integration, adaptation, practicality, implementation, and expansion. With respect to the secondary aim of performing limited efficacy testing on measures of health and functional capacity, the results indicate large effect size values, positive trends, and meaningful improvements in frailty, strength, and functional capacity. No meaningful change was found in terms of psychological, cognitive, and emotional health or physiological and social support measures.

Acceptability

Acceptability of the intervention was evident, with positive feedback on the trial structure, equipment, and exercise prescription. Levels of interest, uptake, and retention suggest that recruitment and screening processes were effective and appropriate. The recruitment rates were similar or higher than other resistance training studies with older adults in residential care (Fien et al., 2016; Johnen & Schott, 2018), and the dropout rates were lower than those reported in RCTs examining exercise programs in older adults (Martin & Sinden, 2001; Paw, Chin, van Uffelen, Riphagen, & van Mechelen, 2008), with no adverse effects reported. The number and range of assessments were well tolerated by all

Table 8 Effects Table: Within- and Between-Group Changes From Baseline to Follow-Up

	Intervention					Wait-list control					Mean difference in changes between groups		
Outcome measure	*n*	Premean (*SD*)	Postmean (*SD*)	Mean difference [95% CI]	*p*	n	Premean (*SD*)	Postmean (*SD*)	Mean difference [95% CI]	*p*	Mean difference [95% CI]	*p*	Effect size (Hedges' *g*)
Knee extion left, peak torque (N·m)	6	79.44 (33.77)	92.93 (43.13)	13.49 [−0.24, 27.21]	.05*	4	49.34 (21.28)	43.51 (15.14)	−5.83 [−22.64, 10.98]	.45	19.31 [−2.39, 41.02]	.07	1.20
Knee extension right, peak torque (N·m)	6	79.86 (33.28)	92.13 (41.68)	12.27 [4.03, 20.50]	.01**	5	52.13 (17.19)	50.04 (12.33)	−2.09 [−14.03, 9.86]	.70	14.35 [2.14, 26.57]	.03*	1.47
Knee flexion left, peak torque (N·m)	6	35.82 (17.96)	44.25 (18.38)	8.44 [0.50, 16.38]	.04*	5	28.75 (7.44)	27.24 (6.05)	−1.51 [−10.21, 7.19]	.70	9.95 [−1.81, 21.70]	.08	1.06
Knee flexion right, peak torque (N·m)	6	44.70 (20.59)	51.73 (22.74)	7.03 [1.78, 12.27]	.01**	5	29.35 (11.96)	28.77 (11.39)	−0.58 [−6.32, 5.17]	.83	7.60 [−0.33, 15.53]	.06	1.22
Hip adduction, peak torque (N·m)	6	94.74 (36.95)	105.41 (42.05)	10.68 [90.28, 21.07]	.05*	5	74.50 (23.25)	72.93 (15.46)	−1.57 [−12.96, 9.82]	.76	12.25 [−3.17, 27.66]	.11	1.00
Hip abduction, peak torque (N·m)	6	61.81 (20.19)	69.22 (20.55)	7.42 [1.23, 13.61]	.02*	5	63.42 (13.56)	60.89 (8.99)	−2.53 [−9.31, 4.26]	.42	9.94 [0.76, 19.13]	.04*	1.36
SPPB balance test (0–4)	6	3.17 (0.75)	3.17 (0.75)	0.00 [−0.70, 0.70]	1.00	5	1.80 (2.05)	1.40 (1.95)	−0.40 [−1.17, 0.37]	.27	0.40 [−0.64, 1.44]	.41	0.48
SPPB gait speed (0–4)	6	2.00 (0.89)	3.17 (0.98)	1.17 [0.12, 2.22]	.03*	5	1.40 (0.55)	1.60 (.089)	0.20 [−0.95, 1.35]	.70	0.97 [−0.58, 2.51]	.18	0.78
SPPB gait speed (m/s)	6	0.55 (0.20)	0.79 (0.19)	0.24 [0.07, 0.40]	.01**	5	0.39 (0.21)	0.46 (0.27)	0.07 [−0.12, 0.25]	.43	0.17 [−0.07, 0.42]	.14	0.88
SPPB chair stand (0–4)	6	0.67 (0.52)	1.00 (1.10)	0.33 [−0.23, 0.90]	.21	5	0.40 (0.55)	0.40 (0.55)	0.00 [−0.62, 0.62]	1.00	0.33 [−0.52, 1.19]	.36	0.50
SPPB total points (0–12)	6	5.83 (1.94)	7.33 (2.25)	1.50 [−0.02, 3.02]	.05*	5	3.60 (3.13)	3.40 (3.29)	−0.20 [−1.86, 1.46]	.79	1.70 [−0.57, 3.97]	.11	0.95
Katz ADL (0–6)	6	5.50 (0.84)	5.17 (0.98)	−0.33 [−0.96, 0.29]	.26	5	4.80 (1.10)	4.60 (1.34)	−0.20 [−0.89, 0.49]	.53	−0.13 [−1.06, 0.79]	.75	−0.18
Fried frailty, weight loss (0–1)	6	0.17 (0.41)	0.00 (0.00)	−0.17 [−0.45, 0.11]	.21	5	0.00 (0.00)	0.00 (0.00)	0.00 [−0.31, 0.31]	1.00	−0.17 [−0.60, 0.26]	.36	−0.50
Fried frailty 2a, depression (0–3)	6	1.33 (1.21)	1.00 (0.89)	−0.33 [−1.59, 0.92]	.56	5	1.00 (0.71)	1.60 (1.14)	0.60 [−0.77, 1.97]	.35	−0.93 [−2.79, 0.92]	.28	−0.63
Fried frailty 2b, depression (0–3)	6	1.00 (1.10)	0.50 (0.55)	−0.50 [−1.34, 0.34]	.21	5	1.20 (1.30)	1.20 (1.30)	0.00 [−0.92, 0.92]	1.00	−0.50 [−1.75, 0.75]	.39	−0.50
Fried frailty, grip strength (kg)	6	21.82 (6.39)	24.55 (7.44)	2.73 [0.82, 4.65]	.01**	5	15.78 (2.96)	16.48 (3.23)	0.70 [−1.39, 2.79]	.47	2.03 [−0.75, 4.82]	.13	0.90
Fried frailty, walk test (s)	6	9.03 (4.48)	5.80 (1.31)	−3.23 [−5.90, −0.56]	.02*	5	16.06 (12.25)	17.07 (12.77)	1.01 [−1.91, 3.93]	.45	−4.24 [−8.19, −0.28]	.04*	−1.34
Fried frailty, walk test speed (m/s)	6	0.60 (0.24)	0.82 (0.17)	0.22 [0.13, 0.31]	.00***	5	0.44 (0.29)	0.40 (0.27)	−0.03 [−0.13, 0.07]	.46	0.25 [0.12, 0.39]	.00***	2.35
Fried MLTAQ (kcal/week)	6	75.61 (89.54)	76.89 (63.88)	1.28 [−72.57, 75.13]	.97	5	32.47 (32.49)	8.55 (16.08)	−23.92 [−104.81, 56.98]	.52	25.20 [−84.34, 134.73]	.62	0.29
Fried frailty total (0–5)	6	3.33 (0.52)	2.00 (0.89)	−1.33 [−1.96, −0.71]	.00***	5	3.20 (0.45)	3.40 (0.55)	0.20 [−0.49, 0.89]	.53	−1.53 [−2.46, −0.61]	.00***	−2.07
GDS total (0–30)	6	5.67 (3.20)	5.33 (3.67)	−0.09 [−74.85, 74.67]	.87	5	6.20 (1.92)	4.80 (3.03)	−1.40 [−3.75, 0.95]	.21	−2.11 [4.25, 0.47]	.47	0.42
HADS anxiety (0–7)	6	2.33 (2.66)	2.83 (3.31)	0.50 [−2.13, 3.13]	.67	4	3.75 (2.06)	3.25 (3.30)	−0.50 [−3.72, 2.72]	.73	1.00 [−3.16, 5.16]	.60	0.32

(continued)

Table 8 *(continued)*

Outcome measure	Intervention					Wait-list control					Mean difference in changes between groups		
	n	Premean (*SD*)	Postmean (*SD*)	Mean difference [95% CI]	*p*	n	Premean (*SD*)	Postmean (*SD*)	Mean difference [95% CI]	*p*	Mean difference [95% CI]	*p*	Effect size (Hedges' *g*)
HADS depression (0–7)	6	4.67 (2.80)	4.33 (3.08)	−0.33 [−1.79, 1.13]	.62	5	2.40 (2.07)	3.80 (3.42)	1.40 [−0.20, 3.00]	.08	−1.73 [−4.56, 1.10]	.17	−1.02
PSS total (0–40)	6	10.33 (6.62)	10.67 (7.58)	0.33 [−4.35, 5.02]	.88	5	14.00 (9.57)	10.00 (7.68)	−4.00 [−9.13, 1.13]	.11	4.33 [−2.61, 11.28]	.19	0.78
SMMSE total (0–30)	6	29.17 (1.17)	29.00 (1.10)	−0.17 [−2.39, 2.05]	.87	5	24.40 (5.13)	24.80 (7.73)	0.40 [−2.03, 2.83]	.72	−0.57 [−3.86, 2.73]	.71	−0.22
ISEL appraisal (0–12)	6	6.67 (3.08)	7.67 (2.07)	1.00 [−1.01, 3.01]	.29	5	7.40 (2.30)	7.20 (1.79)	−0.20 [−2.41, 2.01]	.84	1.20 [−1.79, 4.19]	.39	0.50
ISEL belonging (0–12)	6	5.33 (2.16)	6.17 (2.14)	0.83 [−0.74, 2.40]	.26	5	7.20 (2.28)	6.60 (0.89)	−0.60 [−2.32, 1.12]	.45	1.43 [−0.90, 3.76]	.20	0.77
ISEL tangible (0–12)	6	7.83 (0.98)	8.00 (0.63)	0.17 [−0.97, 1.30]	.75	5	6.00 (1.73)	7.20 (1.10)	1.20 [−0.05, 2.45]	.06	−1.03 [−2.72, 0.65]	.20	−0.77
MNA total (0–14)	6	12.67 (1.51)	11.50 (2.59)	−1.17 [−3.38, 1.05]	.26	5	12.40 (1.82)	11.60 (1.67)	−0.80 [−3.22, 1.62]	.47	−0.37 [−3.65, 2.91]	.81	−0.14
IL-6 (pg/ml)	6	0.60 (1.20)	0.33 (0.36)	−0.27 [−0.89, 0.35]	.35	5	0.44 (0.37)	0.18 (0.14)	0.26 [−0.94, 0.43]	.42	−0.01 [−0.94, 0.91]	.97	−0.02
IL-8 (pg/ml)	6	37.43 (41.22)	20.34 (18.79)	−17.09 [−57.74, 23.55]	.37	5	57.05 (51.57)	18.49 (13.02)	−38.57 [−83.09, 5.96]	.08	21.47 [−38.81, 81.76]	.44	0.45
TNFα (pg/ml)	6	0.99 (0.70)	1.00 (0.53)	0.02 [−0.43, 0.47]	.93	5	1.00 (0.52)	1.08 (0.64)	0.08 [−0.41, 0.57]	.71	−0.06 [−0.73, 0.60]	.83	−0.12
IFNγ (pg/ml)	6	0.06 (0.13)	0.03 (0.04)	−0.03 [−0.14, 0.07]	.49	5	0.01 (0.01)	0.01 (0.03)	0.01 [−0.11, 0.12]	.91	−0.04 [−0.20, 0.12]	.58	−0.32
Cortisol (ng/ml)	6	121.44 (24.93)	150.45 (37.01)	29.01 [−3.53, 61.54]	.07	5	130.89 (38.64)	142.84 (46.42)	11.95 [−23.69, 47.59]	.47	17.06 [−31.14, 65.25]	.42	0.44
DHEAs (ng/ml)	6	409.73 (249.48)	394.37 (225.05)	−15.37 [−85.31, 54.58]	.63	5	600.53 (500.22)	582.49 (432.77)	−18.04 [−94.66, 58.58]	.61	2.67 [−101.07, 106.42]	.95	0.03
Cortisol:DHEAs	6	0.39 (0.19)	0.52 (0.34)	0.14 [−0.02, 0.29]	.08	5	0.71 (1.07)	0.66 (0.92)	−0.05 [−0.22, 0.12]	.50	0.19 [−0.04, 0.42]	.10	1.03

Note. ADL = Activities of Daily Living; CI = confidence interval; DHEAS = dehydroepiandrosterone sulfate; GDS = Geriatric Depression Scale; HADS = Hospital Anxiety and Depression Scale; IFNγ = Interferon gamma; IL = Interleukin; ISEL = Interpersonal Support Evaluation List; MLTAQ = Minnesota Leisure-Time Activity Questionnaire Shortened Version; MNA = Mini Nutritional Assessment; PSS = Perceived Stress Scale; SMMSE = Standardized Mini-Mental State Examination; SPPB = Short Physical Performance Battery; TNFα = Tumour Necrosis Factor alpha.

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$, differences indicated by independent *t* tests.

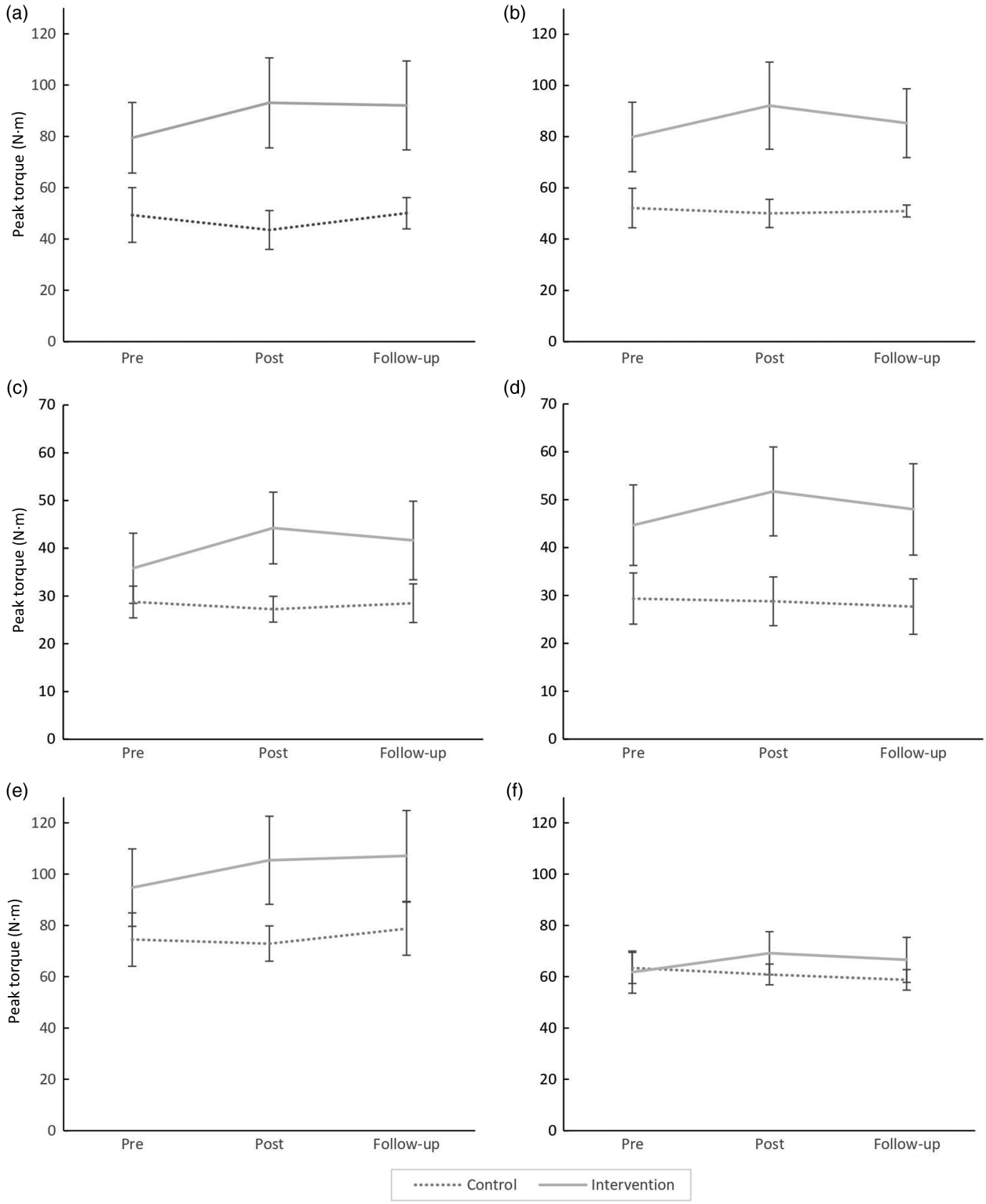

Figure 3 — Strength measures. *Note*. Peak torque measures (in newton meters) over time in intervention and wait-list control groups. (a) Left knee extension, (b) right knee extension, (c) left knee flexion, (d) right knee flexion, (e) hip adduction, and (f) hip abduction. Error bars represent *SE*.

participants, with perceived or measurable changes in strength and functional ability considered to be most relevant and interesting. In line with work by Dionigi and Cannon (2009), these actual and perceived changes appeared to contribute to increased feelings of achievement, confidence, and satisfaction. Despite no meaningful change in social support measures, the participants reported enjoying the social interaction, engagement with other residents and staff, and gaining a sense of purpose. This finding is consistent with Devereux-Fitzgerald, Powell, Dewhurst, and French (2016), who found perceived value, enjoyment, and social interaction to be key

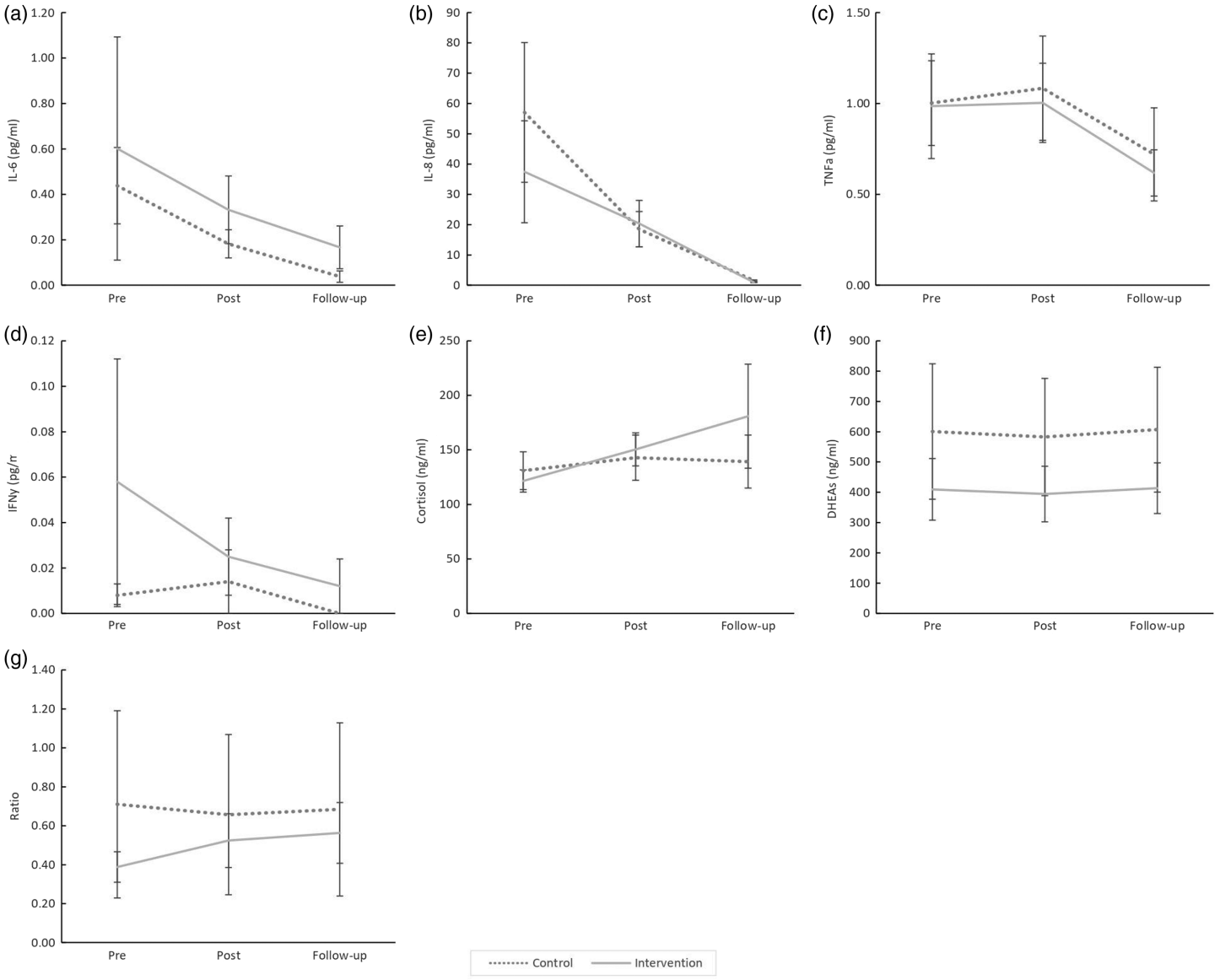

Figure 4 — Physiological measures. *Note*. Blood measures over time in intervention and wait-list control groups. (a) IL-6, (b) IL-8, (c) TNFα, (d) IFNγ, (e) cortisol, and (f) DHEAs, and (g) cortisol. Error bars represent *SE*. IL-6 = Interleukin-6; IL-8 = Interleukin-8; TNFα = tumor necrosis factor alpha; IFNγ = interferon gamma; DHEAs = dehydroepiandrosterone sulfate.

factors relating to older adults' acceptability of physical activity interventions.

Demand

Levels of attendance and adherence were comparable with or higher than previous studies of older adults in long-term care (Ferreira et al., 2018; Finnegan et al., 2015; Forster, Lambley, & Young, 2010), and an exercise frequency of three times per week was considered appropriate. This supports earlier findings from group resistance training interventions (Hruda, Hicks, & McCartney, 2003; Lazowski et al., 1999; Sahin et al., 2018) and is consistent with current exercise guidelines for older adults (Davies et al., 2019; Fragala et al., 2019). Clear differences were identified between the groups for adherence and attendance. Although the magnitude of this difference was surprising, challenges and barriers relating to retention, adherence, and participation are not uncommon. Previous research highlighted the complex multidimensional nature of frailty (Ferrucci et al., 2004; Provencher, Mortenson, Tanguay-Garneau, Bélanger, & Dagenais, 2014) and identified several barriers, including poor health, pain, and fatigue (Burton et al., 2017; Hassan et al., 2016). In the present study, these differences could be attributed to two likely factors that occurred when the wait-list control received their intervention. First, there was lower one-to-one support during this time due to unforeseen reduced availability of the researcher. Second, there was an unanticipated disruption to the schedule due to timetabling conflicts, a period of restricted access due to infection-control measures, and bank holidays. Interest and willingness to be involved was evident, with reported reasons for involvement spanning enjoyment, interaction, improvements in physical function, and a desire to help others by contributing to research. These results match those of previous studies, where participants cited keenness to contribute to society or knowledge

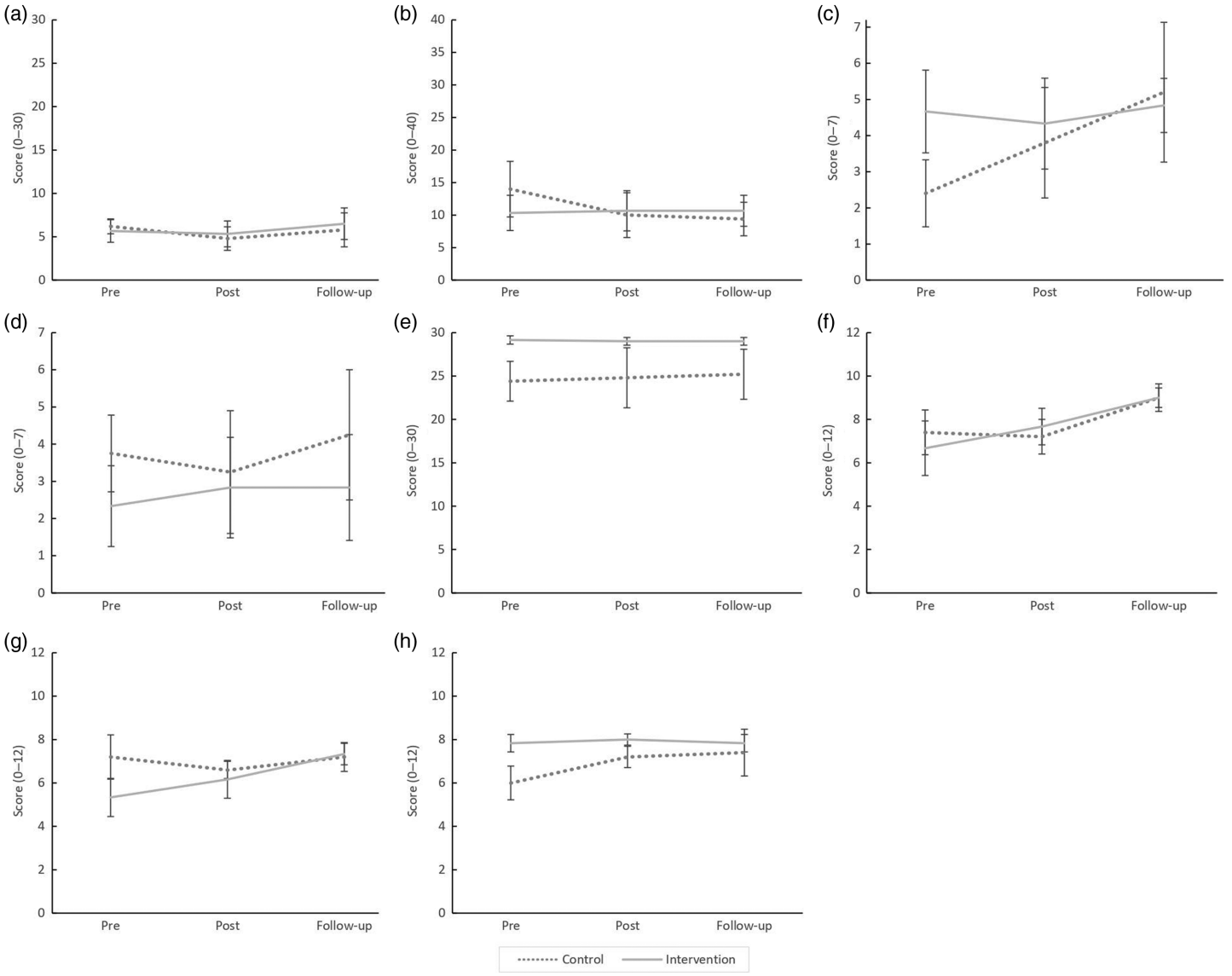

Figure 5 — Psychological, emotional, cognitive, and social support measures. *Note*. Psychological, emotional, cognitive, and social support measures over time in intervention and wait-list control groups. (a) GDS, (b) PSS, (c) Hospital and Anxiety Depression Scale (Depression), (d) Hospital and Anxiety Depression Scale (Anxiety), (e) Standardized Mini Mental State, (f) Interpersonal Support Evaluation List (Appraisal), (g) Interpersonal Support Evaluation List (Belonging), and (h) Interpersonal Support Evaluation List (Tangible). Error bars represent *SE*. GDS = Geriatric Depression Scale; PSS = Perceived Stress Scale.

(Lui, Warburton, & Bartlett, 2009), and enjoyment of social interaction (Devereux-Fitzgerald et al., 2016).

Implementation

The trial was ably supported by the care staff and management team. Consistent with the literature, supportive partnerships with on-site carers and allied health professionals, and enthusiastic backing from welfare activity coordinators and instructors may have been influential in the success of the intervention (Finnegan et al., 2015; Hawley-Hague, Horne, Skelton, & Todd, 2016; Provencher et al., 2014). Using a busy communal area for the equipment, however, remained a somewhat contentious issue throughout. Nonetheless, deliberately creating a high level of visibility in the home may have had a positive influence on levels of adherence, interest, and long-term sustainability (Fien et al., 2016; Fien, Henwood, Climstein, Rathbone, & Keogh, 2019; Mulasso, Roppolo, Liubicich, Settanni, & Rabagliett, 2015).

Implementation of all multidimensional health measures presented some challenges, including scheduling, equipment availability, time commitment, and energy levels. However, the participants did willingly take part, with only limited numbers requiring rescheduling due to unanticipated illness or fatigue. Several participants questioned the requirement for such comprehensive measures and reported finding them repetitive and tiring. These findings correspond with previous observations, which suggest that respondent burden (Ferrucci et al., 2004) and unfavorable benefit-burden ratio (Mody et al., 2008) may negatively impact the recruitment and retention rates of older adults. Given this, and that the meaningful effects here were shown for measures

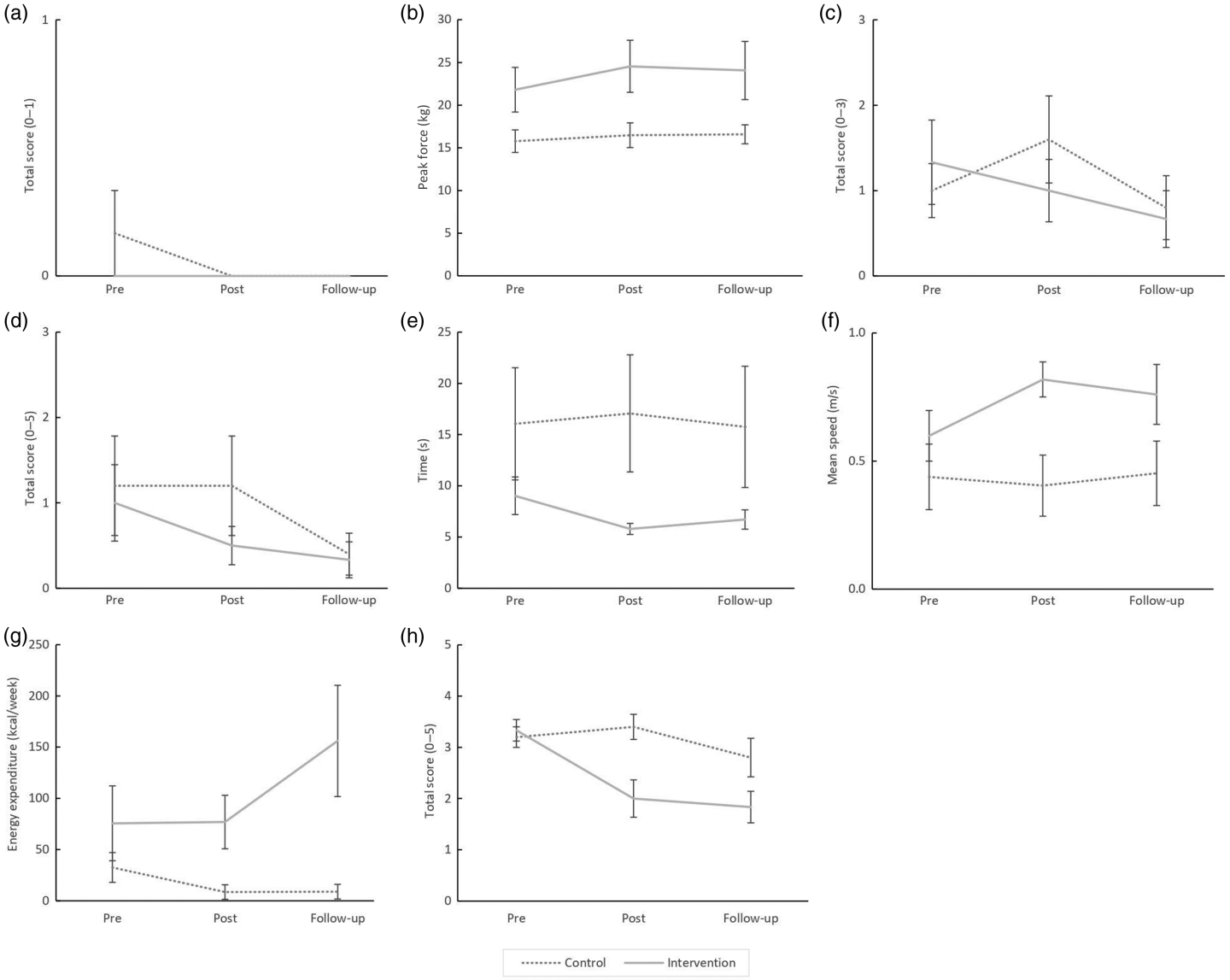

Figure 6 — Eligibility screening and functional capacity measures. *Note*. Fried Frailty Phonotype measures over time in intervention and wait-list control groups. (a) Self-reported unintentional weight loss, (b) grip strength, (c) CES-D Question 1, (d) CES-D Question 2, (e) mean walk test time, (f) mean walk test speed, and (g) MLTAQ Shortened Version. Error bars represent *SE*. CES-D = Center for Epidemiological Studies Depression Scale; MLTAQ = Minnesota Leisure-Time Activity Questionnaire.

of physical function and frailty, fewer assessments of psychosocial factors should be included in the definitive trial, or briefer versions could be considered.

Practicality

The intervention placed some additional demand on staff and management time, and resources. This was most apparent during equipment installation, recruitment, scheduling, and assessment periods. However, the requirement for extra support declined during the exercise intervention phases as routines became established and the participants became increasingly confident and familiar with the program and equipment. These results suggest that the initial financial outlay on specialized resistance machines may pay off longer term with ease of use and individualized progressive programs. Previous research lends support to the use of technology, with Valenzuela, Okubo, Woodbury, Lord, and Delbaere (2018) suggesting that an underused advantage of technology-based exercise programs with older adults is the provision of automatically recorded exercise sessions, load progression, and real-time feedback. Work by Bossers et al. (2014) with older, institutionalized adults with dementia and Johnen and Schott (2018) with nursing home residents also identified the ability to start individualized, progressive programs from a low baseline intensity as a contributor to higher adherence rates. Concerns about space for the equipment and appropriate location and timetabling of group sessions highlighted some potential barriers. These findings are in line with Lazowski et al. (1999), who drew attention to the challenges of intervention delivery, location, and competing appointment times with other activities in long-term care facilities, and Benjamin, Edwards, and Caswell (2009), who reported space constraints and limited designated space for exercise.

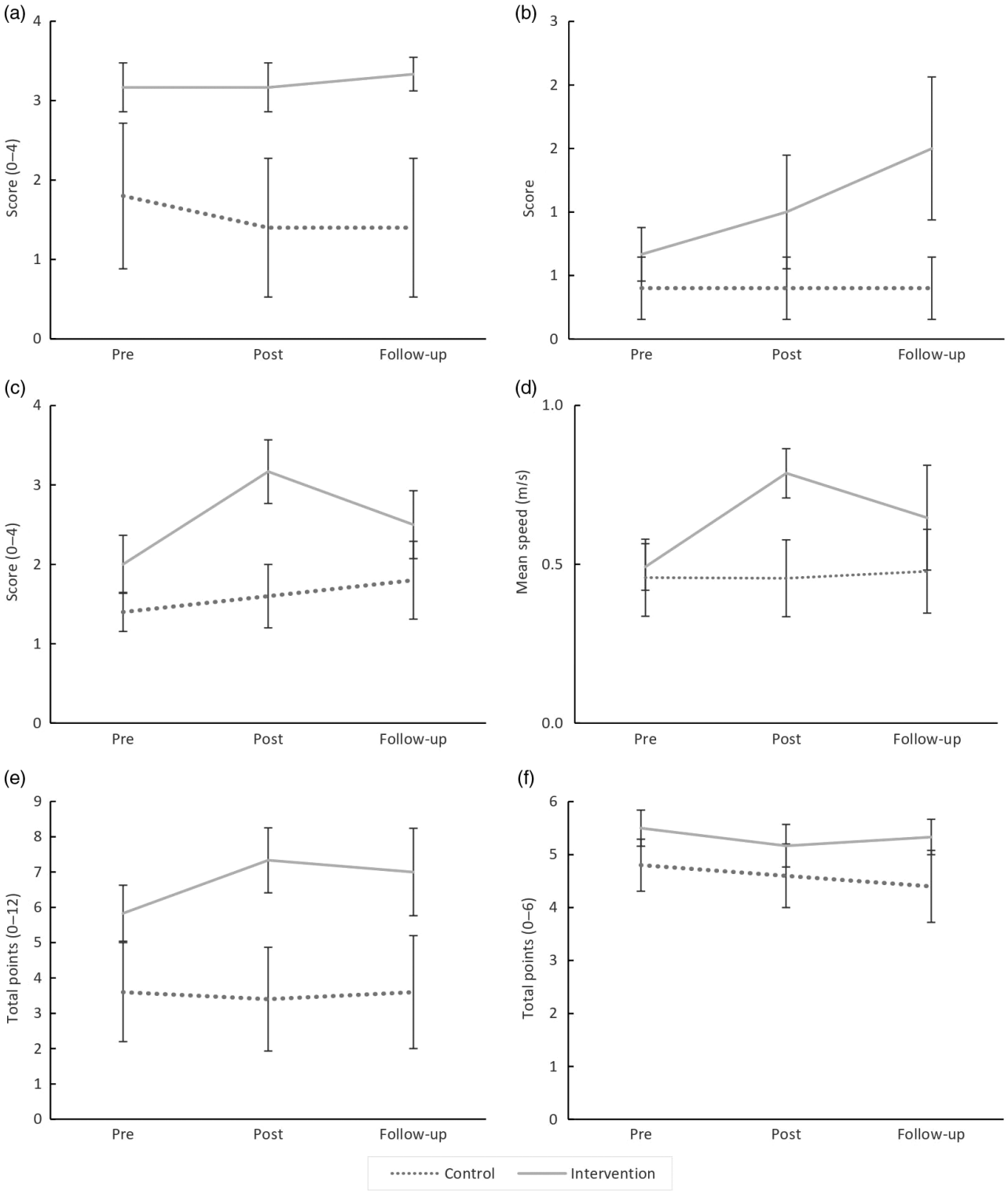

Figure 7 — Functional capacity measures. *Note*. Functional capacity measures over time in intervention and wait-list control groups. (a) SPPB balance test, (b) SPBB chair stand test, (c) SPBB gait speed test, (d) SPBB mean gait speed, (e) SPBB total score, and (f) Katz Index of Independence in ADL. Error bars represent *SE*. SPPB = Short Physical Performance Battery; ADL = Activities of Daily Living.

Integration

The exercise intervention was perceived to fit in well to the existing culture, and once established, it quickly became recognized as part of the care home's broader commitment to wellness and health. A positive attitude toward research from the management and well-being staff was critical to this level of integration. These results broadly support earlier findings citing the positive impact of motivated, enthusiastic staff on attendance for group exercise in nursing homes (Finnegan et al., 2015) and the social influence of

health care workers, health professionals, and physicians on physical activity in older adults (Burton et al., 2017; Rhodes et al., 1999; Wilson & Spink, 2006). Longer term sustainability in this setting appeared viable, with the participants continuing to use the equipment after trial completion, additional requests to use the equipment, and a keen interest in future research. This result agrees with Bastone Ade and Jacob Filho (2004), who, after a 6-month exercise intervention with nursing home residents, reported an expressed hope from participants for the program's continuation. However, this would need a formal longitudinal assessment to establish longer term adherence rates.

Adaptation

Potential modifications to the existing intervention were considered, and although there was no firmly identified need for amendments, there was interest to increase the number and availability of exercise sessions. This was somewhat contrary to expectations, given the age, frailty, and low levels of physical activity of the participants, and may be explained by the reported high levels of enjoyment, social interaction, and achievement. It is encouraging to compare these findings with work by Rydeskog, Frändin, and Hansson Scherman (2009) and Dionigi and Cannon (2009), who reported a rich variety of positive feedback from older adults' experiences of resistance training, including increased zest for life, confidence, enhanced feelings of self-esteem and competency. The requirement to modify one exercise machine that required stepping backward to exit was evaluated in light of risk of injury and concerns by the staff regarding less able participants. This finding agrees with previous work highlighting potential barriers for older adults participating in resistance training, including a lack of age-appropriate training programs, equipment, and facilities (Burton et al., 2017) and concerns about pain and falling (Franco et al., 2015; Freiberger, Kemmler, Siegrist, & Sieber, 2016). However, some participants reveled in mastering this task, and in agreement with Lazowski et al. (1999), this demonstrates the requirement for appropriately challenging individualized programs.

Expansion

Further expansion of the program raised budgetary concerns from the staff relating to the cost of the equipment, maintenance, and training. A requirement for more dedicated space to house equipment and run group sessions was also seen as a potential obstacle. This fits with previous studies that found that, although administrators spoke positively about the benefits of physical activity, they identified substantial staffing and funding constraints, limited space, and a lack of dedicated rooms as barriers to provision in long-term care homes (Baert, Gorus, Calleeuw, De Backer, & Bautmans, 2016; Benjamin et al., 2009; Kalinowski et al., 2012). In fact, the home has retained three of the five machines.

Limited Efficacy Testing

With respect to the feasibility outcome of limited efficacy testing on measures of multidimensional health and functional capacity, the results indicated meaningful change and large effect sizes across some, but not all, measures. Consistent with the literature on progressive resistance training for frail, older adults, this study indicated a positive change in strength and functional capacity (Fragala et al., 2019; Latham, Bennett, Stretton, & Anderson, 2004; Liu & Latham, 2009; Maestroni et al., 2020; Paw et al., 2008; Valenzuela, 2012) and reduction of frailty (Arrieta et al., 2019; Binder et al., 2002; Ferreira et al., 2018). Interestingly, no evidence was found for changes to other multidimensional health measures. These findings are contrary to earlier research that identified overall improved mood and cognitive function, lower state and trait anxiety, and increased IGF-1 levels in older men after 24 weeks of high-intensity resistance training (Cassilhas, Antunes, Tufik, & de Mello, 2007, 2010) and a meta-analysis indicating that physical activity and exercise can be effective in improving mental well-being in older adults aged 65 and over (Windle, Hughes, Linck, Russell, & Woods, 2010). A possible explanation for these findings is that the 6-week exercise intervention was too short to effect significant change in these measures. It is also possible that the supportive, faith-based community within the residential care home positively impacted the stability of the measures of psychological, emotional, and social support status. The qualitative analysis identified a positive meaningful impact on self-reported functional capacity, and high levels of enjoyment and satisfaction with the intervention. Similarly, previous qualitative studies with older adults engaged in regular resistance training reported enhanced appetite for life, calm, self-esteem, and physical confidence (Dionigi & Cannon, 2009; Rydeskog et al., 2009).

Limitations

The present feasibility study had several limitations. First, the short duration of the resistance-training intervention may have influenced levels of uptake and attendance, and might not accurately represent the dropout and adherence rates for a longer duration RCT. This may also have impacted physiological adaptations and affected the lack of measurable changes in other markers of multidimensional health due to a lack of sensitivity to subtle change over a short time course. Second, the specialized equipment utilized in this study may not be accessible or affordable for larger or multicenter trials, consequently, limiting broader expansion. Third, the current study was based on a small sample size, thus limiting statistical power; however, as the primary aim of the study was to investigate feasibility, this was deliberate.

Recommendations and Future Directions

Based on the findings discussed above, we would make the following recommendations for the definitive RCT. To reduce potential bias, where possible, all assessments should be carried out by a researcher who is blinded to group allocation. The exercise sessions should run for at least 12 weeks, with fewer and/or more sensitive questionnaire measures. Ideally, an experienced, enthusiastic instructor should be present at all sessions to ensure consistency of delivery and support. The intervention should also be run in a visible setting and in a group for the positive effects that this brings. Additional help with, and reminders about, session attendance should be provided for participants with disability or mobility limitations, or cognitive impairment. In addition, facilitating a wider use of the equipment by care home residents who are not study participants, staff, and families should be actively encouraged.

As well as the future RCT, future research could usefully explore whether there is any measurable impact on markers of multidimensional health over a longer follow-up. Further studies to determine longer-term attendance and adherence would also be worthwhile. It could equally be valuable to assess the impact of moving toward independent exercising, as this may be important

for longer term adherence, sustainability and expansion. It would also need to examine whether such programs are economically viable. Research is also needed to investigate the effects of resistance training on frail, older adults with cognitive impairment and dementia, which, although included in this study, was not the focus. Prevention of the progression to frailty would also be interesting to examine, by testing the intervention in prefrail older adults in residential care and/or supported housing. Our next project addresses this latter question.

Conclusion

The KARE feasibility trial was found to be feasible in terms of acceptability, demand, integration, adaptation, practicality, implementation, and expansion. Some modifications are recommended to reduce potential assessor bias and ensure consistency of exercise delivery and support. These could be addressed with minor changes to the study design and additional support from the residential care staff.

The limited efficacy testing indicated that a resistance training intervention with frail, older adults may positively impact measures of frailty, strength, and functional capacity. The qualitative feedback suggested that enjoyment, social interaction, achievement, and gaining a sense of purpose were key motivators. The participants also reported a meaningful impact on self-reported functional capacity and physical confidence.

Collectively, these findings support the feasibility of a definitive RCT using a resistance training intervention with frail older adults in residential care. The study findings reinforce the value of resistance training interventions, with improvements in strength and functional capacity contributing to a reduction of frailty.

Acknowledgments

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