

Progression and adherence to an individually prescribed and supervised resistance training intervention in older adults recovering in hospital from lower limb fragility fracture

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Abstract: This study evaluated adherence and progression with a 12-week resistance training program amongst a sample of older adults recovering in hospital from lower limb fragility fracture. Forty-nine participants (mean age 84 years) commenced the resistance training program seven days after the injury. The exercise prescription involved training of the hip and knee extensors, hip abductors, and ankle plantar- and dorsi flexors using resistive bands. Exercise sessions were completed tri-weekly for six weeks under supervision by a physiotherapist and tri-weekly for an additional six weeks independently. Adherence was assessed as the proportion of exercise sessions completed of those prescribed and any progression in resistance was documented. Level of adherence was not found to be influenced by age, gender, cognition or strength but was greater amongst those admitted from the community setting and for the first six weeks when supervision was present. Participants were able to obtain similar levels of resistance for the injured side compared to the noninjured side for all exercises excluding hip abduction and those admitted from the community setting achieved higher levels of resistance compared to those admitted from the residential care setting. These findings suggest that an early resistance training program is feasible and well tolerated amongst older adults recovering from lower limb fragility fracture. Further work is necessary to determine how this level of resistance training translates into functional improvements and how to improve adherence levels in clinical rehabilitation settings.

Keywords: aged, rehabilitation, exercise, adherence, hip fracture

Introduction

The benefits of progressive resistance training across the life span and into later life are well documented. However, the impact of this exercise modality in rehabilitation settings with frail older adults is poorly understood. In studies of resistance training in healthy older adults, it has consistently been shown that marked improvements in gait velocity (Topp et al 1996), muscle strength (Damush and Damush 1999; Jette et al 1999; Capodaglio et al 2002) and reductions in physical and overall disability (Jette et al 1999) can be achieved. There have been few studies of resistance training in frail older adults, but in those that have been reported, it appears that high intensity training is more successful (Fiatarone et al 1994) than low intensity training (Mulrow et al 1994) in achieving gains in strength. Nevertheless translation of these finding into a clinical setting has been difficult. The provision of therapeutic exercise programs in hospitals to post-operative patients has a poor evidence base and the approach varies from therapist to therapist. There is uncertainty about whether patients recovering from an operation are able to adhere to a resistance strengthening program which

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commences within a week of fracture when they are often recovering from an operation and dealing with pain and discomfort.

Poor muscle strength is a risk factor for fall related osteoporotic fractures (Wolfson et al 1995) and a major cause of disability and loss of independence for older adults. Most of the burden is due to lower limb fractures and, in particular, hip fractures. The best treatment options for improvements in muscle strength in this patient group have not been evaluated extensively. There have been no randomized controlled trials amongst hip fracture patients that have commenced an exercise intervention during admission to hospital. The earliest of exercise interventions commenced at discharge from rehabilitation (Hauer et al 2002). In addition, there has only been one randomized controlled trial evaluating the benefits of progressive resistance training in hip fracture patients (Tinetti et al 1999). Similar to previous work, the intervention did not commence until discharge from hospital and only found improvements in upper extremity strength, not other important measures of recovery (Tinetti et al 1999).

The level of adherence to progressive resistance training and the intensity of resistance able to be achieved by patients following lower limb fracture is important to evaluate and report. These data will assist in determining whether such interventions are feasible in this frail clinical group and the levels of resistance necessary to maintain or improve muscle strength.

The objective of this study was to describe a sample of frail older lower limb fracture patients completing a resistance exercise program in terms of exercise progression and adherence.

Methods

An observational study of 49 patients participating in a randomized controlled trial aimed at evaluating the health benefits of an individualized nutrition support program and/or a progressive resistance lower limb training program for older adults admitted to hospital following a fall-related lower limb fracture. The Clinical Research and Ethics Committee of Flinders Medical Centre approved the study procedures.

Recruitment

The data reported in this study are from participants of the ENERGII Trial (ACTRN12605000252617) that were randomly allocated to receive a 12-week resistance training intervention using latex-free resistive elastic bands (REP Band; Magister Corporation, Chattanooga, TN, USA) supervised by a physiotherapist. Details of participant recruitment

are reported elsewhere (Miller et al 2006). In brief, all patients with a fall-related lower limb fracture admitted to a university affiliated teaching hospital between September 2000 and October 2002 were screened for inclusion in a randomized, controlled trial evaluating an individualized, 6-week, oral supplementation program and/or a 12 week progressive resistance lower limb strength training program. Eligibility criteria included 70 years or older and at risk of malnutrition. All participants included in this report received the 12-week resistance training intervention (alone or in combination with the 6-week oral supplementation program) concurrently with all other prescribed therapy, including routine physiotherapy.

Procedures

Data were collected from medical case notes and included age, gender, and admission accommodation. Cognition was assessed using the Short Portable Mental Status Questionnaire (Pfeiffer 1975). Knee extensor strength of the injured and noninjured limb was measured to the nearest 0.1 kg using a hand-held Nicholas Manual Muscle Tester (NMMT; Lafayette Instrument, Lafayette, IN, USA). Participants were required to be seated on a firm chair and grip the seat with both hands. The limb being assessed was placed flexed at the hip and knee to 90°. The limb not being assessed was placed relaxed with knee flexed. The assessor assumed a kneeling position directly in front of the participant and placed the NMMT on the distal tibia immediately proximal to the ankle joint, along the line of the tibia. A small pad was placed between the NMMT and shin to protect the participant. With the assessor holding the NMMT with both hands, the test procedure was explained and demonstrated to the participant. When directed, the participant was required to attempt to extend their knee by pushing their ankle outwards against the assessor through the NMMT. The assessor applied sufficient force to prevent movement of the limb. The participant was instructed when to stop pushing (three seconds) and the peak force was documented. The participant rested for 15 seconds and then repeated the test procedure twice. The average of the values obtained for the second and third trials were used for subsequent analyses.

The progressive resistance exercises involved training of the hip and knee extensors, hip abductors, ankle plantar- and dorsi-flexors. These muscle groups were chosen because of their importance in functional activities (Bassey et al 1992). Commencing resistance was appropriate to baseline strength, pain level, and range of movement of both the injured and noninjured limb. Resistance was increased as soon as two sets

of eight repetitions of the exercise could be completed in good form, determined on an individual basis at the discretion of the supervising physiotherapist. Five levels of resistance were used: Level 1 (Peach) – 1.4 kg; Level 2 (Orange) – 2.0 kg; Level 3 (Green) – 2.7 kg; Level 4 (Blue) – 3.4 kg; and Level 5 (Red) – 4.1 kg. The load associated with each level is 100% of the load achieved when band is extended. Adherence and progression were documented by the physiotherapist, the participants and/or next of kin using a standardized format in a trial diary. Side effects were noted and sessions were not attempted if the participant was deemed medically unstable. Adherence was calculated as the number of sessions completed of those prescribed (total sessions = 36).

Statistical analyses

Baseline characteristics of participants were analyzed using simple descriptive procedures and the Wilcoxon Signed Ranks Test was used to test for difference in baseline knee extensor strength according to injured side or noninjured side.

Adherence to the prescribed exercise intervention was converted to ranks for all ANOVA analyses due to severe nonnormality in the adherence proportions. ANOVA was used to screen for an effect of exercise (ankle plantar flexion vs. ankle dorsi flexion vs. hip abduction vs. hip knee extension), side (injured vs. noninjured) or level of supervision (week 1–6 vs. week 7–12). All subsequent analyses were performed on the overall adherence across exercise and side of injury.

The effect of categorical variables (gender, cognition, and admission accommodation) on adherence was determined separately using ANOVA with level of supervision included as a within-subjects factor. An insufficient sample size to complete a data matrix between the three categorical variables prevented any two or three way interactions from being investigated in a single model. The effect of continuous variables (age, knee extensor strength [injured], and knee extensor strength [noninjured]) on adherence was determined using linear regression.

The maximum band level achieved by participants is illustrated according to each exercise and side. The level of agreement for side (injured vs. noninjured) was investigated using the Kappa index (weighted) for each exercise separately and subsequent analyses were performed using the maximum band level achieved for each exercise regardless of side. The number of participants progressing to a high level of resistance (red or blue), moderate resistance (green or orange), or low resistance (peach or gravity) is described for categorical

variables (gender, cognition, admission accommodation) whilst median (IQR) is presented across the three categories of resistance for continuous variables: age and knee extensor strength (injured and noninjured). Significant differences in level of resistance achieved were determined using either Kruskal-Wallis for continuous variables or Fisher's Exact test for categorical variables.

A significance level of $P < 0.05$ was applied throughout. All analyses were conducted using the Statistical Package for Social Sciences (SPSS) for Windows (Version 11.0.0; 2001, SPSS Inc., Chicago IL, USA).

Results

Participant characteristics

The mean (SD) age of the 49 participants (37 female) was 84 (6) years. Thirty eight participants were previously residing in the community and 29 were assessed as having no cognitive impairment at baseline. The majority of the sample had suffered a fractured neck of femur ($n = 43$) and surgical fixation by internal fixation ($n = 24$) or Austin Moore Prosthesis ($n = 18$). Median (interquartile range [IQR]) of length of stay in acute care was 10 days (8.5) and 16 received the trial intervention in the residential care setting on discharge. Median (IQR) knee extensor strength of participants at baseline was 2.0 kg (2.8) and 4.8 kg (4.1) for the injured and noninjured side, respectively ($P < 0.001$).

Adherence to the exercise treatment

Test of within-subject effects for exercise, side, and level of supervision showed no two- or three-way interactions. Adherence to the prescribed program of resistance training was, however, higher during the period where supervision was high (week 1–6) compared with when the level of supervision decreased (week 7–12: $P = 0.005$). The overall median (IQR) adherence level for participants from week one to week six was 0.997 (0.056) and from week seven to week twelve was 0.913 (0.276).

Level of adherence was not affected by age or baseline knee extensor strength (Table 1) nor was it affected by gender or cognition (Table 2). There was no significant interaction between supervision and admission accommodation, however, admission accommodation was significant ($P = 0.014$) with participants who entered hospital from the community achieving a higher level of adherence.

Progression

The maximum band level achieved by participants according to each exercise and side of injury is presented

Table 1 Results of the separate linear regression models for effect of age and knee extensor strength on level of adherence (%)

Independent variables	Regression Co-efficient (B)	t	P-value
Supervised adherence (Week 1 – Week 6)			
Age, years	–0.4	–0.798	0.429
Knee extensor strength, kg			
Injured	–0.6	–0.445	0.658
Noninjured	1.2	1.574	0.122
Unsupervised adherence (Week 7 – Week 12)			
Age, years	–1.0	–1.452	0.153
Knee extensor strength, kg			
Injured limb	–1.2	–0.590	0.558
Noninjured limb	1.6	1.389	0.171

in Figure 1. The level of agreement for maximum band level achieved according to side of injury was high for each of the exercises: ankle dorsi flexion, $K = 0.864$; ankle plantar flexion, $K = 0.779$; hip abduction, $K = 0.715$; hip knee extension, $K = 0.847$. For all exercises (excluding hip abduction), only 6% reached a different maximum band level according to the side of injury and only one third of these differed by more than one level of resistance. For hip abduction, 21% reached a different maximum band level according to the side of the injury and half of these differed by more than one level of resistance.

For all exercises, those admitted from the community were more likely to achieve higher levels of resistance (Table 3). For hip-knee extension, those participants who were cognitively intact were more likely to achieve higher levels of resistance ($P = 0.021$). There was no significant effect of age, baseline knee extensor strength or gender on the level of resistance achieved (Table 3).

Discussion

This is the first study to describe evidence on adherence to exercise prescriptions within seven days of a lower limb fracture using resistive bands for progressive resistance training. It provides evidence that this form of resistance training is well suited to an older, frail lower limb fracture group. Exercise adherence remained high in hospital, in residential care and community settings but it did decline slightly without regular supervision. Progression within the exercise program was steady with most participants reaching very similar maximal band levels for injured and noninjured sides. This training modality appears to be a suitable alternative for this patient group where traditional methods are limited due to pain, weakness and limited mobility post-hip fracture. It is also an inexpensive option, patients can be educated whilst in hospital and monitored infrequently resulting in reduced travel costs (therapist to home or patient to facility) and resistive bands cost very little.

Several studies have reported mixed findings on the effects of rehabilitation interventions commencing at various times after hip fracture. Binder and colleagues (2004) found that six months of extended outpatient rehabilitation including progressive resistance training improves physical functioning, quality of life and reduces disability compared with low intensity home exercise in community dwelling men and women over 65 years. Hauer and colleagues (2002) reported that three months of progressive resistance and functional training provided better improvements in muscle strength, gait velocity and balance than stretching exercises and memory tasks. Tinetti and colleagues (1999) showed no difference in muscle strength, balance, gait, and activities of daily living function between groups undertaking a six month low intensity home-based rehabilitation program using resistive elastic bands and controls. While the present study does not specifically examine outcomes relating to a resistance

Table 2 Level of adherence (proportion) across categories and results for separate ANOVA. All values expressed as median (IQR)

Independent variables	Adherence		F ratio _(1,46)	
	Supervised (Week 1–6)	Unsupervised (Week 7–12)	Interaction	IV main effect
Gender			1.552	0.973
Male	1.00 (0.10)	1.00 (0.23)		
Female	0.98 (0.06)	0.90 (0.35)		
Cognition			3.489	2.471
Intact	1.00 (0.06)	1.00 (0.19)		
Impaired	0.99 (0.06)	0.83 (0.50)		
Admission accommodation			3.790	6.547 ^a
Community	1.00 (0.06)	1.00 (0.19)		
Residential care	0.94 (0.09)	0.82 (0.45)		

Abbreviation: IV, independent variable.

Note: ^a $P < 0.05$

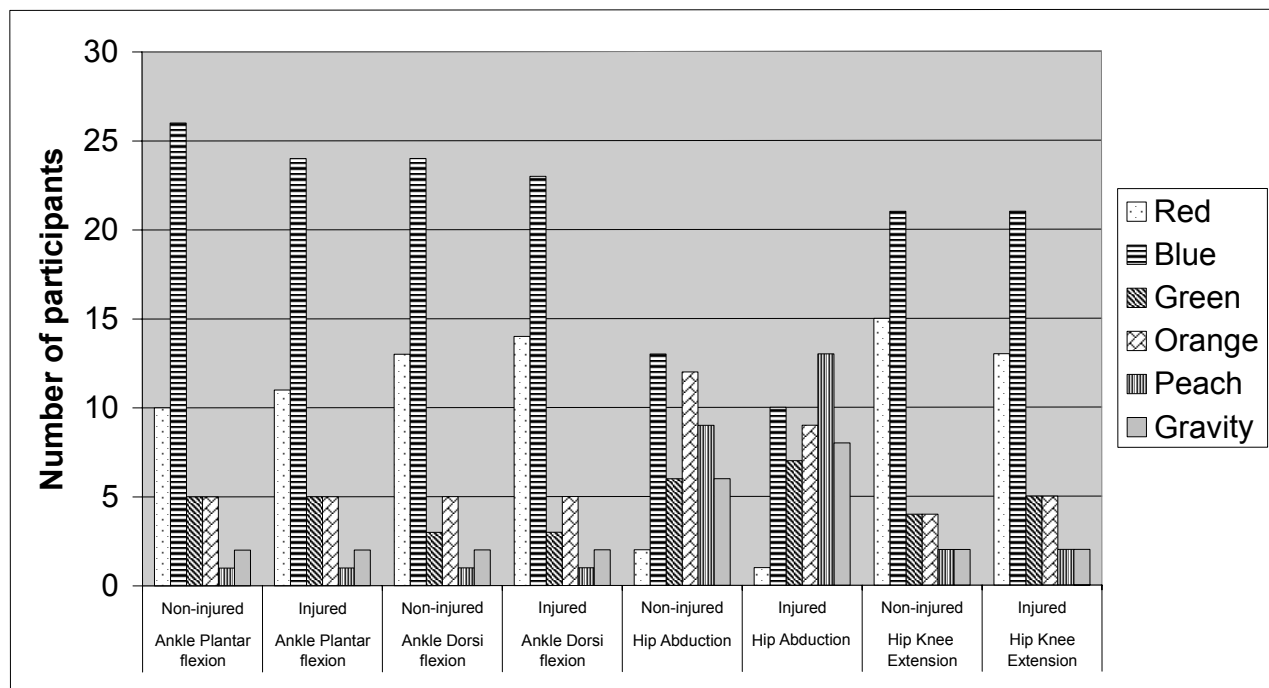


Figure 1 Maximum resistance achieved for each participant across the four prescribed exercises and according to side of injury.

training program, it does provide some evidence for the feasibility of using resistive elastic bands to provide an early resistance training intervention to this vulnerable clinical group. It is anticipated that early and sustained intervention, such as that described in the present study, could assist in preventing the rapid deconditioning that occurs during acute recovery from lower limb fracture and in the longer term translate into improvements in functional outcomes.

The high number of exercise sessions completed over the 12-week study period demonstrates that the resistance training program is acceptable to this patient group, even during the early stages of recovery. The overall adherence rate of 95% achieved in the present study compares favorably with the 78% reported by Capodaglio and colleagues (2002) and 58% of Jette and colleagues (1999) that were obtained with nondisabled 65–87 year old participants. However it is important to acknowledge that adherence in the present study was highest during the supervised period (99.7%; weeks 1–6) compared with the unsupervised period (91.3%; weeks 7–12). This could possibly reflect a decrease in motivation that accompanied a reduction in physiotherapist contact from three times per week initially to only once per week in the final six weeks of the intervention. This reduced supervision may also have had an adverse effect on the social component of regular interaction with the physiotherapists that the program facilitated, which can be an important motivating

factor in elderly women. The high adherence rates achieved in the present study are also likely a result of the training program being tailored to suit each individual based on initial strength and pain level of both the injured and noninjured limb. This specificity would have undoubtedly enhanced each participant's ability to perform the prescribed exercises.

The maximum band level differences between the injured and noninjured sides were greatest for hip abduction, which is the movement most likely to be influenced by hip fracture. The remaining three exercises showed very little variation according to side of injury with only 6% overall exhibiting different maximum band levels suggesting that strength levels are being maintained in the movements less influenced by the fracture. The lower agreement for hip abduction (21% difference in maximal levels) and wide differences (50% were greater than one band level) mean this movement was probably difficult or painful to perform at this stage of the recovery process for some patients. The higher band levels achieved by patients admitted from the community and those cognitively intact could stem from higher motivation levels, possibly linked to a desire to remain out of residential care, or from a superior understanding of how to execute the exercises properly.

The modest sample size and heterogeneous nature of the sample limit the applicability of these findings. The aim of the study was to investigate the tolerability of a resistance training program in older lower limb fracture patients;

Table 3 Number (proportion) of participants (unless stated otherwise) achieving the three levels of resistance according to age, gender, cognition, admission accommodation, and baseline knee extensor strength

Independent variables	Resistance			P-value ^d
	Low ^a	Moderate ^b	High ^c	
Ankle dorsi flexion				
Median age (IQR)	95 ^e	87 (10.00)	82 (7.75)	0.09
Knee extensor strength				
Injured, median (IQR)	0.65 ^e	1.00 (3.63)	2.75 (2.44)	0.122
Noninjured, median (IQR)	1.50 ^e	2.00 (6.73)	5.20 (3.93)	0.110
Gender	0.854			
Male	0 (0.00)	2 (0.17)	10 (0.83)	
Female	3 (0.08)	7 (0.19)	26 (0.72)	
Admission accommodation				0.015
Community	1 (0.03)	5 (0.13)	32 (0.84)	
Residential care	2 (0.20)	4 (0.40)	4 (0.40)	
Cognition				0.078
Intact	0 (0.00)	5 (0.17)	24 (0.83)	
Impaired	3 (0.16)	4 (0.21)	12 (0.63)	
Ankle plantar flexion				
Median age (IQR)	95 ^e	87 (9)	82 (7.50)	0.064
Knee extensor strength				
Injured, median (IQR)	0.65 ^e	1.08 (3.60)	2.65 (2.60)	0.223
Noninjured, median (IQR)	1.50 ^e	3.50 (7.84)	5.10 (3.75)	0.165
Gender				0.85
Male	0 (0.00)	2 (0.17)	10 (0.83)	
Female	3 (0.08)	6 (0.17)	27 (0.75)	
Admission accommodation				0.009
Community	1 (0.03)	4 (0.11)	33 (0.87)	
Residential care	2 (0.20)	4 (0.40)	4 (0.40)	
Cognition				0.053
Intact	0 (0.00)	4 (0.14)	25 (0.86)	
Impaired	3 (0.16)	4 (0.21)	12 (0.63)	
Hip abduction				
Median age (IQR)	86 (9)	81.50 (7.75)	82.0 (9)	0.266
Knee extensor strength				
Injured, median (IQR)	1.60 (2.50)	1.40 (2.35)	3.20 (3.65)	0.226
Noninjured, median (IQR)	3.80 (3.70)	5.20 (2.54)	5.85 (5.95)	0.093
Gender				0.287
Male	2 (0.17)	4 (0.33)	6 (0.50)	
Female	13 (0.36)	14 (0.39)	9 (0.25)	
Admission accommodation				<0.001
Community	7 (0.18)	18 (0.47)	13 (0.34)	
Residential care	8 (0.80)	0 (0.00)	2 (0.20)	
Cognition				0.094
Intact	6 (0.21)	14 (0.48)	9 (0.31)	
Impaired	9 (0.47)	4 (0.21)	6 (0.32)	
Hip-knee extension				
Median age (IQR)	91 (13.25)	86.5 (10.25)	82.0 (7.75)	0.076
Knee extensor strength				
Injured, median (IQR)	0.55 (1.03)	2.05 (3.46)	2.40 (2.65)	0.131
Noninjured, median (IQR)	1.30 (2.16)	4.40 (7.60)	5.20 (4.10)	0.078

(Continued)

Table 3 (Continued)

Independent variables	Resistance			P-value ^d
	Low ^a	Moderate ^b	High ^c	
Gender				0.732
Male	0 (0.00)	2 (0.17)	10 (0.83)	
Female	4 (0.11)	6 (0.17)	26 (0.72)	
Admission accommodation				0.001
Community	1 (0.03)	4 (0.11)	33 (0.87)	
Residential care	3 (0.30)	4 (0.40)	3 (0.30)	
Cognition				0.021
Intact	0 (0.00)	4 (0.14)	25 (0.86)	
Impaired	4 (0.21)	4 (0.21)	11 (0.58)	

Notes: ^aLow resistance (Peach/Gravity); ^bModerate resistance (Green/Orange); ^cHigh resistance (Red/Blue); ^dSignificance calculated according to Kruskal-Wallis for continuous data and Fisher's Exact Test for categorical data; ^eIQR not calculated as n = 3.

therefore, it was not powered to detect changes in muscle strength values and this has not been discussed. Furthermore, the composition of our group which included patients from residential care, those with cognitive impairment and the fact that not all subjects suffered from the same type of fracture, increased the variability in functional status and may have influenced our findings. While the adherence data from the initial six week period were maintained by the supervising physiotherapist, the final six week period was based on patient self-report, which may therefore have been artificially elevated. However, the nature of the progression data support the high adherence values reported.

In conclusion, the present study demonstrates that a simple progressive resistance training program implemented in a hospital setting within seven days of lower limb fracture is well tolerated in terms of adherence and progression by frail older adults from both community and nursing homes. The use of resistive elastic bands to provide the training stimulus can facilitate the early intervention and possibly reduce the deconditioning and subsequent strength losses associated with this type of injury. It is unclear whether adherence to this program was better than to a conventional physiotherapy program and future studies should investigate adherence to different approaches as well as the impact that similar interventions have on patient outcomes including muscular strength, physical function, and quality of life.

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