ORIGINAL ARTICLE

Strength training and detraining effects on muscular strength, anaerobic power, and mobility of inactive older men are intensity dependent

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Background: Although strength training (ST) enhances physical function in the elderly, little is known about the effect of training intensity on training and detraining adaptations in musculoskeletal fitness.
Objective: To determine the effect of exercise intensity on strength, anaerobic power, and mobility of older men subjected to a 24 week ST protocol followed by prolonged detraining.
Methods: Fifty two healthy but inactive older men (mean (SD) age 71.2 (4.1) years) were assigned to a control (n = 14), low intensity training (LIST; n = 18; 55% 1RM), or high intensity training (HIST; n = 20; 82% 1RM) group. They carried out a 24 week, whole body (10 exercises, two to three sets/exercise) ST programme followed by a 48 week detraining period. Upper and lower body strength, anaerobic power (Wingate testing), and mobility (timed up and go, walking, climbing stairs) were measured at baseline and immediately after training and during detraining.
Results: Although low intensity training improved ($p<0.05$) strength (42–66%), anaerobic power (10%), and mobility (5–7%), high intensity training elicited greater ($p<0.05$) gains (63–91% in strength, 17–25% in anaerobic power, 9–14% in mobility). All training induced gains in the LIST group had been abolished after four to eight months of detraining, whereas in the HIST group strength and mobility gains were maintained throughout detraining. However, anaerobic power had returned to baseline levels after four months of detraining in both groups.
Conclusions: Higher intensity training protocols induce greater gains in strength, anaerobic power, and whole body physical function of older men. Moreover, higher intensity training may maintain the gains for more prolonged periods after training ceases.

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About 18% of older people are not independent with respect to one or more activities of daily living that require adequate strength, power, and mobility.[1] Inadequate strength makes it difficult to lift and carry objects, and stair climbing is hindered because of reduced lower limb power. Performance of physically demanding tasks is diminished because of loss of anaerobic power (AP) in older adults.[2] Muscle strength and power as well as mobility are attenuated because of age associated changes in the neuromuscular system, muscle atrophy, and gradual fibre denervation thereby imposing limitations.[3 4]

Strength training (ST) is an effective countermeasure to sarcopenia and age related strength loss in older adults.[3 5 6] Participation in an ST intervention can improve strength,[7] flexibility,[8] and functional status in this section of the population.[7] Although high intensity ST (HIST) has been recommended for the aged, [3 5] there is considerable evidence that low intensity ST (LIST) programmes (or power training) may also be beneficial in increasing neuromuscular performance.[9–12] HIST involves heavy resistance at moderate to low velocity, whereas power training (LIST) uses light resistance at higher velocities. Although the greatest increases in muscle strength and mass have been derived from HIST,[6 8 9] some argue that LIST may be more effective in improving physical function and AP.[13–15] Muscle power has been associated with functional status in the aged, contributing to better performance in tasks such as chair rising, stair climbing, fast walking, and fall prevention.[16 17] However, it is not clear whether LIST induces greater gains than HIST with regard to AP and physical function in the elderly.[2 18] LIST that incorporates faster movements may improve whole body physical function through a more efficient motor unit firing rate, discharge synchronisation, and muscle recruitment compared with traditional HIST.[19] However, that remains to be elucidated as there is limited information on the effect of ST intensity on AP and mobility adaptations of inactive elderly.

In many instances, previously resistance trained older adults may need to abstain from systematic exercise because of health problems. Although strength may be maintained for 5–27 weeks after training ceases (detraining) in older adults,[20–22] limited information is available about AP and mobility changes after ST cessation in the elderly. Furthermore, little is known about the effects of training intensity on detraining adaptations not only on muscle strength but also on power and mobility status in the aged. Therefore the purpose of this study was to determine the effect of intensity level on strength, power, and mobility adaptations of older men after (*a*) 24 weeks of ST and (*b*) 48 weeks of detraining.

METHODS

Subjects and study design

Fifty two white men volunteered to participate in the study (recruited from a volunteer database, by word of mouth, and fliers sent to medical practitioners and nursing homes). A written consent form was signed by all participants after they had been informed of all risks, discomforts, and benefits involved. Procedures were in accordance with the ethical standards of the committee on human experimentation at

Abbreviations: AP, anaerobic power; LBS, lower body strength; ST, strength training; TUG, timed up and go; UBS, upper body strength; $\dot{V}O_2MAX$, maximal oxygen consumption

Table 1 Basic information on the subjects in each exercise group

	C	LIST	HIST
Age (years)	71.2 (4.1)	70.3 (4.4)	72.4 (3.5)
Height (m)	1.64 (0.8)	1.63 (1.3)	1.65 (0.9)
$\dot{V}O_{2MAX}$ (ml/kg/min)	17.1 (2.5)	16.3 (3.1)	16.9 (2.0)
Baecke questionnaire score	8.22 (1.2)	8.05 (1.2)	8.34 (0.7)
Activity level*	Low	Low	Low
Average number of repetitions	N/A	13.2 (0.6)	7.6 (0.5)
Average intensity (%)	N/A	56.3 (2.0)	82.2 (2.3)

Values are mean (SD).
*According to Baecke physical activity questionnaire.
C, Control group; LIST, low intensity training group; HIST, high intensity training group; $\dot{V}O_{2MAX}$, maximal oxygen consumption.

the institution at which the work was conducted and with the Helsinki declaration of 1975. Table 1 shows the physical characteristics of the subjects.

Subjects were enrolled if they were over 65, completely inactive before the study (a maximal oxygen consumption ($\dot{V}O_{2MAX}$) below 20 ml/kg/min and had a score below 9.0 on the modified Baecke questionnaire for older adults),[5 23] and were free from health problems and potentially damaging orthopaedic, neuromuscular, metabolic, and cardiovascular limitations. Eighty seven men volunteered to participate. Twenty three were excluded (five were too frail, 12 had medical limitations, six were too fit), and five declined to participate. During training, five more men were asked to stop because they had missed more than three training sessions (subjects were required to complete at least 69 training sessions), and two more stopped because of injury. There were no differences between those who dropped out of the study and those who completed the study with respect to physical activity and $\dot{V}O_{2MAX}$.

On the initial visit, subjects signed the informed consent form, were medically screened, had their $\dot{V}O_{2MAX}$ measured, and completed a physical activity questionnaire. During their second visit, they had their baseline AP and mobility measured. During a third visit, subjects were taught the lifting techniques to be used during training and were randomly assigned to one of three groups: control (C; n = 14); LIST (n = 18); HIST (n = 20). In a fourth visit, baseline maximal strength was measured. Subjectss trained for 24 weeks. Thereafter, they stopped training for 48 weeks. Measurements were repeated after training and at 16, 32, and 48 weeks of detraining.

Measurements

$\dot{V}O_{2MAX}$ was determined (table 1) at baseline during a graded exercise test on a treadmill (modified Bruce protocol) to determine fitness level.[5] Blood pressure, 12 lead electrocardiography, and ratings of perceived exertion (6–20 Borg scale) were continuously monitored during exercise and recovery.[5] A SensorMedics (Yorba Linda, California, USA) Vmax$_{29}$ pulmonary gas exchange system was used to measure $\dot{V}O_2$ and $\dot{V}CO_2$ continuously by breath by breath analysis (averaged every 60 seconds) using a computerised online system. $\dot{V}O_{2MAX}$ had been attained if there was no further increase in $\dot{V}O_2$ with increasing work rate (levelling off), age predicted maximal heart rate was attained, and respiratory exchange ratio was greater than 1.10. These criteria were met by 95% of the subjects.

Before maximal strength testing (one repeat maximum (1RM)), subjects were familiarised with correct lifting techniques to reduce injury risk and large early gains in strength through motor learning.[21] 1RM was measured bilaterally on a Universal (Irvine, California, USA) leg press (lower body strength (LBS)) and chest press (upper body strength (UBS)) as previously described.[21] The intraclass correlation coefficient for test-retest trials within the same week was 0.94 and 0.92 for LBS and UBS respectively.

AP was assessed by the Wingate anaerobic cycle (Monarch 814E, Varberg, Sweden) test as previously described.[2] A doctor supervised the Wingate testing to monitor signs of cardiovascular discomfort. Power was expressed relative to lean thigh volume (determined by anthropometric measurements) to normalise power values.[24]

Mobility tests were modified from validated procedures as previously described and included the timed up and go (TUG), 50 foot walk (walk), and climbing (walking up and down eight stairs).[25] Subjects rose from the chair, walked around a cone (10 feet away), returned to the chair, and sat for the TUG, walked quickly for 25 feet, turned, and walked back to the start for the walk test, and walked up and down an eight stair flight carrying a 2.3 kg weight for the step test. Subjects performed the requested tasks quickly but safely, and scoring was based on time (measured by photocells) required to perform these tasks.

Subcutaneous skinfold thickness was measured sequentially, in triplicate (chest, biceps, triceps, subscapula, abdomen, suprailiac, anterior thigh) by the same investigator using Harpenden skinfold callipers (HSK-BI; British Indicators, Luton, UK) and a standard technique.[5] The mean of three measures for each skinfold was used, and their sum was used as an index of body fatness. The relation between thigh skinfolds and thigh circumference was used to estimate changes in muscle mass during the 24 month training intervention.

Intervention

Subjects trained three times a week for 24 weeks. A 3–5 minute warm up (cycling at 40% of maximal heart rate) preceded training. Each session lasted 50–60 minutes and included continuous blood pressure and heart rate monitoring during exercise and recovery. Subjects exercised on eight resistance exercise machines (Universal) selected to stress the major muscle groups in the following order: chest press, leg extension, shoulder press, leg curls, latissimus pull down, leg press, arm curls, and triceps extension (two sets/exercise in weeks 1–8, and three sets/exercise thereafter). Subjects performed 14–16 maximal repetitions/set (50–55% 1RM) in the LIST protocol, and six to eight maximal repetitions/set (80–85% 1RM) in the HIST protocol (table 1). Participants also performed abdominal crunches and low back extensions (two sets at six repetitions in weeks 1–12, and three sets at 10 repetitions in weeks 13–24). 1RM was retested every four weeks so that resistance could be adjusted properly. 1RM intraclass correlation coefficient for repeated measurements was 0.89–0.95 for all exercises. Participants were instructed to perform each repetition in 6–9 seconds (raise the weight in 2–3 seconds, pause for 2–3 seconds, lower the weight for

2–3 seconds) with a 2–4 second pause between repetitions and three and six minute rest between sets (for LIST and HIST respectively).[6 8]

After completion of the ST programme, subjects in the exercise groups were instructed to resume their normal lifestyle and avoid any type of systematic exercise for 48 weeks. During detraining, subjects were contacted systematically to ensure that they were not engaged in regular exercise.

Statistical analysis

Means (SD) were calculated. One way analysis of variance was conducted initially to examine if there were differences among the three groups in pre-training values for each dependent variable. Repeated measures (time by treatment) multivariate analysis of variance was performed on each dependent variable to detect differences in each group for each time point. When F ratios were significant, post hoc mean comparisons were analysed with Scheffe's multiple comparison tests. Significance was accepted at $p<0.05$.

RESULTS

There were no differences among the groups with respect to age, height, and physical activity level at baseline (table 1). All participants exhibited low fitness and physical activity level (table 1). Subjects in the LIST and HIST groups exercised at 56.3% and 82.2% of 1RM respectively (table 1).

Table 2 shows changes in body composition, strength, mobility, and AP during training and detraining. No differences were noted between groups in body composition, UBS, LBS, AP measures, and all mobility tests at baseline.

Body weight and sum of skinfolds had decreased ($p<0.05$) in the LIST group (1.9% and 1.6%) and HIST group (3.4% and 2.6%) after training, with HIST being more effective ($p<0.05$) than LIST (table 2). These changes were maintained ($p<0.05$) for four months in the LIST group and for eight months in the HIST group during detraining. Thigh circumferences did not change over time, but thigh skinfold thickness decreased ($p<0.05$) with training (table 2) in both groups, suggesting an increase in thigh muscle mass, with HIST being more effective ($p<0.05$) than LIST at all times. However, these changes were only maintained ($p<0.05$) in the HIST group during detraining.

UBS had increased ($p<0.05$) by 66% in the LIST group and 91% in the HIST group after training. UBS returned to baseline values within eight months of detraining in the LIST group but remained raised in the HIST group throughout detraining. LBS had increased ($p<0.05$) by 43% in the LIST group and 63% in the HIST group after training. Detraining resulted in a 57% decline ($p<0.05$) in these gains in the LIST group within four months and a return to baseline levels thereafter. In contrast, LBS in the HIST group remained ($p<0.05$) above baseline values throughout detraining. Nevertheless, it had declined by 25%, 46%, and 62% after four, eight, and 12 months of detraining.

AP was improved ($p<0.05$) in the LIST group (peak power by 10.3% and mean power by 9.8%) and HIST group (peak power by 25.5% and mean power by 16.9%), but the latter was a bigger ($p<0.05$) response. Peak power remained raised in the HIST group until eight months into detraining, but returned to baseline in the LIST group during the first four months of detraining. Mean power had returned to baseline after four months of detraining in the HIST group and immediately after training in the LIST group.

ST improved ($p<0.05$) TUG (6.5% in the LIST group and 13.4% in the HIST group), walking ability (5% in the LIST group and 9% in the HIST group), stepping up (6.5% in the LIST group and 12.6% in the HIST group), and stepping down (7% in the LIST group and 14% in the HIST group), with HIST eliciting greater ($p<0.05$) gains than LIST in all tests. In the LIST group, TUG and walking capability were maintained for four months of detraining, whereas stepping up and down returned to baseline levels within the first four months of detraining. In contrast, in the HIST group, TUG, walking, and stepping up performance was maintained above baseline values throughout detraining, and only stepping down values returned to baseline after eight months of detraining.

DISCUSSION

The major finding of this study was that HIST was more effective than LIST in improving strength, AP, and physical function in inactive older men. Furthermore, HIST maintained training induced gains in physical function more effectively than LIST during detraining.

Training responses

UBS and LBS were increased by LIST and HIST in an intensity dependent manner. Published recommendations on ST intensity in the elderly state that about 80% 1RM should be used to maximise strength.[26] There is considerable evidence to suggest that HIST elicits large increases in maximal strength.[8 9 12 26] Nevertheless, other studies have reported that low and very low ST programmes are also effective in improving strength.[2 11 12 27] One can argue that LIST and HIST induced adaptations are not directly comparable because total work performed is different in the two treatments. However, in a study in which subjects on LIST and HIST programmes performed equal amounts of total work, LIST still induced strength gains that were considerably less than those induced by HIST.[27] In our study, gains in the LIST group were larger (50% *v* 30% increase) than those observed in a study that used a lower intensity (40% 1RM),[10] but similar to those seen in the study of Pruitt *et al*[27] after 12 months training at 45% 1RM. Therefore it appears that, although LIST induces smaller strength gains than HIST, it is effective in eliciting significant increases in strength in inactive elderly. Strength increases may be attributed to enhanced motor unit activation of the trained muscles and muscle hypertrophy, as previous research has shown.[28] HIST seems to have profound anabolic effects in older adults by enhancing nitrogen balance, which greatly improves nitrogen retention, which may affect muscle hypertrophy.[29] In our investigation, thigh circumferences did not change over time, whereas thigh skinfold thickness decreased with training in both groups, suggesting an intensity dependent increase in thigh muscle mass.

AP was improved in both groups, with HIST inducing greater improvements. The results from this study are in contrast with previous findings[2] that AP was not improved by either HIST or LIST. This discrepancy may be attributable to the intensity level adopted throughout the study, the number of exercises, and the training duration. We found that AP improved despite the fact that subjects were not familiar with cycling. Nevertheless, Wingate testing in untrained older men with little cycling experience does induce anaerobic metabolism according to lactate values.[17] According to these results, AP in the inactive elderly can be improved by either a HIST or LIST approach in an intensity dependent manner. More research is needed to confirm these results.

Training induced increase in strength and AP was accompanied by improvement in mobility, with HIST inducing greater gains. ST improves mobility tasks such as walking, climbing, and TUG performance[13 25 30] and the ability of older adults to carry small objects.[14] TUG scores have been shown to improve after ST in older adults by as much as 5.2%.[25] In the present study, TUG improved by 13% in the HIST group and 6.5% in the LIST group. Walking time has been shown to remain unaffected by ST,[25] but in this study improved by 9% and 5% in the HIST and LIST group

Table 2 Changes in body composition, strength, anaerobic power, and mobility in the three groups after resistance training and detraining

Variable	Baseline	After training	% change from baseline	4 months detraining	% change from after training	8 months detraining	% change from after training	12 months detraining	% change from after training
Body weight (kg)									
C	81.3 (4.9)	82.0 (6.1)‡§		81.8 (4.1)‡§		82.3 (3.9)§		82.5 (7.4)	
LIST	81.9 (5.1)	80.3 (4.7)†‡	1.9	81.2 (6.4)*†‡	56.2	82.2 (4.4)		82.6 (8.1)	
HIST	82.1 (5.1)	79.3 (4.6)*§¶	3.4	79.9 (4.2)*†§¶	27.2	80.6 (6.2)*†§¶	59.0	81.0 (7.7)*¶	77.2
Sum of skinfolds (mm)									
C	131.5 (8.0)	131.9 (9.5)‡§		131.7 (7.1)‡§		132.8 (8.6)§		134.1 (10.1)	
LIST	131.3 (7.1)	129.2 (5.1)†‡	1.6	130.2 (7.9)*†‡	28.5	131.5 (9.9)*		132.0 (13.2)	
HIST	132.0 (7.4)	128.6 (9.7)†§¶	2.5	129.2 (8.6)†§¶	17.6	130.4 (5.9)*†§¶	52.9	131.6 (12.4)*	
Thigh skinfold (mm)									
C	27.5 (6.4)	27.1 (7.2)‡§		27.9 (3.6)‡§		27.7 (4.9)§		8.5 (4.8)	
LIST	25.8 (8.5)	24.0 (4.0)†‡	7.0	24.9 (3.2)*†‡	50.0	25.6 (6.9)‡		26.1 (3.9)	
HIST	25.9 (7.2)	23.3 (3.8)†‡§¶	10.0	23.8 (4.0)†§¶	19.2	24.3 (5.3)†§¶	38.4	25.3 (2.8)*	
Thigh circumference (cm)									
C	55.3 (4.8)	54.9 (6.3)		55.8 (7.2)		55.6 (5.5)		55.1 (6.2)	
LIST	54.4 (3.8)	54.6 (7.1)		54.6 (6.9)		54.5 (6.0)		54.9 (7.6)	
HIST	54.9 (8.1)	55.2 (9.1)		55.5 (9.1)		54.9 (8.8)		55.0 (6.2)	
Chest press 1RM (kg)									
C	29.8 (4.6)	29.2 (6.3)‡§		30.3 (7.1)‡§		29.4 (3.9)		27.8 (6.8)	
LIST	27.4 (3.5)	45.5 (6.2)†‡	66.0	34.7 (3.8)*†‡	59.6	30.1 (7.8)*		25.9 (4.9)*	
HIST	28.2 (5.1)	53.8 (7.4)†§¶	90.7	45.5 (6.1)*†§¶	32.4	39.8 (5.5)*†§¶	54.6	34.6 (4.6)*†§¶	75.0
Leg press 1RM (kg)									
C	55.9 (6.4)	56.4 (8.5)‡§		55.1 (7.0)‡§		54.7 (6.9)‡§		54.1 (9.1)§	
LIST	53.8 (4.8)	76.8 (9.4)†‡	42.7	63.7 (7.2)*†‡	56.9	57.1 (6.0)*		52.2 (7.9)*	
HIST	56.2 (5.2)	91.7 (8.2)†§¶	63.1	82.8 (9.1)*†§¶	25.0	75.3 (7.3)*†§¶	46.1	69.7 (8.8)*†§¶	61.9
Peak power (W/l)									
C	72.4 (10.3)	70.5 (11.9)‡§		71.4 (7.6)‡§		68.8 (10.6)‡§		67.1 (12.8)	
LIST	68.8 (16.4)	75.9 (8.1)†‡	10.3	67.4 (9.2)*	77.4	69.1 (14.2)		66.4 (9.2)	
HIST	67.8 (12.8)	82.1 (9.7)†§¶	25.5	75.8 (11.1)*†§¶	42.5	71.9 (8.5)†§¶	71.3	64.9 (12.7)*	
Mean power (W/l)									
C	59.4 (8.2)	57.5 (6.5)‡§		57.1 (9.1)§		55.6 (7.6)§		54.9 (9.4)§	
LIST	56.8 (7.9)	62.4 (5.8)†‡	9.8	57.0 (8.8)*	96.4	55.4 (9.1)		53.7 (10.5)	
HIST	55.3 (5.1)	64.7 (6.4)†§¶	16.9	60.5 (2.7)†§¶	44.6	57.1 (9.8)		53.8 (9.6)	
TUG (s)									
C	7.8 (2.3)	7.9 (2.6)‡§		7.7 (1.8)‡§		7.9 (1.9)§		8.0 (2.6)§	
LIST	7.7 (2.1)	7.2 (1.8)†‡	6.5	7.4 (0.8)†‡	40.0	7.6 (2.0)		7.9 (1.9)*	
HIST	8.2 (0.9)	7.1 (1.1)†§¶	13.4	7.2 (1.3)†§¶	9.0	7.3 (1.7)†§¶	18.1	7.7 (1.6)*†§¶	54.5
Walking (s)									
C	11.8 (2.9)	11.7 (2.2)‡§		11.7 (1.9)‡§		11.9 (3.1)§		11.8 (3.6)§	
LIST	11.6 (1.9)	11.0 (2.5)†‡	5.1	11.3 (2.0)*†‡	50.0	11.5 (3.2)		11.7 (1.6)	
HIST	12.0 (3.0)	10.9 (1.7)†§¶	9.1	11.1 (2.5)†§¶	18.1	11.2 (2.4)†§¶	27.2	11.6 (2.1)*†§¶	63.6
Stepping up (s)									
C	5.9 (1.1)	6.1 (1.4)‡§		6.1 (1.0)§		6.0 (2.2)§		6.2 (1.4)§	
LIST	6.1 (1.8)	5.7 (1.3)†‡	6.5	6.1 (1.9)*		6.2 (2.0)		6.0 (2.8)	
HIST	6.3 (2.1)	5.5 (0.9)†§¶	12.6	5.7 (1.2)†§¶	25.0	5.8 (1.8)†§¶	38.0	6.0 (1.3)†§¶	63.0
Stepping down (s)									
C	5.5 (0.8)	5.7 (2.2)‡§		5.5 (0.7)§		5.6 (1.7)§		5.8 (0.6)	
LIST	5.8 (3.1)	5.4 (1.6)†‡	6.9	5.7 (0.9)*		5.9 (1.9)		6.0 (1.2)	
HIST	5.8 (2.0)	5.0 (2.0)†§¶	13.7	5.1 (1.3)†§¶	12.5	5.4 (1.5)†§¶	50.0	5.6 (0.7)	

Values are mean (SD).
*Significant difference from last measurement ($p<0.05$).
†Significant difference from baseline ($p<0.05$).
‡Significant difference between C and LIST ($p<0.05$).
§Significant difference between C and HIST ($p<0.05$).
¶Significant difference from LIST ($p<0.05$).
C, Control group; LIST, low intensity training group; HIST, high intensity training group; TUG, timed up and go test.

respectively. It has been suggested that LIST elicits greater neural activation than HIST, which may help to improve timed task performance.[19] However, in our study, participants in the HIST group performed time dependent tasks faster than those in the LIST group. Discrepancies between studies may be attributed to different training duration, frequency, exercises selected, and training status of the subjects.

Detraining responses

Although previous investigations reported that strength is maintained after 4–32 weeks of detraining in young subjects[13 19 30 31] and 5–27 weeks in the elderly,[20–22 32 33] little is known about the effects of ST intensity on the magnitude and rate of strength loss during detraining. The results of this study are in agreement with previous reports, as UBS and LBS were maintained for eight and 12 months in the LIST and HIST group respectively. However, it appears that exercising at a higher intensity results in a lower rate of strength loss during detraining (the rate of strength loss was 20–25% lower in the HIST group throughout detraining), and strength gains are maintained for a longer period of time (strength never reached baseline levels in the HIST group but returned to baseline in the LIST group within eight months of detraining). In a previous study, muscle activation as well as muscle power was maintained above baseline values after a 24 week detraining period.[20] In that study, older men followed a ST protocol of progressively increased intensity (50–80%). Another study used a nine week ST protocol, which also used an intensity of 50–80% 1RM, and reported that older adults were able to maintain strength after 31 weeks of detraining.[21] Despite the fact that previous studies did not compare ST intensities directly, it appears

What is already known on this topic

- Strength training induces significant gains in strength, anaerobic power, and mobility in inactive elderly
- A low intensity approach to more frail elderly appears to be effective in inducing positive adaptations

What this study adds

- A more pronounced improvement in musculoskeletal fitness of inactive elderly is obtained with high intensity strength training protocols
- Positive adaptations in the physical function of previously inactive older men are maintained for longer periods after high intensity strength training programmes

that moderate to high ST intensities may maintain training induced gains in the elderly during detraining. Detraining induced strength losses have been attributed to deterioration of fibre size and motor unit recruitment efficiency, with strength declining more slowly than muscle size.[21 34]

AP deteriorated more rapidly than strength in both groups during detraining. There are few data on AP adaptations during detraining. Hakkinen *et al*[20] showed that explosive jumping power remained unaltered after prolonged detraining. However, power measurement by the Wingate test does not allow direct comparison with power measurement by the jumping test because of the differences in metabolic and movement patterns between the two test conditions.

There is very limited information on mobility changes after training cessation. In one study, walking time remained raised after 24 weeks of ST cessation.[20] In the present investigation, mobility measurements remained raised in the HIST group throughout detraining, whereas in the LIST group they returned to baseline values within four months of detraining (TUG and walking) or even earlier (climbing stairs). Therefore it appears that, although strength remains raised for an extended period of time (four to eight months) after LIST, the functional capacity of previously inactive older men deteriorates at a faster rate. In contrast, the functional capacity of elderly men after HIST is maintained well above baseline levels for at least 12 months of sedentary lifestyle. It is plausible to hypothesise that HIST is more beneficial than LIST for long lasting positive adaptations of functional status in the elderly.

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