The role of chair exercises for older adults following hip fracture

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Objectives. To examine the influence of regular participation in chair exercises on postoperative deconditioning in respect of selected physiological, psychological and anthropometric variables.

Design. Quasi-experimental, non-randomised control group pre-test/post-test design where test group (N = 20) and control group (N = 10) were not equivalent because random selection and assignment were not possible.

Subjects. Patients discharged from an orthopaedic ward 8 - 10 days after hip surgery who were cognitively competent (mean score on Mini-Mental State Examination 26 (SD 3.5)), sedentary (mean score on Habitual Physical Activity Questionnaire for the Elderly 7.4 (SD 3.3)) women aged 70 years and above (mean 80 (SD 6.6) years).

Setting. Hip fracture patients admitted to a multidisciplinary geriatric hospital for further medical observation.

Measurements. Abstraction of medical records provided information about co-morbidities and questionnaires assessed demographic, affective and cognitive function. Physiological, psychological and anthropometric status was measured pre- and post-intervention.

Results. Data revealed high variability, suggesting that the effect of the independent variable was obscured by the heterogeneity of the cohort. Both groups improved similarly in grip strength, and in levels of depression and confidence. Body composition data explained the weight maintenance as a consequence of significant gains in fat-free mass in the experimental group. The significant change in systolic blood pressure and heart rate over the exercise and recovery period suggested that the 6-week period of moderate-intensity exercise was adequate to stimulate cardiovascular adaptations.

Conclusions. Whether or not the submaximal chair exercise regimen was of optimal benefit remains unclear. However, the intervention did appear to have contributed to the maintenance of the physical condition of older women temporarily disabled as a result of a fracture and subsequent hip surgery.

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Falls among the elderly are important health risk markers which signal increasing frailty and risk of dying. The high annual prevalence rates of falls documented among community-living and institutionalised elderly[1-3] suggest that strategies of avoidance and effective intervention are necessary, particularly when injuries occur in at least half of those who fall. Fractures are the most common consequence of falls, with hip fractures occurring more frequently with increasing age.[4] Sequelae from hip fractures include substantially reduced functional status,[5-8] heightened anxiety, loss of confidence and fear of falling,[9] causing a reluctance to walk after surgery. Downton and Andrews[10] provide compelling evidence that this fear is sufficient to restrict activity in 42% of over-75-year-old community-living first-time fallers.

The prognosis and rehabilitation of elderly fallers recovering from hip fracture surgery are not very promising. Fifteen per cent of a given sample will die as a direct consequence of the fracture,[11] and the majority of those who survive will be dependent on walking aids.[6,12] Coupled with reduced mobility and enduring pain in the affected hip, many of these patients will also experience persistent depressive symptoms.[13] Craik[12] cautions that most elderly post-hip fracture patients have not returned to pre-fracture levels of function 1 year after the surgery. Early postoperative intervention to avoid the initial rapid physical deconditioning which occurs in the first few weeks after surgery is important. Marottoli *et al.*[6] examined the impact of hip fractures on community-living older adults (65 - 74 years) and showed that 60% still needed assistance after 6 months. They found that better baseline physical function and intact mental status predicted better physical function at 6 weeks and 6 months post-fracture. However, it was noted that the decline in post-fracture physical function was more pronounced than expected, even in those individuals whose baseline function had been good.

The reported high incidence of post-hip fracture morbidity[14] and enduring post-fracture disability[6] emphasises a potentially major public health problem and suggests that attention should be given to ameliorating the disabling conditions that follow the event. The purpose of this investigation was to examine the influence of exercise on the initial deterioration in condition that occurs in the first few weeks following hip surgery in older adults. It was hypothesised that participation in a specific set of chair exercises for a period of 6 weeks. 4 times a week for 50 minutes, at an average intensity level of 60% of age-predicted maximum heart rate (max. HR) would arrest postoperative deconditioning changes in selected physiological, psychological and anthropometric variables.

Patients and methods

The study was conducted between 1993 and 1995 at Kensington Clinic, a small state-funded, multidisciplinary geriatric hospital in Johannesburg.

Women patients, who were post-hip surgery and aged 70 years and above, took part. They had been discharged from an orthopaedic ward at Johannesburg Hospital after meeting standard mobilisation goals within 8 - 10 days of surgery.

Patients who were unable adequately to perform essential activities of daily living such as ablutions and getting in and out of bed without assistance, who lived alone or had other complications which required further medical observation were admitted to Kensington Clinic. These patients were eligible to volunteer for the experimental group. Patients who were discharged to their own residences served as matched controls for the study.

Eligibility and exclusion criteria

Eligible subjects were invited to participate in the study. Informed consent was obtained in accordance with the ethical policy of the University of the Witwatersrand.

A comprehensive clinical assessment was made by the attending physician within 14 days of surgery. All patients were considered to be in stable health, although many had medical problems, including hypertension, angina pectoris, diabetes and hypothyroidism, and were on appropriate therapy.

The following criteria excluded subjects from participating: cognitive function, as indicated by a Folstein Mini-Mental State Examination (MMSE)[15] score of less than 17 points; a subsequent fall; premature discharge prior to the completion of the 6-week exercise programme; and voluntary discontinuance.

Of the 71 subjects who agreed to participate, 30 completed all assessments, 20 in the experimental group and 10 in the control group. Table I summarises their baseline characteristics and clinical profiles. Hospital strikes and the presence of a particularly resistant influenza virus frustrated the progress of the study and accounted for the discontinuance of 42% of the subjects in the experimental group.

Baseline measurements

Functional and anthropometric baseline measurements of the participants were made within 1 week of discharge from the orthopaedic unit. The data were collected during two consecutive 3-hour sessions. The MMSE,[15] Falls Efficacy Scale (FES),[16] Habitual Physical Activity Questionnaire for the Elderly (HPAQ)[17] and Beck's Depression Inventory (BDI)[18] were administered on the first day, and the physiological and

Table I. Baseline clinical profile and characteristics of the experimental and control groups

	Experimental group (*N* = 20)			Control group (*N* = 10)		
Clinical profile	Occurrence (%)	Mean	(SD)	Occurrence (%)	Mean	(SD)
Age (yrs)		80.0	(6.2)		79.4	(7.8)
Height (cm)		153.8	(9.5)		156.4	(6.25)
Weight (kg)		57.6	(2.53)		55.5	(1.26)
Predicted body fat (%)		22.2	(1.72)		22.0	(2.11)
Fitness (HPAQ score) *		7.3	(4.62)		7.6	(2.19)
Cognitive functioning (MMSE score)†		26.0	(4.19)		26.9	(3.06)
Hip fracture procedure						
Open reduction internal fixation	45			60		
Total hip replacement	55			40		
Mobility status at 'baseline'						
Non-weight bearing	15			10		
Weight bearing with assistance	75			90		
Medication						
Analgesic (prn)	60			30		
Haematological	55			30		
Cardiac	55			70		
Metabolic	30			40		
Emotional — sedative/antidepressant	35			50		
Anti-inflammatory	15			10		
Neuromuscular — Parkinsonian therapy	10			10		
(3 or more medications/subject)	40			40		
Enduring medical complications						
Cardiovascular (hypertension, angina, etc.)	65			70		
Metabolic (diabetes)	40			50		
Neurological (Parkinson's)	10			10		
Repeat procedure						
Same hip	20			20		
Other hip	10			10		

* HPAQ: Fitness classification levels: low activity levels = < 9.4 moderate activity levels = < 16.5, high activity levels = > 16.5.
† MMSE: Cognitive aspects of mental function: maximum score = 30, mean score of cognitively competent adults = 27.

anthropometric data were collected on the next day. Post-intervention data were collected in the same way 6 weeks later. Pre- and post-intervention measurements were made by a single trained research assistant who was blinded as to whether the subjects fell into the experimental or the control group. Post-intervention measurements were made without reference to baseline values. Details of the pre- and post-intervention measurements are set out in Table II.

Mass and stature. Mass was determined on a Seca balance beam (Model 713, Vogel and Halke, Hamburg, Germany) and stature was measured with a Holtain digital anthropometer (Holtain Ltd., Crymyth, UK). Where subjects were unable to stand, stature was estimated by means of the formula of Chumlea *et al.*[19]

Predicted percentage body fat. Skinfold measurements were taken at the triceps, supra-iliac and abdominal sites[20] and were used to predict body density[21] and percentage body fat.[22] In order to assess the effect of the exercise programme on fat patterning, thigh and calf skinfolds of the non-afflicted limb were also measured.

Range of motion. Range of motion (ROM) of the neck, shoulder, wrist and ankle were measured with a standard clinical protractor goniometer. Each measurement was repeated three times. Where consistent increases were noted, the measurement was repeated a fourth time in accordance with the protocol of Raab *et al.*[23]

Lung function. Lung volumes and expiration efficiency were used to measure lung function with the Mijnhardt Vicatest P2A Expiratory System (Mijnhardt, Bunnik, Holland). After a single practice, the standard maximum expiration inspiration respiratory manoeuvre was performed twice, allowing a rest period between the two tests.

Maximal grip strength. Grip strength was measured three times for each hand with an adjustable grip dynamometer (Grip Dynamoter Model 1201 Takeikiki Kogyo, Tokyo, Japan). The best of three maximal efforts, with appropriate rest intervals, was recorded for each hand. Left and right hand grip measurements were summed for analysis[24] in order to eliminate the effect of hand dominance.

Exercise intervention. A supervised 50-minute chair

Table II. Change in functional status variables

	Experimental group (N = 20)					Control group (N = 10)					Difference	
Variable	Post (mean)	Pre (mean)	Change (mean)	t	PRT > [t]	Post (mean)	Pre (mean)	Change (mean)	t	PRT > [t]	t stat	Prob > [t]
Strength												
Grip sum	34.91	33.75	1.15	1.15	0.27	31.52	30.72	−0.49	−0.44	0.67	−1.09	0.29
Anthropometric												
Mass (kg)*	58.34	57.57	0.07	0.12	0.91	**53.94**	**55.48**	**−1.54**	**−3.87**	**0.00**	**−2.16**	**0.04**
% Body fat	**20.77**	**22.15**	**−1.39**	**−3.11**	**0.01**	**20.59**	**22.00**	**−1.41**	**−2.00**	**0.08**	−0.03	0.98
Fat mass	**11.89**	**12.69**	**−0.80**	**−2.46**	**0.03**	**11.16**	**12.39**	**−1.23**	**−2.59**	**0.03**	−0.75	0.46
Fat-free mass	45.68	44.90	0.78	1.18	0.26	41.88	42.12	−0.24	−0.45	0.67	−1.12	0.28
Arm circum. (cm)	25.78	25.75	0.03	0.09	0.93	25.66	25.83	−0.02	−0.44	0.67	−0.39	0.70
Hip circum. (cm)	95.57	96.78	−0.48	−0.48	0.64	94.88	95.63	−0.76	−0.81	0.44	−0.20	0.84
Waist circum. (cm)*	82.65	82.41	0.24	0.51	0.61	**76.72**	**80.23**	**−3.51**	**−2.55**	**0.03**	**−2.58**	**0.03**
Calf circum. (cm)	**33.02**	**32.14**	**0.88**	**3.25**	**0.00**	**32.41**	**31.91**	**0.50**	**3.11**	**0.01**	−1.20	0.24
Calf skinfold (cm)*	**17.75**	**14.71**	**2.57**	**2.74**	**0.01**	14.80	15.09	−0.60	−1.15	0.30	**−2.95**	**0.01**
Thigh skinfold (mm)	20.56	19.28	1.29	1.75	0.10	19.70	19.85	−0.15	−0.22	0.83	−1.42	0.17
Triceps skinfold (mm)	13.04	13.43	−0.39	−0.84	0.41	**10.84**	**12.13**	**−1.32**	**−2.27**	**0.05**	−1.25	0.23
Supra-iliac skinfold (mm)	**10.94**	**12.99**	**−1.41**	**−2.91**	**0.01**	9.76	10.86	−1.10	−1.53	0.17	0.35	0.73
Abdom. skinfold (mm)	**16.27**	**17.38**	**−2.24**	**−3.43**	**0.00**	18.04	19.61	−1.57	−1.68	0.13	0.59	0.56
Respiration												
FEV_1 (%)	79.00	78.05	0.56	0.98	0.34	80.80	78.70	2.10	0.73	0.48	0.16	0.87
FVC (l)	1.92	1.93	0.07	1.66	0.12	1.84	1.81	0.03	0.25	0.81	−0.35	0.73
Range of motion (°)												
Dorsiflexion	35.63	37.29	−1.13	−0.59	0.56	38.22	31.56	6.67	1.58	0.15	1.69	0.12
Plantar flexion	21.76	19.28	1.76	0.93	0.37	19.89	22.00	−2.11	0.73	0.49	−1.12	0.28
Shoulder flexion	125.15	127.20	−2.05	−0.44	0.67	120.10	114.10	6.00	1.29	0.23	1.22	0.23
Cervical rotation (R)	53.40	55.21	−0.58	−0.26	0.80	58.80	60.60	−1.80	−0.61	0.55	−0.33	0.75
Cervical rotation (L)	55.40	52.15	3.25	1.13	0.27	56.80	57.30	−0.50	−0.36	0.73	−1.17	0.25
Wrist flexion	68.25	65.45	2.80	0.98	0.34	81.00	81.40	−0.40	−0.14	0.90	−0.78	0.44
Wrist extension	59.05	56.10	2.95	1.72	0.10	52.40	53.50	−1.10	−0.73	0.48	−1.77	0.09
Psychological												
BDI	**10.45**	**16.75**	**−6.30**	**−2.24**	**0.04**	**10.50**	**15.90**	**−5.40**	**−2.48**	**0.04**	0.25	0.80
FES confidence	**29.10**	**63.05**	**−33.95**	**−8.33**	**0.00**	**33.00**	**66.80**	**−33.80**	**−4.83**	**0.00**	0.02	0.99
FES fear	**25.35**	**47.15**	**−21.80**	**−3.92**	**0.00**	**27.90**	**52.30**	**−24.40**	**−5.20**	**0.00**	−0.36	0.72

* Indicates a difference at the 5% level of significance for the two independent sample t-tests.
Change = the average difference between the 'post' and the 'pre' measures (note that this may not be equal to the difference between the mean values for 'post' and 'pre', as there are some missing data); t and Pr > [t] (P-values) for the experimental and control groups represent the results of the paired comparisons t-test for a significant change from the 'pre' to the 'post' value; t and Pr > [t] for the difference represents the results for the two independent sample t-tests for a difference in change from 'pre' to 'post' for the experimental and control groups; FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity.
Values in **bold** indicate significant changes at the 5% level.

exercise programme was developed for this study, and was commenced on the 14th day after surgery. Participants sat facing inward on straight-backed chairs in a circle formation with adequate space to allow for unhindered lateral movements. The choreographed seated exercise routine was high-paced and included relatively complex movement co-ordinations.

The exercise routine remained unchanged for the entire period of the study (18 months). An intensity goal of 60% max. HR for 20 minutes of exercise was established. To assess this, HR was monitored continuously with an HR monitor (Polar Advantage, NV HRM, Polar Electro Oy, Finland).

New entrants to the programme were usually unable to sustain the effort required to reproduce the movements at the prescribed tempo. They were therefore advised to take rests, or to perform fewer repetitions, so as to avoid undue strain, fatigue or pain. In this way the subjects were able to control their own adaptation to the exercise programme.

Exercise sessions were conducted daily. A minimum of four exercise periods per subject was expected. Subject compliance was high, with a mean attendance of 92% of the total of 24 scheduled exercise sessions. This was contributed to by the popular sing-along music, the opportunities for social interaction and the sense of satisfaction and achievement experienced by the participants as they compared their progress with that of the new entrants joining the programme.

The same physiotherapist led all exercise classes to ensure consistency over time. Classes began with a 10-minute warm-up. Thereafter, the pace was increased and the emphasis was on both muscle endurance and range of movement.

Simple items such as lengths of ribbon, light tympanic instruments, balloons and brightly coloured balls were used to make the exercises more interesting and to encourage a fuller range of joint motion, particularly in the shoulder, arm and hand. The exercise session was concluded with a 5-minute tapering, calming and reflective period.

HR and blood pressure were measured with an automatic blood pressure monitor (Cardioline Automatic BP Monitor Model SD3, Remco, Italy) at 5-minute intervals during the exercise session and at 1-minute intervals during the recovery period.

Data analysis

Results were expressed as means, standard deviations and standard errors for each of the interval scale variables. In the case of demographic and qualitative data, responses were coded into generic information categories and scored as relative frequencies per category. To determine the difference between pre- and post-test scores, where subjects acted as their own controls, the paired-sample *t*-test for related samples[25] was used. Where differences between the groups were analysed, the two-sample *t*-test of independent samples was applied. The significance level for the two-tailed test was designated at $P = 0.05$.

Analysis of variance (ANOVA) was used to analyse the association between the initial fitness level of subjects and the change in functional status variables. In the case of the cardiovascular data for the experimental group, recorded during the 50-minute exercise class, ANOVA with repeated measures[26] was applied. The same technique was used to examine the effect of exercise intensity and cardiac medications on the heart rate and blood pressure variables. All statistical analyses were performed with the Statistical Analyst System (SAS, a registered trademark of the SAS Institute Inc.).

Results

There were no significant differences in the baseline characteristics and clinical profiles of the experimental and control groups (Table I). Fig. 1 summarises the profile of participants with regard to economic status, education, professional qualifications, living circumstances and health status.

The changes in functional status variables of the experimental and control groups at baseline and post-intervention are shown in Table II. Significant changes occurred within both groups in levels of confidence (as measured by the FES[16]) and in depression levels (as measured by the BDI[18]). The between-group difference was not significant. This suggests that the passage of time alone may have resulted in an improvement in these variables. The role of the exercise programme in the experimental group or the familiar home environment and encouragement by others in the control group is not clear.

The significant body composition changes noted in the experimental group were attributed to the exercise intervention. Non-significant, but right-direction differences included larger post-intervention values for active tissue (fat-free mass), strength and weight control in the experimental group. The body composition data appeared to explain the weight maintenance of the experimental group (as opposed to the weight loss by the control group) as a consequence of gains in fat-free mass at the expense of fat mass. In general, the data revealed considerable variability suggesting that the effect of the exercise intervention may have been obscured by the large differences between individuals in this study.

To examine the effect of pre-fracture levels of fitness on the changes attributed to the exercise intervention, subjects were classified into fitness categories in accordance with Voorrips *et al.*'s HPAQ[17] protocol. Fitness levels were derived from estimated energy expenditure relative to the reported intensity, duration and frequency of habitual activities, such as household chores, leisure-time activities and sport. Scores < 9.4 indicated low activity levels, whereas scores of 9.4 - 16.5 were classified as moderate and > 16.5 as high. The mean score for participants in both groups was 7.3, suggesting that few subjects had been physically active during the past year. Twenty-six (79%) fell into the low, unfit category and 7 (21%) were classified as moderately fit. Comparisons, relative to fitness category, indicated a significant association between dorsiflexion ($P = 0.0397$) and pre-fracture levels of fitness. Subjects in the least fit category experienced an average improvement of 3.75° in dorsiflexion. This was not demonstrated in the moderately fit group.

The effect of the intensity of the exercise during the programme was examined in terms of the age-related percentage max. HR for each individual.[27] Following the

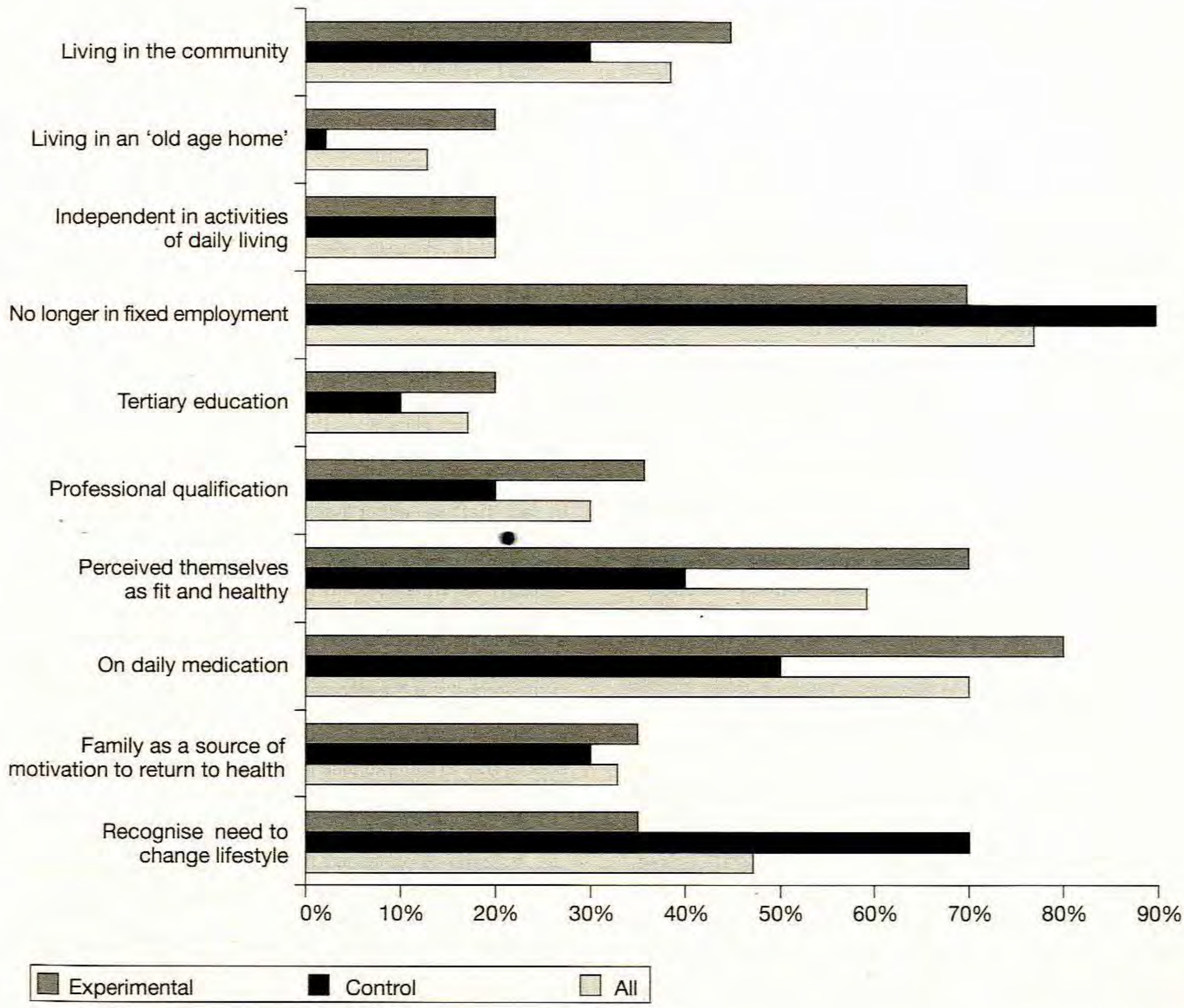

Fig. 1. Demographic profile of subjects (*N* = 30).

recommendation[28] that regular participation in mild-to-moderate endurance-type training for a period of at least 6 - 8 weeks is adequate to stimulate cardiovascular and musculoskeletal adaptations and reverse the detraining effect of bed rest, it was assumed that subjects who exercised at 60% of max. HR and above would experience a significant training effect. Accordingly, subjects in the experimental group were categorised into two groups, those exercising above 60% max. HR and those below.

Analysis of variance with repeated measures was used to assess the effect of exercise on HR over the first six exercise periods and the five subsequent recovery periods, while the 'time' factor (the exercise and recovery periods) was the repeated measure element of the design. The independent variables were 'test' (pre- and post-intervention) and 'exercise intensity level' where the group of subjects able to sustain an average HR response to exercise above 60% were compared with those unable to sustain that intensity. Two sets of analyses were run, one with the exercise intensity level calculated from the pre-test data and the other from the post-test data.

A significant 'test' effect would indicate a change in average HR from the beginning to the end of the 6-week exercise intervention. A significant 'exercise intensity level' effect would indicate that different HR levels would be found for the two levels of exercise intensity. A significant 'test × exercise intensity level' interaction effect would indicate that the effectiveness of the exercise programme was moderated by the intensity of the exercise.

The same analyses were repeated for systolic and diastolic blood pressure data. Table III provides results of these analyses. The 'time' effect was significant for both HR and systolic blood pressure with changes as expected in both variables during the exercise and recovery periods. The 'test' effect was significant for systolic blood pressure only, with an increase in the average systolic blood pressure from the beginning to the end of the exercise intervention being noted. 'Exercise intensity level' was significant for HR, with

Table III. Results of ANOVA with repeated measures

Exercise intensity level effect	Heart rate df	Heart rate F	Systolic BP df	Systolic BP F	Diastolic BP df	Diastolic BP F
Pre-intervention						
Time	10.17	8.315**	10.9	6.524**	10.9	2.315
Test	1.26	0.01	1.18	9.85**	1.18	2.28
Exercise intensity level	1.26	14.81**	1.18	0.19	1.18	0.49
Text × exercise intensity level	1.26	0.02	1.18	6.66*	1.18	0.52
Post-intervention						
Time	10.17	8.220**	10.9	4.674**	10.9	2.310
Test	1.26	0.00	1.18	6.69**	1.18	1.96
Exercise intensity level	1.26	15.57**	1.18	0.07	1.18	0.45
Text × exercise intensity level	1.26	0.27	1.18	4.3	1.18	0.54

* $P < 0.05$.
** $P < 0.01$.
BP = blood pressure.

higher HRs being associated with higher levels of exercise intensity. The 'test × exercise intensity level' interaction effect on the pre-test data was significant, but not on post-test data, suggesting that the exercise intensity did affect the change in HR.

Discussion

Although the experimental hypothesis was not conclusively supported, relevant, right-direction trends were evident and significant associations found. The small size of the study sample was a problem which may have adversely affected the differences observed between the two groups.

The demographic profile of participants was similar to that of other elderly hip fracture patients described in the literature.[3,7,29,30] Hip fracture patients constitute a frail subset of the elderly population[8] and these subjects were no exception. As a group, the elderly women in this study were inactive with moderate depression and low confidence levels, and had associated medical problems. Their grip strength was poor, and they were slender, both in terms of lean body mass and total body weight. The collective influence of pre-fracture characteristics should not be undermined and may set limits on the potential of the individual to return to function after surgery.

A striking finding was the high compliance rate shown by the experimental group. Regular participation in the exercise class was probably attributable to the social benefit of the group format used as well as to the mood-elevating effect of exercise.[30] The exercise programme proved to be safe and no untoward incidents occurred. In the period under investigation, 1 subject developed vertigo and was withdrawn from the exercise class.

In spite of the presence of mild-to-moderate baseline BDI[18] depressive symptoms and high scores on the FES,[16] which are associated with low self-efficacy, both groups showed significant differences in the 'confidence' and 'depressive state' variables, suggesting that these changes might be the result of time rather than the intervention. Subjects in the experimental group appeared to be slightly more depressed than the control group at the commencement of the intervention. This could be explained by fact that they either lived alone and were unable to go home until they were able to perform essential activities of daily living without assistance, or required further medical therapy. Nevertheless, this intervention appears to have contributed to the change in the depressive state seen in the experimental group, which is in keeping with the well-described mood-elevating effect of exercise.[30] However, the improvements in the depression score were no better than those obtained in the control group. Methodological limitations made it impossible to distinguish between those effects due to the exercise intervention and those which resulted from social or personal factors.

The most promising finding was the maintenance of fat-free mass during the period of post-surgery recovery in the experimental group, relative to the control group. The three significant differences in the change from 'pre' to 'post' between the two groups resulted from an increase in overall body mass and a decrease in body fat (calf skinfold site) for the experimental group, whereas the control group experienced a decrease in body mass (fat mass) and a decrease in percentage body fat. The sparing of active (fat-free) tissue may be a useful 'recovery' indicator in future research where exercise is used in post-surgery geriatric rehabilitation settings. Body composition changes in this direction have been shown to have an important effect on health and functional capacity.[31,32]

Changes in grip strength were interesting. Although right-direction changes were evident in grip strength, similar improvements were seen in both groups. This was attributed to the sudden weight-bearing demands placed on the arms of all participants by the use of walking aids during the initial period of recovery. The additional isometric-type muscle actions incorporated in the exercise intervention appear to have had little additive effect on the strength gains shown in the experimental group. Comparisons with similar studies, where significant differences in strength among institutionalised frail elderly have been found,[33-36] suggest that the relatively short duration of the intervention and the absence of weight-resisting exercises in the programme may have accounted for the smaller than expected changes in grip strength.

Preservation of flexibility is essential to the performance of activities of daily living such as dressing and transferring.

However, both pain and sedentary lifestyles were implicated in the postural and joint motion limitations found in the majority of participants. These conditions may have been sufficient to decrease the ROM of the joints measured, and this may have undermined the effect of the exercise regimen in the experimental group. This study applied standardised ROM protocols[20,23] and found that both substantial restriction and irreversible impairment in some joints, but not all, could have accounted for the intra-individual differences observed, as well as for the consistently smaller mean ROM for all joints when compared with data from other exercise intervention studies for the elderly.[23,37] Because it is recognised that decreased flexibility has been related to physical disability[38] and falls[39-41] in the elderly, it was hoped, but not expected, that after 6 weeks right-direction exercise-induced improvements in ROM would be found, particularly in the ankle joint. With the exception of ankle dorsiflexion, shoulder flexion and cervical rotation to the right, the changes in the experimental group were in the right direction and larger than the changes in the control group.

Analysis of the cardiovascular responses to the exercise programme indicated that the exercise programme was sufficiently intense to influence the cardiovascular parameters measured. The increase in systolic blood pressure from pre- to post-test may have been due to a training adaptation which enabled subjects to sustain their efforts for a longer period. Further, the gradual changes in systolic blood pressure, HR and the stability of diastolic blood pressure during the exercise session suggest that the chair exercise programme of moderate intensity was sufficient to induce small cardiovascular improvements and was safe for the population under investigation. These findings support the work of others[42-44] who report significant cardiovascular training effects in the elderly following 8, 12 and 16 weeks of moderate-intensity exercise programmes. The cardiovascular training effect found in this study was very encouraging.

The change from baseline data in the experimental group, in comparison to the changes observed in the control group, suggests that participation in the chair exercise programme prevented further deconditioning and, in some cases, improved the frail and insecure disposition of the group. However, research in frail elderly populations, particularly studies evaluating the effect of exercise,[45] presents many difficulties. This study was no exception, and although the project was carefully designed, methodological drawbacks such as the non-randomisation of the experimental and control groups, the absence of a controlled intervention for the control group to 'mimic' the treatment in every aspect except the activity, and the difficulty inherent in the small study sample necessitated the unbalanced design. The limit set on the duration of the exercise intervention as a result of the 6-week rehabilitation goal set by the clinic for mobilisation and relocation of hip fracture patients presented a further problem. Had the study continued for a longer period, the effect of the intervention may have supported the evidence of others[32-36,46] that flexibility, functional capacity and strength are trainable even among the frail elderly. Indeed, the fact that significant improvements were found in several variables over this short period provides support for the contention that the functional capacity of the frail elderly is trainable. Further long-term studies are required to clarify the optimal type, duration and intensity of exercise which will most benefit this growing subgroup of the elderly population.

Conclusion

This study used demographic, medical and functional status measures to assess the effect of exercise as a 'global' factor in variable change over time among an older adult post-hip fracture surgery cohort. Whether or not the submaximal chair exercise regimen was of optimal benefit remains unclear. However, the intervention did appear to have contributed to the maintenance of the physical condition of the older women who were temporarily disabled as a result of a fracture and subsequent hip surgery. This study has demonstrated that the frail elderly participants were no worse off for their involvement in the 6-week chair exercise programme, and in the area of body composition, showed some significant improvements over the control group.

The most notable contribution of the exercise intervention was the maintenance of fat-free mass and the cardiovascular training effect exhibited. More compelling evidence is necessary to explore the possible mechanisms and conditions which reverse the loss of stamina, fitness and rate of physical and psychological decline associated with hip fractures among the elderly.

Notwithstanding the high incidence of multiple chronic medical problems and concurrent medications, only 1 person was withdrawn from a single exercise session because of the development of vertigo. The exercise programme, which required no special equipment, was easily implemented, appeared to be safe for the frail elderly participants and was cost-effective and applicable in a nursing home setting.

This study has shown that baseline measurements of the patient's postoperative functional status provide a reference against which the effect of a particular therapeutic intervention may be examined. Further research in this field is essential.

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