Original Article

Progressive resistance training in a post-acute, older, inpatient setting: A randomised controlled feasibility study

Sinéad A. Coleman[1], Conal J. Cunningham[2], Niamh Murphy[1], Jean Feaheny[1], David Robinson[2], Rosaleen Lannon[2], Kevin McCarroll[2], Miriam Casey[2], Joseph Harbison[2], N. Frances Horgan[3]

[1]Physiotherapy Department, St James's Hospital, Ireland;
[2]MedEl Directorate, St James's Hospital, Ireland;
[3]School of Physiotherapy, Royal College of Surgeons in Ireland, Ireland

Abstract

Objectives: Progressive resistance training can successfully target functional decline in healthy older community-dwelling adults. There are concerns about the safety and acceptance of its use in frail older populations. The aim of this study was to evaluate the feasibility of using progressive resistance training in an older, post-acute, inpatient setting. **Methods**: A randomised controlled feasibility study was conducted. Appropriate older inpatients undergoing post-acute rehabilitation were recruited. Feasibility measures examined were safety, recruitment, outcome measurement, adherence and retention rates and satisfaction. A range of clinical measures were used to capture changes in body structure and function, activity and participation. Assessments were performed on admission to the study and six weeks later. **Results**: A sample of 33 patients were included and randomised to the treatment group (n=16) or the control group (n=17). There were no serious adverse events, adherence rates were 63% and retention rates were 82%. While both groups improved between time 1 and 2, there were no significant differences in clinical measures between the groups. **Conclusion**: Progressive resistance training is a safe and acceptable intervention for use with this population. Further work on the effectiveness of progressive resistance training in this setting is now required.

Keywords: Older inpatients, Progressive resistance training

Introduction

The process of ageing can cause deterioration in cardiovascular fitness, strength, postural stability, flexibility and psychological function which can lead to a decline in functional performance[1]. A further decline in function is common following an acute hospital admission due to the presence of an acute medical condition, polypharmacy, nutritional deficiencies[2], low physical activity and bedrest which are all common in hospitalised older patients[3]. This inactivity can have detrimental effects on muscle mass, strength and physical function. Post-acute rehabilitation is a combination of recovery, recuperation and rehabilitation whose function is to further the goals of acute care[4]. It aims to provide continuing interdisciplinary care to prevent premature institutionalisations and reduce unnecessary hospital readmissions[5].

Resistance training (RT) is the most effective intervention in slowing down this decline and increasing muscle mass and strength even in a frail older population[6]. Older adults can achieve similar gains to younger adults with RT[1] and have demonstrated substantial adaptive plasticity in skeletal muscle and the neuromuscular system[7,8].

Progressive resistance training (PRT) is a type of exercise where "participants exercise their muscles against some type of resistance that is progressively increased as

their strength improves"[9]. PRT has been shown to be well tolerated and have many benefits, including an increase in muscle mass and strength[10] and functional performance[11] in healthy community-dwelling older adults. There is currently a shortage of available evidence investigating the feasibility and effects of using PRT as a rehabilitation intervention in an older, post-acute, inpatient population. It has been recommended that frail or recently medically unwell older people should be closely monitored for adverse responses to PRT, such as musculoskeletal complaints, as this has not been well documented previously[9]. Examining the feasibility of tailored exercise programmes is critical in the safe implementation of these programmes in a post-acute, inpatient setting.

Previous research in this post-acute rehabilitation unit examined outcomes following six weeks of inpatient rehabilitation and showed that frail older inpatients improved in aspects of functional mobility, balance, exercise tolerance, health-related quality of life (QoL), frailty and ability to perform activities of daily living (ADLs). However, lower limb (LL) strength was shown not to improve significantly[12].

As older people make up the biggest segment of the population participating in rehabilitation, meeting their needs adequately is a challenge for rehabilitation services. It is vital that safe and effective interventions are employed to optimise the rehabilitation outcomes of this population. The aim of this study was i) to investigate the feasibility and acceptability of implementing PRT in an older, post-acute, inpatient population and ii) to evaluate changes in strength, function and QoL following six weeks of PRT.

Materials and methods

Study design

This was a Phase 1 prospective, single-blinded, randomised controlled feasibility study exploring the potential for a future randomised controlled trial in the context of a post-acute inpatient physiotherapy service for older service users. Bowen's framework for feasibility studies[13] and recent guidelines for reporting feasibility studies were applied[14] and the Medical Research Council framework for complex interventions was followed[15]. The study was registered on ClinicalTrials.gov NCT02141126. The trial received ethical approval from the local research ethics committee.

Patient selection and setting

A convenience sample of consecutive patients admitted to three 18-bedded rehabilitation wards in a large urban teaching hospital between July 2013 and June 2014 were invited to participate. They represented a sample of heterogeneous older adults with multiple co-morbidities. Participant recruitment occurred within 72 hours of admission to the rehabilitation service. Participants were identified from a daily medical ward list and eligibility for participation was confirmed through communication with treating physiotherapists. *Inclusion Criteria*: patients admitted for rehabilitation with an expected length of stay (LOS) of six weeks in the rehabilitation unit, >65 years of age, able to achieve a sit-to-stand (STS) transfer independently and to stand independently with the use of the parallel bars in the physiotherapy gym, be medically stable (as determined by their treating consultant) and be able to give informed consent. *Exclusion criteria*: patients unable to follow one-stage commands, acute pain or fracture and those who were admitted with a recent diagnosis of stroke.

Recruitment process

Appropriate patients were approached by a gatekeeper and given a study invitation letter and participant information leaflet with 48 hours to consider involvement in the study. Written informed consent was obtained prior to enrolment in the study. Outcome measurement was performed at entry to the study (T1) and again at six weeks (T2). Following completion of the T1 assessments, patients were randomised into two groups, progressive resistance training (PRT) or control (CON). Patient allocation was stratified based on age, gender and muscle strength (knee extension) using the technique of minimisation, which was performed using Microsoft Excel® 2003 software. Stroke patients were excluded due to the need to additionally stratify based on the criteria of initial stroke severity, stroke type and time since stroke which would not have been feasible in such a small sample. The CON group received usual care physiotherapy five days per week. Usual care physiotherapy delivered by existing physiotherapy staff members, included balance and gait training and endurance exercise but did not routinely include LL PRT.

Intervention

The **PRT group** received usual care physiotherapy as well as twice weekly tailored PRT for the LLs. PRT sessions were delivered by the lead researcher (SAC) in a supervised class (usually with 2-3 patients) with a circuit-type setting, lasting approximately 45 minutes and included warm-up and cool-down periods. Exercises were tailored to each patient. Four exercises were included - bilateral hip flexion and abduction using ankle weights and STS and heel raises using a weighted vest. **Ankle weights**: moderate-intensity 65%[16] of participant's 1-Repetition Maximum (1RM) was used. The 1RM was determined using submaximal strength testing at the beginning of Week 1 and was re-assessed at the beginning of Weeks 3 and 5 to progress exercise intensity. **Weighted vest**: this was calculated at 5-7% of body weight as used in previous research[17]. The weight prescribed in the weighted vest was calculated at 5% of body weight at the beginning of Week 1 and increased to 7% at the beginning of Week 4. Hip flexion and abduction exercises and heel raises were performed in standing, holding onto the parallel bars. STS was performed from a chair 45 cm in height. Participants were instructed to stand up from the chair,

using the armrests if required, to come to a full standing position and to return to a seated position in a controlled manner. Participants were encouraged to maintain good posture throughout the exercises to ensure specific muscle group activation. All exercises were performed in a slow and controlled manner to ensure the correct technique. A rest period of one minute was given between each set. There was at least one day of rest between PRT sessions. PRT sessions occurred twice per week, meaning four PRT sessions over a two-week period. Repetitions and sets were progressed over a two-week period as follows: Session 1-15 repetitions x 2 sets, session 2-15 repetitions x 3 sets, session 3-20 repetitions x 2 sets, session 4-20 repetitions x 3 sets.

Descriptive measures

Demographic baseline information, discharge destination and LOS were recorded. Baseline mobility and transfer status was recorded at T1 and T2.

Outcome Measures

Measures of Feasibility: Primary outcomes were based on the feasibility of the intervention and data collection across the study period and included:
1) Safety: Monitored using adverse events records following the PRT interventions.
2) Recruitment: Identified using the number of patients transferred to the rehabilitation unit during the recruitment period.
3) Outcome Measurement: Suitability, appropriateness, timeliness.
4) Adherence Rates: Evaluated using weekly attendance records.
5) Retention Rates: Evaluated using the proportion of participants who attended for T2 assessment against the proportion who attended for T1 assessment.
6) Satisfaction: Evaluated using a non-validated satisfaction questionnaire, designed specifically for use in this study.

Physical performance and daily activity

Secondary outcome measures evaluated changes in impairment (grip strength and LL strength, height, weight and Body Mass Index (BMI)), activity (Timed Up and Go Test (TUG), Clinical Frailty Scale (CFS), Stair Negotiation Test (SNT)) and participation (Euro Qol-5D (EQ-5D)). During the course of the study, there were two blinded Physiotherapy assessors and two blinded Clinical Nutrition assessors. Depending on functional status and level of assistance needed, assessments took between 45 and 60 minutes to complete.

Measures of impairment - Grip strength was measured using a dynamometer (SAEHAN Hydraulic hand Dynamometer, model SH5001). The mean score of three attempts was used [18]. LL strength was measured using a hand-held dynamometer (HHD) (MICROFET 2, Hoggan Health Industries) using a standardised procedure[19]. For the purpose of this study, the 'Make Test' was used. This is an isometric contraction held for three to five seconds. Height was measured from ulna length[20], weight was measured using body composition scales (Tanita SC-331S Total Body Composition Analyser), and BMI was calculated using these measures. Skeletal muscle mass was calculated using a validated equation based on bioelectrical impedance analysis from the body composition scales. Participants were required to stand on the body composition scales in their bare feet, without holding onto any support, for 30 seconds[21].

Measures of activity - The TUG was used to test basic functional mobility[22]. The CFS is a measure of frailty based on clinical judgement[23]. It is an ordinal scale which ranges from 1 to 9, with 1 indicating 'very fit' and 9 indicating 'terminally ill'. The SNT is a strong predictor of declining ADL ability and mobility in older adults[24] and is a clinically relevant measure of LL strength[25].

Measures of participation - Health-related QoL was assessed using the EQ-5D[26].

Sample size

This was a feasibility study therefore no formal power calculation was carried out. Part of this feasibility study was to assess whether enough participants could be recruited and retained in the study and outcome data generated to inform the potential for a future Phase II study. We did not power the study for specific outcomes but aimed to recruit 40 participants with the goal of retaining 30 to follow-up. The sample size was deemed to give sufficient insights into the intervention implementation and data collection process, and sufficient data to conduct meaningful analysis and to be relevant for sample size calculation for a future randomised study. The attrition rate varies between 13% and 21% as demonstrated by previous studies[27,28].

Data analysis

Baseline demographic and outcome variables were described at all assessment times. Information on missing or incomplete data from all outcome measures was reviewed. Although not powered for effectiveness, tests were completed with a 0.05 level of significance. Data was coded and collated in a Microsoft Excel® Version 22 spreadsheet and Stata 12 was used for statistical analysis. Descriptive statistics were primarily used. The distribution of the data was assessed and, where appropriate, parametric methods were used in analysis. Two sample t-tests were used to compare groups and paired t-tests were used for within group comparisons. The non-parametric equivalent was used where data was not normally distributed. A significance level of $p<0.05$ was set. Due to the small sample size, only those who had a value for T2 were included in data analysis. The data from the outcome variables was quantitative and consisted of a combination of nominal, ordinal, ratio and interval data. Data was tested for normality using the Shapiro-Wilk test. The independent t-test or Mann-Whitney test, where appropriate, was used to test for differences between treatment groups.
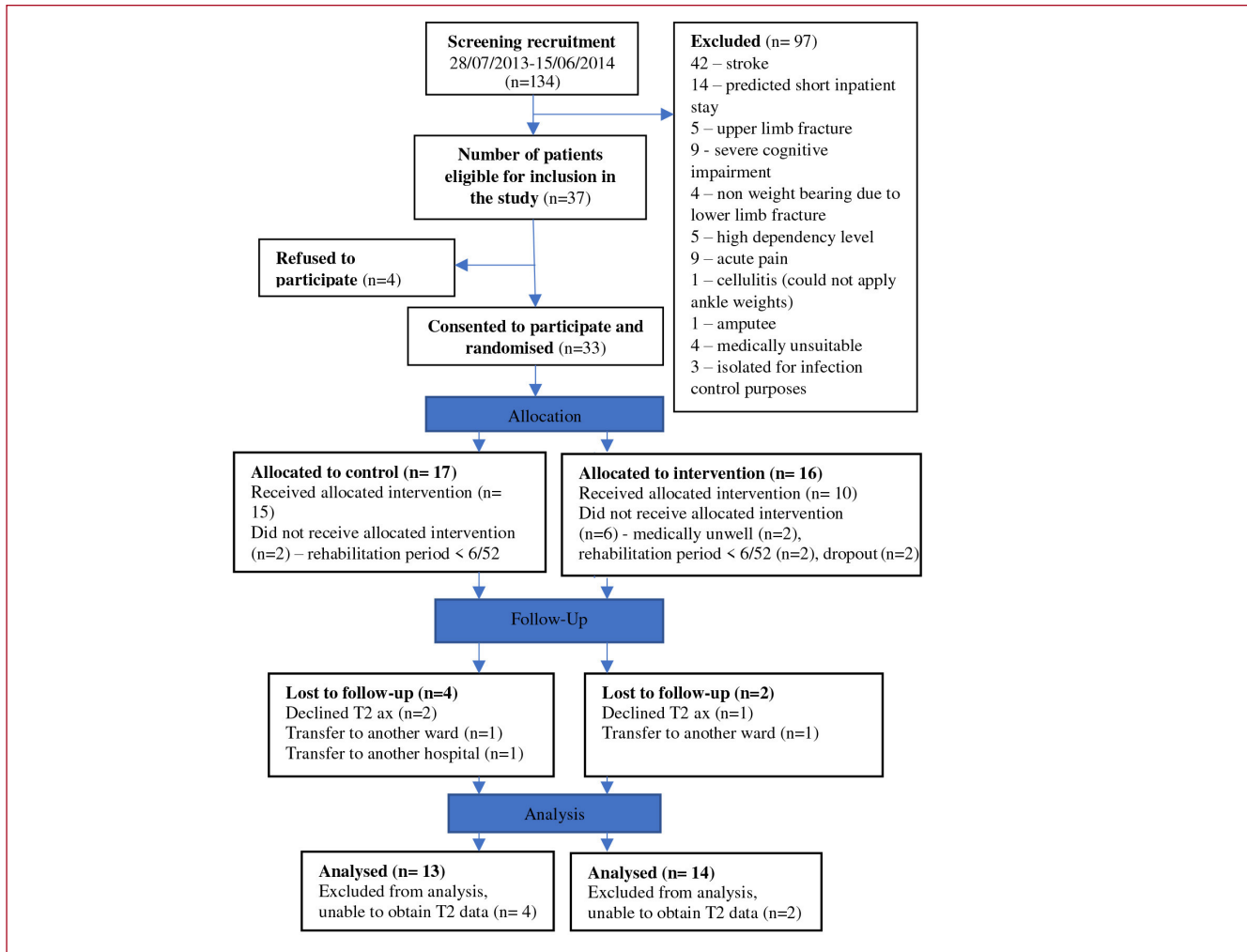
Figure 1. CONSORT diagram demonstrating patient flow through the study.

Results

Participant description

One hundred and thirty-four patients were admitted to the rehabilitation service between July 2013 and June 2014. Of these, 37 were eligible for inclusion in the study and 33 agreed to participate. Twenty-seven patients completed the assessments at T1 and T2. The flow of patients through the study is presented in Figure 1. Baseline demographic data and clinical characteristics are presented in Table 1. The sample was a heterogeneous group of mildly frail, older inpatients. The median age was 82.9 years and there was an equal distribution of male and female across the entire sample. The sample was dependent in relation to mobility on admission to the rehabilitation service, while many had a history of hip fracture, immobility and falls. The majority of the sample lived alone prior to admission.

The mean length of time in the acute hospital setting before transfer to the inpatient rehabilitation unit was 33.9 days (SD 27.5) for the CON group and 32.8 days (SD 28.4) for the PRT group. The mean LOS in the rehabilitation unit was 85.4 days (SD 80.2) for the CON group and 67.6 days (SD 30.9) for the PRT group. These values were not statistically significant. The mean number of routine physiotherapy visits received by the CON group was 21.5 (SD 7.4) and 21.6 (SD 6.9) for the PRT group. The mean number of PRT interventions received by the PRT group was 7.6 (SD 3.63). Discharge destination was recorded for each participant who completed the T1 assessment (Table 2).

Measures of feasibility

1) Safety: There were no serious adverse events for those participating in the PRT group. Three mild to moderate musculoskeletal adverse events were reported by three

Characteristic		CON (n=17) N (%)	PRT (n=16) N (%)
Gender	Male	8 (47.1)	8 (50.0)
Age	Median age	82.7 (6.3)	83.1 (6.1)
Presenting diagnosis	Falls	5 (29)	10 (62)
	Hip fracture	1 (6)	2 (13)
	Pubic ramus fracture	3 (18)	0 (0)
	Other (vertebral fracture, gastrointestinal, cardiac, oncology)	8 (47)	4 (25)
Mobility on admission to rehabilitation	IND	0 (0)	0 (0)
	IND + walking stick	1 (6)	1 (6)
	IND + walking frame	4 (23)	4 (25)
	Supervision	9 (53)	5 (31)
	Assistance	3 (18)	6 (38)
Transfers on admission to rehabilitation	IND	7 (41)	4 (25)
	Supervision	4 (23)	7 (44)
	Assistance	6 (34)	5 (31)
Social History	Lives alone	10 (58.8)	10 (62.5)
	Lives with family	5 (29.4)	6 (37.5)
	Other	2 (11.8)	0 (0)
KG		Mean (SD)	Mean (SD)
Grip (R)		12.69 (7.37)	13.87 (6.56)
Grip (L)		11.29 (7.15)	11.2 (5.58)
HA (R)		5.77 (2.35)	4.97 (2.44)
HA (L)		5.25 (1.45)	4.92 (2.29)
HF (R)		5.48 (2.63)	4.54 (1.66)
HF (L)		4.89 (1.41)	4.71 (1.93)
HE (R)		6.12 (2.08)	6.19 (2.65)
HE (L)		6.24 (2.08)	6.19 (2.39)
KE (R)		5.55 (2.34)	5.2 (2.15)
KE (L)		5.35 (1.99)	5.33 (2.31)
AP (R)		6.09 (3.36)	4.77 (2.21)
AP (L)		5.36 (2.26)	4.64 (2.38)
AD (R)		4.33 (2.48)	3.52 (1.67)
AD (L)		4.04 (1.75)	3.11 (1.54)
Comorbidities		5.4 (2.1)	3.3 (1.5)
BMI		23.19 (3.31)	24.65 (3.61)
Muscle Mass (KG)		42.19 (8.85)	46.97 (6.71)
TUG (s)		46.03 (29.35)	57.18 (29.22)
SNT Ascent (s)		16.04 (16.3)	13.13 (5.14)
SNT Descent (s)		18.11 (16.71)	15.74 (6.09)
CFS (/9)		5.35 (1.27)	5.62 (1.09)
EQ-5D VAS (/100)		50 (22.64)	61.87 (20.89)

CON=control group, PRT=progressive resistance training group, IND=independent, SD=standard deviation, KG=kilograms, (R)=Right, (L)=left, HA=hip abduction, HF=hip flexion, HE=hip extension, KE=knee extension, AP=ankle plantarflexion, AD=ankle dorsiflexion, BMI=body mass index, TUG=Timed Up and Go, s=seconds, SNT=Stair Negotiation Test, CFS=Clinical Frailty Scale, EQ-5D VAS=EuroQol 5D Visual Analogue Scale.

Table 1. Baseline demographic data and clinical characteristics of participants (n=33)

Discharge Destination	CON (n=17) N (%)	PRT (n=16) N (%)
Home	5 (29.4)	3 (18.8)
Home with follow-up in Primary Care	5 (29.4)	6 (37.5)
Long Term Care	2 (11.8)	5 (31.3)
Other hospital	2 (11.8)	0 (0)
Deceased	3 (17.6)	2 (12.5)
CON=control group, PRT=progressive resistance training group.		

Table 2. Discharge destination of participants.

different participants. Two participants each reported one episode of back pain and one participant reported one episode of thigh pain. One of these participants chose to discontinue the intervention due to the aggravation of already present back pain. The other two participants were happy to continue in the study.

2) Recruitment: One hundred and thirty-four patients were admitted to the rehabilitation unit during the recruitment period. Only 28% of these were eligible to participate due to the study exclusion criteria - this included 43% who were stroke presentations, 14% had a predicted LOS of less than 6 weeks, 9% were unable to follow one-stage commands. Of the 37 patients who were eligible to participate, 33 patients gave informed consent. The number of eligible patients who agreed to participate in the study was high (89%). Reasons given for those who declined to participate were: 1) family members were concerned about their older relative undertaking RT exercises and 2) patients did not want to participate.

3) Outcome Measurement: HHD - During the recruitment phase, a second blinded physiotherapy assessor joined the study. There were noticeably higher T1 values during this time. Inter-rater reliability testing was performed between the two blinded physiotherapy assessors using HHD. Reliability was poor (Interclass Correlation 0.006-0.802) for most of the muscle groups. To ensure maximum intra-rater reliability, the same assessor performed both the T1 and T2 assessments on the participants that they tested. The TUG, CFS, SNT and EQ-5D proved to be quick and easy to use in this patient cohort. Skeletal muscle mass was only measured on 23 participants at T1. This was due to a variety of reasons. Pacemakers were contra-indicated and several participants were unable to stand unaided for the 30 seconds required to perform measurements.

4) Adherence Rates: The mean number of PRT interventions received by the intervention group was 7.6 (SD 3.63) which equates to the delivery of 63% of the possible total number of intervention sessions. The remainder of the intervention sessions were not delivered for a variety of reasons. Two patients became medically unwell, two patients had achieved their optimal rehabilitation potential and had

been discharged home early and two patients dropped out of the study.

5) Retention Rates: This evaluated the proportion of participants who attended for T2 assessment against the proportion who attended for baseline assessment. The T2 assessment was not completed for four participants (23%) of the CON group and two participants (12%) of the PRT group. Of the six participants who did not receive a T2 assessment, one had been transferred to another hospital to continue their rehabilitation, three had been discharged home and declined to come back for reassessment and two had been transferred to another ward as they had become medically unwell.

6) Satisfaction was evaluated using a non-validated satisfaction questionnaire with nine participants - 4 PRT and 5 CON. One participant from the PRT group said that they would not participate in the study again, as he felt that he did not benefit from being in the study. Other participants reported that they were very satisfied with their overall involvement in the research process and those that were in the PRT group reported benefits in strength and balance following the intervention, including an improved ability to perform their ADLs.

Physical performance and daily activity
Measures of Impairment

There was no significant difference in the change in median scores from T1 to T2 in the two groups in grip strength (Table 3). The only significant change in LL strength between the two groups was an improvement in left ankle dorsiflexion strength in the PRT group. There was no significant difference in the change in median scores from T1 to T2 in the two groups in skeletal muscle mass (Table 3).

Measures of activity

There was no significant difference in the change in median scores from T1 to T2 in the two groups in measures of activity (Table 3). TUG - The median TUG score at T2 was 32 seconds for the CON group and 31.42 seconds for the PRT group. SNT - The median SNT Ascent score at T2 was 7.7 seconds for the CON group and 7.16 for the PRT group.

Dynamometry (KG)	CON=13 PRT=14	T1 Median (Min, Max)	T2 Median (Min, Max)	T2-T1 Median (Min, Max)	p
Grip (R)	CON	9.8 (3.5, 29.3)	12 (5, 29)	1.40 (-6.00,4.70)	0.681
	PRT	15.7 (2, 22.7)	14.3 (2, 25.7)	0.70 (-7.70,7.30)	
Grip (L)	CON	10.7 (2, 25.7)	9.7 (3.3, 25.7)	1.30 (-5.30,6.70)	0.472
	PRT	12.7 (1.7, 23.3)	14.3 (3.3, 17)	0.30 (-9.00,8.00)	
HA (R)	CON	6.1 (2.5, 9.9)	4.5 (3.1, 12.1)	0.90 (-2.70,5.10)	0.234
	PRT	4.55 (1.6, 9.7)	6.35 (2.5, 11.8)	1.45 (-1.40,7.30)	
HA (L)	CON	5.1 (2.8, 7.5)	4.1 (2.3, 9.3)	0.20 (-2.60,3.40)	0.382
	PRT	4.7 (1.4, 9.1)	5.4 (2.5, 10.8)	0.40 (-2.50,5.50)	
HF (R)	CON	4.5 (2.3, 12.3)	4.4 (2.7, 11)	0.40 (-9.10,3.40)	0.645
	PRT	4.3 (1.9, 8.4)	4.95 (2.7, 9.9)	0.7 (-3.8, 2.7)	
HF (L)	CON	4.3 (2.8, 7.4)	4.6 (2.5, 8.2)	0.1 (-1.3, 2.6)	0.645
	PRT	4.5 (2.2, 9.5)	5.05 (3.1, 7.8)	0.8 (-3.4, 3.4)	
HE (R)	CON	5.7 (3.5, 10.6)	6.4 (4.4, 10.6)	0.6 (-3.6, 4.8)	0.512
	PRT	6 (2, 10.6)	7.05 (2.5, 11)	1.3 (-5.8, 5.4)	
HE (L)	CON	5.5 (3.1, 10.5)	5.8 (4.2, 10.3)	-0.6 (-3.4, 3.5)	0.099
	PRT	6.2 (2, 10.8)	7.05 (3.4, 11.3)	0.3 (-2.1, 4.9)	
KE (R)	CON	5.6 (2, 9.5)	5.7 (2.3, 11.7)	0.5 (-2.8, 4.2)	0.752
	PRT	5.35 (1.9, 9.9)	5.7 (2.7, 10.5)	0.2 (-3.1, 3.8)	
KE (L)	CON	5 (1.6, 8.2)	5.3 (3, 11.1)	0.2 (-1.6, 3.5)	0.789
	PRT	5.5 (1.8, 10.6)	5.7 (2.5, 10.5)	0.2 (-3.2, 3.5)	
AP (R)	CON	4.7 (2.1, 15.4)	4 (1.9, 10.9)	-0.9 (-4.5, 2.6)	0.207
	PRT	3.9 (2, 9.4)	5 (1.7,11)	-0.3 (-21, 4.3)	
AP (L)	CON	4.2 (2.9, 10.7)	5 (1.9, 10.5)	-0.2 (-3.7, 4.4)	0.544
	PRT	4 (1.6, 10.7)	4.3 (2.5, 10)	-0.2 (-2.3, 3.8)	
AD (R)	CON	3.4 (1.8, 10.6)	3.8 (2.1, 9.4)	-0.3 (-1.9, 1.9)	0.697
	PRT	3 (1.9, 7.3)	3.7 (1.8, 6.8)	-0.1 (-3.8, 3.9)	
AD (L)	CON	3.6 (1.8, 8.1)	3.6 (2, 7.6)	-0.3 (-3.6, 1.6)	0.027*
	PRT	2.65 (1.6, 7.1)	4.1 (2, 7)	0.7 (-1.2, 3.3)	
Skeletal Muscle Mass (KG)	CON	39.9 (31.7, 60.7)	38.8 (31.9, 48)	0 (-11.5, 14.1)	0.655
	PRT	45.5 (35.6, 55.4)	44.1 (38.5, 54.6)	0.4 (-3.9, 2.9)	
TUG (s)	CON	37.96 (17.13, 129)	32 (17.2, 104)	-12.4 (-60.8,51.6)	0.923
	PRT	49.82 (22.2, 125)	31.42 (18.95,136)	-12.8 (-74.3,59.0)	
SNT Ascent (s)	CON	13 (3.1, 70)	7.7 (4, 22.6)	-2.7 (-62.1, 6.3)	0.734
	PRT	11.6 (6.1, 25.93)	7.16 (4.15,20.62)	-4.9 (-11.6, 4.7)	
SNT Descent (s)	CON	13.45 (4.9, 75)	10.2 (3.58, 25)	-2.7 (-64.8, 16.1)	0.961
	PRT	15.11 (7, 32.2)	8.45 (5.3, 42.7)	-4.8 (-15.5, 22.7)	
CFS (/9)	CON	6 (3, 7)	5 (3, 7)	0 (-1, 0)	0.550
	PRT	6 (4, 7)	5 (4, 6)	0 (-2, 1)	
EQ-5D VAS (/100)	CON	50 (0, 90)	60 (50, 90)	10 (-20,60)	0.156
	PRT	60 (30, 100)	70 (40, 100)	0 (-25, 55)	

T1=Assessments at entry to the study, T2=Assessment at six weeks, CON=control group, PRT=progressive resistance training group, (R)=Right, (L)=left, KG=kilograms, HA=hip abduction, HF=hip flexion, HE=hip extension, KE=knee extension, AP=ankle plantarflexion, AD=ankle dorsiflexion, s=seconds, TUG=Timed Up and Go, SNT=Stair Negotiation Test, CFS=Clinical Frailty Scale, EQ-5D VAS=EuroQol 5D Visual Analogue Scale.

Table 3. Changes in grip strength and LL dynamometry, skeletal muscle mass, TUG, SNT, CFS and EQ-5D VAS from initial to final assessment (n=27).

The median SNT Descent score at T2 was 10.2 seconds for the CON group and 8.45 for the PRT group. CFS - The median CFS score at T2 was 5 for both groups.

Measures of participation

EQ-5D - While all sections of the EQ-5D were completed, the visual analogue scale (VAS) properties support quantitative analysis, and was used in the analysis. The maximum score for the EQ-5D - VAS is 100. The median EQ-5D - VAS score at T2 was 60 for the CON group and 70 for the PRT group. There was no significant difference in median scores from T1 to T2 in the EQ-5D-VAS between the two groups (Table 3).

Progression of intensity in the PRT group

During the course of the study, participants in the PRT group (n=16) demonstrated a mean increase in their 1RM in right hip abduction of 73%, left hip abduction of 72%, right hip flexion of 70% and left hip flexion of 57%. This in turn lead to an equivalent increase in the prescription of the load used in the ankle weights. Training weights used varied greatly which reflected the diverse range of muscle strength of the participants.

The prescription and progression of resistance used in the weighted vest was calculated as a percentage of body weight. The starting weight used at Week 1 was 5% of body weight, this was progressed to 7% of body weight at Week 4. The mean load in the weighted vest increase from 3.1 kgs to 4.49 kgs.

Discussion

This feasibility study aimed to examine the feasibility of employing PRT as an intervention in this patient cohort, under the headings of safety, recruitment, outcome measurement, adherence, retention and satisfaction. The intervention appeared to be safe, while there were no serious adverse events for those participating in the intervention group, three mild to moderate musculoskeletal adverse events were reported by three different participants. This agrees with previous research. Previous studies examining early rehabilitation programmes in the acute hospital setting, but not specifically PRT, reported few adverse events in the intervention groups with no significant differences when compared to the control groups[29,30]. No adverse events were reported in previous RCTs looking at PRT in an older inpatient population[27,28].

Due to the setting of the study, a post-acute rehabilitation unit, patient turnover was lower than in an acute ward which resulted in a low recruitment rate. During the period of recruitment, 134 patients were admitted to the rehabilitation unit. Due to study exclusion criteria, 72% were not eligible for the study. Over half of these were stroke presentations or had a predicted length of stay of less than 6 weeks. While, just over a quarter of patients (28%) who transferred to the rehabilitation unit were eligible for inclusion in this feasibility

study, 89% of these agreed to participate in the study. This high rate of acceptance was unexpected as participants were aware that if they were randomised to the intervention group, that they would be receiving PRT. This is much higher than the 54% of participants who consented to participate in a similar study[28].

A range of outcome measures were used in the feasibility study to capture strength and physical performance. HHD was used to assess LL muscle strength. This outcome measure has previously been shown to be reliable in an older population[31] and the author found this outcome measure to have good intra-rater reliability in a previous study[12]. However, following the addition of a second blinded Physiotherapy assessor, there were noticeable variations in measurements and inter-rater reliability was poor for the majority of muscle groups tested. Tester strength is as important a determinant of reliability as the characteristics of the sample being tested[32] and may have been a potential factor in the poor inter-rater reliability results. The author would recommend a single assessor to ensure optimal reliability when using the HHD in future studies. This outcome measure was also time-consuming, taking 15-20 minutes per participant. Skeletal muscle mass measurement, using bio impedance scales, could only be performed on 70% of participants at T1, the main reason for not being able to perform the test was the participants' inability to stand unaided on the scales. Other outcome measures used; TUG, SNT, CFS and EQ-5D have previously been shown to have good reliability and validity in older populations. They were found to be quick and easy to use for the purpose of this feasibility study. Both groups demonstrated gains in all measures of activity and participation, and the majority of the dynamometry scores after a period of six weeks of inpatient rehabilitation. However, there were no statistically significant differences between the two groups. A post-hoc power calculation was performed which determined that 100 participants (50 per group) would be required to test the efficacy of the intervention in a future study (assuming power of 80% and alpha of 5%).

Adherence rates were affected by the post-acute nature of the patient cohort in the feasibility study. Two patients became medically unwell and were transferred to another ward for medical management, while two patients had achieved their optimal rehabilitation potential earlier than six weeks and had been discharged home early. A further two participants dropped out of the study. Similar adherence rates were reported in a previous study[29] but this was much lower than the 96% adherence rate reported in another study[27] both examining exercise programmes in an older inpatient population. Similar reasons were given for reduced adherence rates. Retention rates examined the number of participants who attended for T2 assessment compared with those who attended for baseline assessment. Retention rates were also affected by the nature of the patient cohort, three participants declined the T2 assessment, two

participants were medically unwell and one participant had been transferred to another hospital. Nine of the participants completed a satisfaction questionnaire. Satisfaction rates were high with only one participant reporting that they would not engage in the study again. Participants from the intervention group also reported perceived benefits in strength and balance following the intervention, including an improved ability to perform their daily activities.

As previously discussed, there is a scarcity of research performed which explores PRT as an intervention in an older post-acute inpatient population. For this reason, it is important to tailor PRT to the participant cohort. The cohort in this study was mildly frail, deconditioned and demonstrated limitations in mobility and balance. Therefore, in order to enable participation and ensure patient safety, the exercises were performed either standing from a chair or holding onto the parallel bars in the physiotherapy gym. Gains in muscle strength and function in older inpatient cohorts have been reported following a series of bed-based[29,33] and chair-based PRT[34,35], indicating that this intervention can be tailored to suit all levels of mobility, balance and dependency. Similarly, if this patient group achieved independent mobility and were followed up in a community setting, the exercises could be progressed to include more functional tasks, for example, using the weighted vests while practicing stairs or including ankle weights during gait re-education, as seen in previous research[36,37].

The American College of Sports Medicine have recommended a prescription of PRT for older adults of at least two days per week, between moderate to vigorous intensity[38]. This feasibility study employed PRT of twice-weekly, moderate intensity (65% of 1RM) exercise in addition to usual care physiotherapy, up to five days per week. Submaximal testing performed at the beginning of weeks 1, 3 and 5 ensured that the load was progressed every two weeks, while the number of repetitions and sets was also progressed. Previous authors recommended submaximal testing instead of 1RM testing for older adults to reduce the risk of injury[39]. This prescription was shown to be safe and well tolerated by the older inpatients in this feasibility study. Significant gains of between 57% and 73% were demonstrated in the loads which participants were able to lift in the ankle weights over the course of the study. As mentioned previously, there is a lack of good quality evidence in the optimum prescription of PRT in this patient cohort. However, this study has shown that PRT was well-tolerated by this patient group, with no serious adverse events and the class format was easily incorporated into routine clinical practice. Following their inpatient rehabilitation, the sample remained a frail group with lower functional mobility and grip strength scores when compared with their age-matched community-dwelling peers[40]. This study demonstrates that PRT is a safe and feasible intervention even for this cohort.

The duration of our study intervention (6 weeks) was based on previous research in the unit where the average length of stay (LOS) was 6 weeks[12]. There is an increasing emphasis on reducing inpatient LOS and performing post-acute rehabilitation in a community or day hospital setting. However, the participants were likely deconditioned following a lengthy LOS in the acute hospital (33.9 days for the CON group and 32.8 days for the PRT group) hence the slower responses to the intervention. It would be preferable to have a longer duration, at least 8-10 weeks, and consider a programme that would transition from the hospital to the community/ day hospital setting. A systematic review of early rehabilitation programmes, found that between 14% and 48% of admitted patients met the inclusion criteria to be enrolled in the programmes, and between 3% and 19% of the patients were not willing to participate[41]. However, most of these studies were trying to recruit patients within 1-2 days of acute hospital admission. Another study found that trying to recruit from the acute hospital setting was not feasible, with only 2% of their sample recruited from this setting, the remainder were recruited post discharge[42].

Limitations

Due to the nature of the patient cohort, the rate of recruitment was slow and there was missing data at both T1 and T2. Issues arose during the study regarding inter-rater reliability of HHD testing. The authors recommend that a single assessor is used to ensure optimal reliability of this outcome measure. Due to the small sample size, conclusions cannot be made about the efficacy of the intervention. A larger multi-centre RCT is recommended to determine efficacy and optimal exercise dosage.

Conclusion

PRT has been shown to be a safe and acceptable intervention in an older post-acute inpatient population. However, its effectiveness is unclear and further research is required. The focus of post-acute rehabilitation is changing, with the emphasis being placed on providing rehabilitation in the community. Future research on PRT should include collaboration between acute and primary care settings, with participants continuing with their PRT after discharge from the hospital setting.

Authors' contributions

SAC: concept and design, acquisition of subjects and baseline data collection, delivery of the intervention, analysis and interpretation of the data, manuscript preparation, accepts responsibility for the integrity of the data analysis. CJC and NFH: concept and design, analysis and interpretation of data, manuscript preparation, study oversight. NM, DR, RL, KMC, MC and JH: concept and design, manuscript preparation. JF: concept and design, data entry, manuscript preparation. All authors have read and approved the manuscript.

References

1. Mazzeo RS, Cavanagh P, Evans WJ, Fiatarone M, Hagberg J, McAuley E, et al. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30(6):992-1008.
2. Stott DJ, Quinn TJ. Principles of rehabilitation of older people. Med. 2013;41(1):1-4.
3. Smith P, Galea M, Woodward M, Said C, Dorevitch M. Physical activity by elderly patients undergoing inpatient rehabilitation is low: an observational study. J Physiother 2008;54:209-213.
4. Kane RL. Assessing the effectiveness of postacute care rehabilitation. Arch Phys Med Rehabil 2007;88(11):1500-1504.
5. Lee WJ, Cheng YY, Liu CY, Peng LN, Liu LK, Chen LK. Dose-dependent effect of rehabilitation in functional recovery of older patients in the post-acute care unit. Arch Gerontol Geriatr 2012;54(3):290-293.
6. Rolland Y, Dupuy C, Abellan van Kan G, Gillette S, Vellas B. Treatment strategies for sarcopenia and frailty. Med Clin North Am 2011;95(3):427-438.
7. Seynnes O, Fiatarone Singh MA, Hue O, Pras P, Legros P, Bernard PL. Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders. J Gerontol A Biol Sci Med Sci 2004;59(5):503-509.
8. Daly RM. Exercise and nutritional approaches to prevent frail bones, falls and fractures: an update. Climacteric. 2017;20(2):119-124.
9. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. Cochrane Database Syst Rev 2009;8(3):CD002759.
10. Damas F, Phillips S, Vechin FC, Ugrinowitsch C. A review of resistance training-induced changes in skeletal muscle protein synthesis and their contribution to hypertrophy. Sports Med 2015; 45(6):801-807.
11. Papa EV, Dong X, Hassan M. Resistance training for activity limitations in older adults with skeletal muscle function deficits: a systematic review. Clin Interv Aging 2017;12:955-961.
12. Coleman S, Cunningham C, Walsh JB, Coakley D, Harbison J, Casey M, et al. Outcomes among older people in a postacute inpatient rehabilitation unit. Disabil Rehabil 2012;34(15):1333-1338.
13. Bowen DJ, Kreuter M, Spring B, Cofta-Woerpel L, Linnan L, Weiner D, et al. How we design feasibility studies. Am J Prev Med 2009;36(5):452-7.
14. Hardin JA. Medical exercise training. In: Bandy WD, Sanders B, eds. Thera-peutic Exercise: Techniques for Intervention. Baltimore, Md: Lippincott Williams & Wilkins; 2001:121-144.
15. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M; Medical Research Council Guidance. Developing and evaluating complex interventions: the new Medical Research Council guidance. BMJ 2008;337: a1655.
16. Steib S, Schoene D, Pfeiffer K. Dose-Response Relationship of Resistance Training in Older Adults: A Meta-Analysis. Med Sci Sports Exerc 2009;42(5):902-914.
17. Greendale GA, Salem GJ, Young JT, Damesyn M, Marion M, Wang MY, et al. A randomized trial of weighted vest use in ambulatory older adults: strength performance and quality of life outcomes. J Am Geriatr Soc 2000;48(3): 305-311.
18. Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and validity of grip and pinch strength evaluation. J Hand Surg Am 1984;9A:222-226.
19. Bohannon RW. Test-retest reliability of hand-held dynamometry during a single session of strength assessment. Phys Ther 1986; 66(2):206-209.
20. Scott A. Screening for malnutrition in the community: the MUST tool. Br J Community Nurs 2008;13(9):406-412.
21. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol 2000;89(2):465-471.
22. Podsiadlo D, Richardson S. The Timed 'Up and Go': a test of basic functional mobility in frail elderly persons. J Am Geriatr Soc 1991;39:142-148.
23. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173(5):489-495.
24. Oh-Park M, Perera S, Verghese J. Clinically meaningful change in stair negotiation performance in older adults. Gait Posture 2012;36(3):532-536.
25. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boire Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39(4): 412-423.
26. Anonymous. EuroQol - a new facility for the measurement of health-related quality of life. The EuroQol Group. Health Policy. 1990;16:199-208.
27. Martínez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, Sáez de Asteasu ML, Lucia A, Galbete A, García-Baztán A, et al. Effect of Exercise Intervention on Functional Decline in Very Elderly Patients During Acute Hospitalization: A Randomized Clinical Trial. JAMA Intern Med 2019;179(1):28-36.
28. Tibaek S, Andersen CW, Pedersen SF, Rudolf KS. Does progressive resistance strength training as additional training have any measured effect on functional outcomes in older hospitalized patients? A single-blinded randomized controlled trial. Clin Rehabil 2014;28(4):319-328.
29. Mallery LH, MacDonald EA. Hubley-Kozey CL, Earl ME, Rockwood K, MacKnight C. The feasibility of performing resistance exercise with acutely ill hospitalized older adults. BMC Geriatr 2003;3:3.
30. Laver K, George S, Ratcliffe J, Quinn S, Whitehead C, Davies O, et al. Use of an interactive video gaming program compared with conventional physiotherapy for hospitalised older adults: a feasibility trial. Disabil Rehabil 2012;13(21):1802-1808.
31. Abizanda P, Navarro JL, García-Tomás MI, López-Jiménez E, Martínez-Sánchez E, Paterna G. Validity and usefulness of hand-held dynamometry for measuring muscle strength in community-dwelling older persons. Arch Gerontol Geriatr 2012;54(1):21-27.
32. Stone CA, Nolan B, Lawlor PG, Kenny RA. Hand-held dynamometry: tester strength is paramount, even in frail populations. J Rehabil Med 2011;43(9):808-811.
33. Kawakami Y, Akima H, Kubo K, Muraoka Y, Hasegawa H, Kouzaki M, et al. Changes in muscle size, architecture, and neural activation after 20 days of bed rest with and without resistance exercise. Eur J Appl Physiol 2001;84(1-2):7-12.
34. Latham NK, Stretton C, Ronald M. Progressive Resistance Strength Training in Hospitalised Older People: A Preliminary Investigation. N

Zeal J Physiother 2001;29(2):41-48.

35. Suetta C, Magnusson SP, Rosted A, Aagaard P, Jakobsen AK, Larsen LH, et al. Resistance training in the early postoperative phase reduces hospitalization and leads to muscle hypertrophy in elderly hip surgery patients--a controlled, randomized study. J Am Geriatr Soc 2004;52(12):2016-2022.

36. LaStayo P, Marcus R, Dibble L, Wong B, Pepper G. Eccentric versus traditional resistance exercise for older adult fallers in the community: a randomized trial within a multi-component fall reduction program. BMC Geriatr 2017;17(1):149.

37. Villanueva MG, Lane CJ, Schroeder ET. Short rest interval lengths between sets optimally enhance body composition and performance with 8 weeks of strength resistance training in older men. Eur J Appl Physiol 2015;115(2):295-308.

38. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, et al. American College of Sports Medicine Position Stand: Exercise and physical activity for older adults. Med Sci Sports Exerc 2009;41(7):1510-1530.

39. Pollock ML, Carroll JF, Graves JE, Leggett SH, Braith RW, Limacher M, et al. Injuries and adherence to walk/jog and resistance training programs in the elderly. Med Sci Sports Exerc 1991;23(10):1194-1200.

40. Kenny RA, Coen RF, Frewen J, Donoghue OA, Cronin H, Sawa GM. Normative values of cognitive and physical function in older adults: findings from the Irish longitudinal study on ageing. J Am Geriatr Soc 2013;61 S2:S279-290.

41. Kosse NM, Dutmer AL, Dasenbrock L, Bauer JM, Lamoth CJ. Effectiveness and feasibility of early physical rehabilitation programs for geriatric hospitalized patients: a systematic review. BMC Geriatr 2013;13:107.

42. Brown CJ, Peel C, Bamman MM, Allman RM. Exercise program implementation proves not feasible during acute care hospitalization. J Rehabil Res Dev 2006;43(7):939-946.