Improvements in Quadriceps Strength With Regular Seated Exercise in the Institutionalized Elderly

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ABSTRACT. McMurdo MET, Rennie LM. Improvements in quadriceps strength with regular seated exercise in the institutionalized elderly. Arch Phys Med Rehabil 1994;75:600-3.

• The quadriceps strength of a group of residents homes for the elderly (mean age 83 years) was assessed in a randomized controlled trial of seated group exercise versus group reminiscence therapy. Fifty-five of 65 volunteers completed the 6-month study, with 4 dropouts from the exercise group, and 6 dropouts from the reminiscence group. There were no adverse effects. Average of attendance at the exercise sessions was 72% (range, 18% to 98%) and 62% (range, 29% to 100%) at the reminiscence sessions. The reminiscence sessions comprised group interaction and discussion prompted by the use of reminiscence aids. By the end of the study, the change observed in the exercise group was significantly different from the reminiscence group in terms of quadriceps strength ($p < 0.01$, Mann-Whitney U test). Both groups improved equally in their ability to climb up steps, but neither cognitive function (Mini-Mental State Examination) nor reaction time altered significantly.

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Elderly people experience age-related loss of stamina and fitness; however, the precise age at which this decline begins and the rate of decline varies from one individual to another. Some of the deterioration is due to the intrinsic process of aging, which is not amenable to intervention. However, it is now acknowledged that many age-related changes once assumed to be solely the result of the aging process are the result of disuse, and therefore are potentially reversible.[1] This concept has prompted studies to examine the potential of exercise to improve stamina and fitness in old age. Most studies have focused on the "young active old" person, and have studied highly selected subgroups of the older population.[2,3] A recent study of the institutionalized elderly has demonstrated for the first time that participation in regular seated exercise can improve both flexibility and functional capacity.[4] The purpose of our study was to explore the possible mechanism by which this improvement occurred. We asked: in the institutionalized elderly, does participation in regular seated exercise strengthen the quadriceps muscles? Is participation in such exercise associated with improved psychomotor or cognitive function?

SUBJECTS AND METHODS

Randomization

Four residential homes with a total of 148 residents, were allocated by home at random to receive one of two interventions: group exercise sessions or group reminiscence therapy sessions. Randomization was by opening sealed envelopes supplied in sequence by the study coordinator, and prepared from a computer-generated random number table.

Subjects and Recruitment

The 12 homes for the elderly in the Dundee (Scotland) area all have identical entrance criteria, namely that residents should be able to toilet, dress, and walk independently. Four homes were excluded from the study, having been the subject of a related research project the previous year. The four homes for this study were selected at random from the remaining eight. Following a series of informal visits by the research physiotherapist, volunteers were invited to take part in the 6-month randomized controlled trial. Residents with severe communication difficulties ($n = 6$) were excluded. No volunteers were excluded on the basis of any specific preexisting medical condition. Sixty-five of 148 residents (44%) volunteered to participate, and were randomized to either an exercise group ($n = 36$) or a reminiscence group ($n = 29$). The study was approved by the Tayside Committee on Medical Ethics, and written informed consent was obtained from the volunteers.

Measurements

Prestudy measurements were done by the research physiotherapist at the same time of day in both groups. The poststudy measurements were done by an independent, blinded observer who was not otherwise involved in the project.

Study Interventions

Both interventions were provided by the research physiotherapist (LMR).

Exercise group. the volunteers participated in a twice-weekly 45-minute group session during which they exercised to music. Because of the general physical frailty, poor balance and limited stamina of the group, all the

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exercises were performed seated. The duration of the sessions was gradually extended, until ultimately each session consisted of a 10-minute warm-up period, followed by 25 minutes of isometric exercises designed to strengthen major muscle groups and improve joint flexibility and muscle tone, and a 10-minute cool-down period. The intensity of the exercise sessions was graduated by increasing the number of repetitions of each exercise and by gradually introducing more gravity-resisted exercises, thereby increasing muscle work.

Reminiscence group. the volunteers participated in a twice-weekly 45 minute control intervention of reminiscence therapy. The reminiscence sessions were designed to promote social interaction and involved group discussion on topics prompted by the use of reminiscence aids, including old photographs, music and archive material.

Outcome Measures

Quadriceps muscle strength. maximum voluntary contraction force of the quadriceps muscle was measured using a chair similar to that described by Davies and colleagues,[5] but modified with a compact portable strain gauge attached to the back of the chair. The coefficient of variation for repeated measurements for one 84-year-old subject on six separate occasions was 6%. During the measurements, the subject's arms were resting passively, and elevation of the hips was prevented with a firmly secured lap strap.

Step test. the ability to climb unassisted up and down different step heights was measured by using a step that could be adjusted in 5cm increments from 5cm to 40cm.[6]

Reaction time. choice reaction time, which is the speed of response to a visual stimulus, was measured by a portable Leeds Psychomotor Tester. Two measurements of speed of response were made, namely the recognition movement time (Reaction time 1), and the total time taken to respond to the visual stimulus (Reaction time 2). For each test sequence a minimum of 20 consecutive readings was performed.

Cognitive state. the cognitive state was measured using the Mini-Mental State Examination (MMSE).[7]

Statistical Analysis and Sample Size Calculation

For each variable, the change that had occurred during the study was calculated by subtracting the baseline values from the 6-month values. The results of these calculations were normally distributed for all variables, except those relating to quadriceps strength and reaction time. The difference between the reminiscence and the exercise groups was therefore analyzed statistically by a Mann-Whitney *U* test for quadriceps strength and reaction time, and an unpaired *t*-test for the other variables. Statistical analysis was performed using the Statgraphics software package.[a]

RESULTS

The mean age of the volunteers was 83 years, with a range of 67 to 98 years. Of the 65 residents assigned to the study groups, 55 completed the 6-month project. In the exercise group 1 volunteer dropped out following a fractured neck of femur and 3 residents died (at 2, 3, and 4 months). In the reminiscence group 2 volunteers dropped out when they were admitted to hospital and 4 volunteers died (at 2, 3, 4 and 5 months).

The average attendance at the group exercise sessions was 72% (range, 18% to 98%) and at the reminiscence sessions 62% (range, 29% to 100%).

There were no adverse events related to either intervention. The death rates in both groups were compatible with the averages for the residential homes. There were no significant differences between the two groups at baseline (table 1).

At the end of the 6-month study, the quadriceps strength of the exercise group increased, whereas that of the reminiscence group decreased (table 2). Both groups showed an improved ability to step up and down varying heights, but there was no significant difference between the two groups. Choice reaction time did not alter significantly during the study. The cognitive score on the MMSE showed a decline in both groups, and the decline was greater in the reminiscence group than in the exercise group, although this trend just failed to attain conventional statistical significance.

DISCUSSION

This study has demonstrated that regular, low-intensity seated exercise can improve quadriceps strength in a group of frail elderly people. Other researchers[2] have shown increases in quadriceps strength in the elderly, but only in a highly-selected group and in response to a program of high-intensity weight-resisted exercise. Our findings support the evidence produced by others[8] that indicates the trainability of the muscles of even the very elderly. The customary activity levels of elderly residents of most institutions is low, and this study has shown that approximately half of residents in the homes contacted were willing to participate in an exercise project. Opportunities to indulge in physical activity are severely limited; our experience indicates that many elderly people welcome the chance to increase their level of physical activity. The acceptability of this type of exercise was reinforced by several residents who, participated in the exercises on a regular basis although they were not part of the study population.

Table 1: Baseline Characteristics of Volunteers Who Participated in the Study

Characteristic	Study Group: Exercise (n = 36)	Study Group: Reminiscence (n = 29)
Mean (SD)		
age (years)	83.7 (6.6)	82.0 (9.6)
*BMI	25.8 (4.8)	26.3 (5.2)
Women:Men	29:7	25:4
MMSE	15.7 (3.6)	15.2 (4.2)
Median (range)		
quadriceps strength (N)	96 (34-265)	108 (34-294)

* $\frac{\text{weight}}{\text{height}^2}$

There were no significant differences between the groups at baseline

Table 2: Changes in Variables (6 months-baseline)

	Study Group		
	Exercise	Reminiscence	*p* Value
Mean (SD)			
Step test (cm)	6.8 (8.8)	5.8 (5.3)	NS
MMSE	−0.4 (2.0)	−1.6 (2.6)	0.06
Median (range)			
Quadriceps strength (N)	18 (−123-432)	−20 (−231-59)	0.009
Reaction time 1 (s)	0.03 (−0.38-2.75)	0.15 (−0.43-1.72)	NS
Reaction time 2 (s)	0.01 (−5.02-4.61)	−0.06 (−3.07-1.89)	NS

The finding that both groups improved equally in ability to step up and down varying height suggests that these changes were probably the result of a practice effect, and that improvements in quadriceps strength occurred independently of alteration in ability to climb steps. This is in keeping with previous work suggesting that "functionally relevant" tests, like stepping height are dependent on too many factors to show a meaningful correlation with any of them.[9]

It has been suggested that physical activity improves "fluid intelligence," possibly by means of a direct activating influence of exercise on the neurophysiological system.[10,11] Others have described an acute improvement in memory in elderly people immediately after exercise.[12] Our study showed a nonsignificant trend for the MMSE score to fall to a greater extent in the control group rather than the exercise group. It is possible that a larger sample size might have yielded a more convincing result. It seems reasonable that if cognitive losses are exacerbated by the inactivity that accompanies institutional living, then participation in exercise may help to restore some aspects of cognitive function. Further work in this area is required.

Decreased psychomotor performance is an accepted consequence of aging[13] and may reflect a general reduction in strength, a decrease in muscle mass, or a reduction in the number of normally-functioning fibers. Studies involving elderly subjects who have been physically active for much of their lives show that they have significantly faster reaction time profiles than their inactive counterparts.[14] In our prospective study reaction time did not alter significantly in either group, a conclusion in accord with that of Panton and associates.[15] The majority of our study population suffered from a moderate degree of cognitive impairment and a large inter-individual variation in reaction times was noted. These factors may have been important in influencing their reaction times.

Studies evaluating the effects of exercise have many difficulties. Our project was carefully designed to answer criticisms that may justifiably be levelled at other work in this field. Our design was that of a randomized controlled trial; the control intervention used (reminiscence) matched the active intervention in all respects except exercise, compliance was recorded, and the outcome assessments were made by a blind observer. One methodological drawback of this study was that randomization was by residential home, and not by individual resident. This was necessary because the sessions were provided in the dining room or sitting room of the homes, where most of the residents spend their day. Establishing both an exercise and a reminiscence group in each home would have been to invite significant contamination of each group by exposure to the other.

This project has demonstrated the safety and effectiveness of a seated group exercise program for the residents of homes for the elderly. Exercise programs of this type require no special equipment, are easily implemented, and do not need highly skilled professional staff.

The philosophy underpinning this approach is that safe and effective exercise should be available to all old people. We excluded no old person on the basis of premorbid medical condition or concurrent medication, and subjected our volunteers to no screening procedures. This is in contrast with other workers, whose screening procedures and criteria for exclusion were such that in one instance, 43% of old people wishing to join an exercise program were excluded.[16] The results of studies on such highly-selected subgroups are of limited interest because they cannot be applied to frail elderly patients who have multiple chronic medical problems and are receiving multiple medications. Though safety is of paramount importance, we believe that too much effort is directed at discouraging older people from exercising, and that too little effort is made to encourage exercise. Our findings can be applied to other frail elderly people in long-term care institutions. Opportunities should be provided to them to exercise and to prolong active life expectancy.

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a. Statgraphics, Manugistics Incorporated, 2115 East Jefferson Street, Rockville, MD 20852.