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Results of a community-based weight-bearing resistance training programme for healthy Chilean elderly subjects

SIR—Among elderly subjects, progressive resistance exercise training improves strength, gait speed and appendicular lean body mass, and has a low incidence of adverse events [1]. Weight-bearing exercises done at home [2, 3], or the use of weighted vests to perform resistance exercises [4], improve balance and can prevent functional decline in the elderly. However, a recent meta analysis did not confirm an effect of exercise on functional performance [5]. Another study, performed in elderly subjects discharged from acute care hospitals, reported no benefit and adverse events such as sprains occurred in 16% of trained individuals [6].

There is also controversial information about the minimal frequency and intensity of exercise required to obtain significant changes in muscle strength. Although most reports indicate that at least two sessions per week are necessary [7], other reports show that, in the elderly, once-weekly training may suffice [8]. The intensity of exercise is also important, since the likelihood of gaining muscle mass is low if resistance exercise is done at an intensity lower than 65% of one repetition maximum (RM) [9].

The aim of this study was to assess the compliance and effectiveness of a community-based, moderate-intensity resistance exercise training programme for elderly subjects.

Subjects and methods

Two hundred and ninety-eight elderly subjects, 211 female, aged 75 ± 5 years and 87 males aged 75 ± 5 years were studied. Exclusion criteria were the presence of cognitive impairment defined as a Mini-Mental State score [10] of <20, being unable to reach a nearby community centre by their own means and the presence of a severe disabling condition. The study was approved by INTA's ethics committee, and each subject gave written informed consent to participate.

At baseline, eligible subjects were assessed by a physician to discard concomitant illnesses and to score 'activities of daily living' using the Katz questionnaire (maximum score = 6) [11], and geriatric depression (worst score = 15) using the Yesavage questionnaire [12]. Mini nutritional assessment scores (maximum score = 30) were recorded for each subject using the questionnaire developed by Vellas *et al.* [13]. A fasting blood sample was obtained to measure blood glucose, serum creatinine, blood lipids and complete blood count. At baseline and 1 year of follow-up, body composition by DEXA, hand grip, biceps and quadriceps strength, and walking capacity using the 12-minute test (using a walking speed of 1 m/s as the cut-off point to define disability) were measured. The details of assessments are shown in Appendix 1 of the supplementary data on the journal website (www.ageing.oupjournals.org).

Subjects were randomly assigned to an exercise or control group, using a computer program based on random number generation. Subjects in the exercise group were invited to attend bi-weekly training sessions of 1 hour each. Training included functional weight-bearing exercises, exercises with Thera Bands and walking (details are given in Appendix 2 of the supplementary data).

Every month, all subjects were seen at an outpatient clinic and asked about adverse events and concomitant diseases. If a subject failed to attend their appointment at the clinic for 2 months or more, or if they decided not to continue in the study, they were considered a dropout. If a subject failed to attend more than two training sessions, they were contacted and encouraged to return.

Normally distributed values are expressed as mean ± standard deviation. Values with a non-normal distribution are expressed as median (range). Trained and control groups were compared at baseline and 1 year, in an intention-to-treat analysis. Subsequent analyses compared subjects with low and high compliance to exercise. A Kruskal–Wallis ANOVA was used to compare changes in muscle strength. A two-way ANOVA was used to compare changes in body composition. Proportions were compared using the χ^2 test.

Results

Six subjects (four males and two females, three in the exercise group and three in the control group) died during the year of follow-up (the causes of death were previously undiagnosed cancer in three, upper gastrointestinal bleeding in one, cerebrovascular accident in one and disseminated intravascular coagulation in one), and 51 subjects were considered as dropouts (22 female, 10% of all females and 29 males, 33% of all males admitted to the study, $P < 0.01$). Dropouts had a lower

Mini-Mental State score than subjects who completed the follow-up (24.2 ± 3.2 and 25.6 ± 3.1, respectively, $P = 0.003$).

Of the 241 subjects who completed the follow-up, 111 subjects were ascribed to the exercise group (94 females and 17 males). The initial demographic, anthropometric and laboratory values in training and control groups were similar (see Appendix 3 of the supplementary data on the journal website). Subjects in the exercise group attended 52 ± 24% of programmed sessions. Those subjects attending <50% of training sessions were considered as non-compliant (47 out of 111, 42%).

At baseline, walking impairment was present in 22 controls and 21 trained subjects. At 1 year of follow-up it was present in 41 controls and 17 trained subjects ($\chi^2 = 4.01$, $P = 0.046$). During the year of follow-up, trained subjects improved their gait speed, quadriceps and biceps strength. No effect of training was observed on hand grip strength (Table 1). Compliant females improved their walking capacity, quadriceps and biceps strength more than non-compliant and control subjects. Compliant men improved their quadriceps strength more than their non-compliant and control subjects (see Appendix 4 of the supplementary data on the journal website).

Trained men had a higher basal fat-free mass than controls. No basal differences in body composition were observed among women. No effect of training on body composition was observed (Table 2). Compliant women preserved their appendicular fat-free mass. No effect of compliance on body composition was observed among men (see Appendix 5 of the supplementary data on the journal website).

During follow-up, there were 24 falls among subjects in the control group and 25 among trained individuals ($\chi^2 = 0.61$, NS). No significant changes were observed in Mini-Mental Score, depression score or mini nutritional assessment.

Discussion

The results of this study show that a long-term resistance training programme is associated with a 19% attrition rate, and results in significant improvements in muscle strength.

Table 1. Muscle strength at baseline and 1 year of follow-up in control and trained subjects

	Controls	Trained	*P*
Women	(*n* = 92)	(*n* = 94)	
Walking capacity			
Initial value (m)[a]	787.3 ± 184.5	763.5 ± 213.3	0.42
Final value (m)[a]	719.9 ± 234.5	838.3 ± 248.5	<0.01
% change[b]	−7.2 (−73.90, 52.40)	6.05 (−94.10, 66.70)	<0.01
Quadriceps strength			
Initial value (kg)[a]	19.7 ± 10.7	20.2 ± 9.7	0.74
Final value (kg)[a]	16.7 ± 6.7	22.5 ± 8.6	<0.01
% change[b]	−14.6 (−71.40, 395.00)	8.65 (−76.70, 443.90)	<0.01
Biceps strength			
Initial value (kg)[a]	10.4 ± 4.7	10.7 ± 4.2	0.71
Final value (kg)[a]	11.3 ± 3.4	14.3 ± 6.2	<0.01
% change[b]	−6.0 (−56.90, 224.40)	8.15 (−80.60, 299.30)	<0.01
Hand grip strength			
Initial value (kg)[a]	20.1 ± 4.4	19.2 ± 5.0	0.18
Final value (kg)[a]	19.0 ± 4.5	19.1 ± 4.7	0.96
% change[b]	−5.90 (−56.70, 47.10)	0.00 (−50.00, 66.70)	0.08
Men	(*n* = 38)	(*n* = 17)	
Walking capacity			
Initial value (m)[a]	960.3 ± 164.4	972.2 ± 200.2	0.82
Final value (m)[a]	804.7 ± 283.4	973.3 ± 391.0	0.08
% change[b]	−11.90 (−72.10, 55.30)	10.10 (−23.00, 90.00)	<0.01
Quadriceps strength			
Initial value (kg)[a]	22.2 ± 9.6	23.4 ± 6.8	0.66
Final value (kg)[a]	21.1 ± 6.2	30.7 ± 10.2	<0.01
% change[b]	−0.95 (−58.30, 124.30)	43.50 (−1.50, 102.90)	<0.01
Biceps strength			
Initial value (kg)[a]	16.2 ± 5.3	16.1 ± 5.4	0.94
Final value (kg)[a]	20.4 ± 5.6	24.8 ± 8.7	0.03
% change[b]	37.3 (−26.40, 114.60)	65.60 (−8.20, 285.00)	0.33
Hand grip strength			
Initial value (kg)[a]	30.8 ± 6.4	32.4 ± 6.6	0.41
Final value (kg)[a]	30.5 ± 6.8	31.1 ± 9.5	0.79
% change[b]	−2.70 (−25.00, 23.30)	−2.80 (−83.30, 23.50)	0.84

[a]Expressed as mean ± standard deviation. Differences calculated using Student's *t* test.
[b]Expressed as median (range). Differences calculated using Kruskal–Wallis ANOVA.

Table 2. Body composition at baseline and 1 year of follow-up in control and trained subjects

	Controls		Trained	ANOVA *P* control vs trained
Women	(*n* = 92)		(*n* = 94)	
Fat-free mass (kg)				
Total body baseline	34.0 ± 3.6		34.5 ± 3.6	0.24
Total body 1 year	33.6 ± 3.5		34.3 ± 3.8	
ANOVA *P* baseline vs 1 year		0.06		
Appendicular baseline	14.2 ± 1.9		14.5 ± 1.9	0.39
Appendicular one year	13.9 ± 1.9		14.1 ± 2.0	
ANOVA *P* baseline vs 1 year		<0.01		
Fat mass (kg)				
Total body baseline	23.4 ± 7.2		24.0 ± 7.3	0.735
Total body 1 year	24.2 ± 7.6		24.4 ± 7.3	
ANOVA *P* baseline vs 1 year		<0.01		
Appendicular baseline	10.6 ± 3.9		10.6 ± 3.8	0.385
Appendicular 1 year	10.7 ± 3.9		10.7 ± 3.8	
ANOVA *P* baseline vs 1 year		<0.01		
Men	(*n* = 38)		(*n* = 17)	
Fat-free mass (kg)				
Total body baseline	47.4 ± 5.1		50.7 ± 5.5	0.04
Total body 1 year	47.3 ± 5.1		50.3 ± 5.5	
ANOVA *P* baseline vs 1 year		0.12		
Appendicular baseline	20.9 ± 2.9		22.2 ± 3.4	0.09
Appendicular 1 year	20.5 ± 3.0		22.2 ± 3.4	
ANOVA *P* baseline vs 1 year		0.07		
Fat mass (kg)				
Total body baseline	18.5 ± 6.7		17.9 ± 7.3	0.69
Total body 1 year	18.9 ± 6.6		18.0 ± 7.6	
ANOVA *P* baseline vs 1 year		0.37		
Appendicular baseline	7.4 ± 2.9		6.8 ± 3.5	0.69
Appendicular 1 year	7.4 ± 2.9		7.3 ± 3.8	
ANOVA *P* baseline vs 1 year		0.03		

The attrition rate observed by us is lower than that reported by other authors [5]. This may be due to the telephone calls to those who failed to attend more than two training sessions, which provided active reinforcement to encourage participation in the programme. The lower Mini-Mental Score found among dropouts is not surprising, since cognitive impairment is a known predictor of compliance with health care programmes [14].

The increase in muscle strength and walking capacity (12–40% improvement) obtained with training in this study is similar to that obtained by other authors [15]. As expected, this improvement was dependent on the compliance with the training programme. We used inexpensive devices to train our subjects, which did not allow measurement of the exact percentage of RM at which they were working. We relied on the Borg scale, which is a subjective measure of the workload during training. Studies that have compared this subjective assessment with more objective indices of workload have shown that the former is equally effective to obtain improvements in muscle strength or endurance [16]. This scale can replicably measure the levels of exertion and detect changes after interventions [17].

In the elderly, one of the objectives of exercise is to revert sarcopenia [18]. Old people can increase muscle protein synthesis with training as efficiently as young individuals [19]. In this study, we observed that in compliant females, training was associated with a preservation of appendicular fat-free mass. We did not observe this in males, but this may be a type 2 error owing to the lower number of observations. Other authors have also reported changes in lean body mass with training in the elderly [1], but this is not a universal finding [20, 21].

A recent meta analysis concluded that there is no evidence of an improvement in overall quality of life in the elderly with progressive resistance training [3]. However, in this study we observed that training reduced the progression of walking impairment, which has a direct relationship with quality of life, and other authors have demonstrated a positive effect of training in activities of daily living [2]. The lack of effect of exercise on falls that we observed is surprising. A meta analysis showed that untargeted exercise is not effective in preventing falls, but individually prescribed strengthening exercises and balance training can reduce the incidence of falls [22]. When exercise is part of a targeted fall prevention programme, it is also effective for fall prevention [23]. It is likely that a greater emphasis on balance and equilibrium exercises is required to have a positive effect in reducing the number of falls.

In summary, a community-based progressive resistance training in the elderly had a good record of compliance and improved strength and walking capacity in the elderly.

Key points

- Progressive resistance training in healthy elderly subjects increased quadriceps strength and gait velocity.
- There was an association between compliance with the training programme and the increase in muscle strength.
- An increase in appendicular lean body mass was only observed among women attending more than 50% of training sessions.

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