Two Years of Resistance Training in Older Men and Women: The Effects of Three Years of Detraining on the Retention of Dynamic Strength

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Abstract/Résumé

Dynamic muscle strength (1-RM) and symptom-limited treadmill endurance were compared among three groups (5 M and 5 F per group) of older adults (mean age 72.5 yrs) who had either weight-trained continuously twice per week for 5 years (Tr), ceased to weight train after 2 years (Detr), or acted as controls throughout (Con). The Tr and Detr trained hard (progressing up to 3 sets at up to 80% of 1-RM) for 2 years; the Tr continued training for an additional 3 years at a maintenance level (2 to 3 sets at 60–70% 1-RM), whereas the Detr stopped training for those 3 years. The Con subjects did not train for the duration of the study but took part in identical testing procedures. After 2 years of resistance training, dynamic strength in the Tr and Detr groups increased significantly above baseline and Con values for all exercises, $p < 0.0001$. Following 3 years of maintenance level training, arm curl, leg press, and bench press 1-RM (sum of both limbs) in the Tr remained significantly above baseline values (21.6 kg = 17%; 15.7 kg = 82%; 8.3 kg = 34%, respectively). The 1-RM in Detr were 18.4 kg (14%), 5.3 kg (24%), and 1.4 kg (9%) above baseline for leg press, arm curl, and bench press after 5 years, whereas the Con declined over the 5-yr period by 18.4 kg (–9.7%), 4.4 kg (–19%), and 3.5 kg (–6%), respectively. There were nonsignificant

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improvements in treadmill performance in the Tr and Detr, and a decline in the Con after 2 years. Treadmill performance declined between Years 2 and 5 in all groups despite continued training (ns). We conclude that: (1) dynamic strength gains from 2 years of resistance training in older individuals are not entirely lost even after 3 years of detraining; (2) these effects may be specific to the exercises performed in the training program; (3) adoption of maintenance-level moderate-intensity training significantly attenuates the decline in dynamic strength of previously trained muscles.

La force musculaire dynamique (1-RM) et l'apparition de symptômes à l'épreuve d'endurance sur tapis roulant ont été comparées chez trois groupes: 5 femmes et 5 hommes par groupe, âge moyen, 72,5 ans. Un groupe (Tr) s'est entraîné à la force durant 5 ans à raison de 2 fois par semaine; un autre groupe (Detr) a cessé l'entraînement à la force après 2 ans; et un dernier groupe (Con) a servi de témoin. Les deux premiers groupes se sont entraînés vigoureusement durant 2 ans jusqu'à réaliser 3 séries à un niveau aussi haut que 80% de 1-RM; le groupe Tr a continué un entraînement de maintien à niveau durant 3 autres années par des séances de 2 ou 3 séries à 60–70% de 1-RM; et le groupe Con ne s'est pas entraîné tout au long de l'étude, mais a participé aux mêmes séances d'évaluation. Après 2 ans d'entraînement à la force, la force dynamique des groupes Tr et Detr a augmenté significativement au-delà des valeurs initiales et de celles du groupe Con, et ce, pour tous les exercices, $p < 0{,}001$. Après 3 ans d'un entraînement de maintien, la force dynamique (1-RM) du groupe Tr au cours d'exercices de flexion des coudes, de développé des membres inférieurs, et des membres supérieurs (somme gauche-droite) est restée au-dessus des valeurs initiales, 21,6 kg (17%), 15,7 kg (82%), et 8,3 kg (34%), respectivement. Après 5 ans, la force dynamique (1-RM) du groupe Detr au cours d'exercices de développé des membres inférieurs, de flexion des coudes, et de développé des membres supérieurs resta plus importante: 18,4 kg (14%), 5,3 kg (24%), et 1.4 kg (9%); celle du groupe Con diminua au cours de ces 5 années: 18,4 kg (–9,7%), 4,4 kg (–19%), et 3,5 kg (–6%), respectivement. Après 2 ans d'entraînement, la performance sur tapis roulant ne s'est pas améliorée significativement chez les groupes Tr et Detr ni détériorée significativement chez le groupe Con. Au cours des 3 années subséquentes, la performance sur tapis roulant a diminué, mais non significativement, chez tous les groupes. En conclusion: (1) les gains de force dynamique en 2 ans d'entraînement à la force chez des personnes âgées ne sont pas complètement perdus 3 ans après la cessation de l'entraînement; (2) ces effets sont probablement spécifiques aux exercices réalisés durant la période d'entraînement; (3) un entraînement de maintien constitué d'exercices modérés, contribue à réduire significativement la diminution de la force dynamique des muscles soumis à un entraînement préalable.

Introduction

With aging comes a general decline in muscular strength beginning during the 6th decade of life and accelerating thereafter. Cross-sectional studies estimate the decline in muscular strength between the ages of 20 and 70 years to be between 24 and 65% (Hurley, 1995; Larsson et al., 1979; Lexell, 1995; Vandervoort and McComas, 1986). Longitudinal studies of older men and women have reported 25–35% reductions in maximal isometric strength after 11 years (Aniansson et al., 1992) and 12 years (Winegard et al., 1996) in the quadriceps and the plantar-flexors and dorsiflexors, respectively. This evidence suggests that the decline in muscular strength with aging may be underestimated by cross-sectional investigations.

There are now numerous studies demonstrating the beneficial effects of high-intensity resistance training in older men and women. Short-term (Brown et al., 1990; Charette et al., 1991; Fiatarone et al., 1990; 1994; Frontera et al., 1988) and long-term (Lexell et al., 1995; McCartney et al., 1995; 1996; Pyka et al., 1994) resistance training has resulted in dramatic improvements in dynamic muscular strength ranging between 30% and 225% of baseline (pretraining) values, and the increases in muscular strength have been associated with improvements in measures of functional capacity (Fiatarone et al., 1994; McCartney et al., 1995; 1996). Improvements in dynamic strength with resistance training appear to be the result of both an increase in muscle size (hypertrophy) and an improvement in the neural activation of the muscles involved in resistance training (Sale, 1988).

The relative contribution of each and their time course of influence have yet to be determined in older persons, but it is suggested that the initial increase in dynamic strength is the result of neural adaptations and that any further improvements are the result of hypertrophy (Hortobagyi et al., 1993; Sale, 1988). Nevertheless, in our previous 2-year study of resistance training in older persons, we noted increases in dynamic strength throughout the training period, yet only modest gains in muscle hypertrophy (McCartney et al., 1996), which could perhaps be explained by progressive improvements in neural learning and control.

Despite the growing body of evidence which suggests that resistance training of moderate to high intensity helps attenuate the effects of aging on muscular strength, little is known about the length of time these beneficial effects are maintained (or the process) once training has ended. In younger persons, significant reductions in muscular strength and endurance are found following short and long periods of detraining (Hortobagyi et al., 1993; Narici et al., 1989; Staron et al., 1991). In contrast, relatively few studies to date have examined the effect of detraining on muscular strength in older persons following resistance training. Fiatarone and colleagues (1990) (8 weeks of training) and Lexell and colleagues (1995) (11 weeks of training) reported significant 32% and nonsignificant 5% reductions in dynamic muscular strength following 4 and 26 weeks of detraining, respectively. Despite these changes, the subjects' dynamic muscular strength still remained significantly elevated above their pretraining levels. Recently, Ivey et al. (2000) reported that after a 9-week resistance training intervention in older adults, specific force remained elevated above baseline following 31 weeks of detraining.

These studies suggest that relatively short periods of detraining in the elderly result in only modest declines in dynamic muscular strength, but whether a similar pattern would be evident following a longer resistance training program or a longer period of detraining has yet to be determined.

The purpose of the present study was threefold: (1) to examine the effects of 5 years of resistance training on dynamic strength in a group of older individuals; (2) to examine the effects of 3 years of detraining, following 2 years of high-intensity resistance training, on dynamic strength; (3) to follow the age related losses in dynamic strength in healthy community-dwelling older men and women over a 5-year period.

Methods

SUBJECTS

Thirty healthy men and women ages 65 to 81 years volunteered for the study. The study was approved by the President's Committee on Ethics of Research on Human Subjects, McMaster University, and each volunteer gave his/her written informed consent to participate. Exclusion criteria included cardiopulmonary disease, osteoporosis, orthopedic disability, smoking, and a relative body weight of >130% of predicted (McCartney et al., 1995; 1996).

STUDY DESIGN

Subjects formed three groups, 5 men and 5 women per group, who had either done: (a) a 2-year resistance training study (McCartney et al., 1996) and then voluntarily continued for 3 more years (Tr); (b) ceased to train for 3 years after the 2-year study ended (Detr); (c) had acted as nonexercising controls throughout (Con). The Tr and Detr groups participated in twice weekly, high intensity resistance training for 2 years. The Tr group then continued to train at a lower intensity maintenance level for an additional 3 years, whereas the Detr group stopped training. The 10 control subjects did not do any resistance training for the duration of the study but were involved in identical testing procedures.

At the 5-year follow-up testing time, each subject completed the modified Baecke questionnaire for older adults as a measure of habitual physical activity (PAH-Q), which has been shown to be both valid and reliable in the elderly (Voorrips et al., 1991)

TRAINING

For 2 years, subjects in the Tr and Detr groups participated in a supervised, progressive resistance training program twice per week, each session lasting about one hour. They performed two to three sets of 8–10 repetitions for the upper body (unilateral arm curl, overhead unilateral military press, bilateral supine bench press, and bilateral triceps extensions) and 10–12 repetitions for the lower body (unilateral leg press and calf press, unilateral knee extensions, and unilateral dorsi- and plantar-flexion) exercises, at an intensity of up to 80% of 1-RM. The Tr and Detr groups were strength tested on a regular basis to ensure that they were training at the appropriate intensity (McCartney et al., 1995; 1996).

Following the 2 years of heavy resistance training, subjects in the Tr group continued resistance training twice weekly at a more moderate intensity (2 to 3 sets at 60–70% 1-RM). In addition to resistance training, each session included stretching exercises and aerobic activities such as stationary cycling and treadmill walking, and the total exercise time was increased from 1 to 1.5 hours. The Detr and Con groups were not involved in any type of formal resistance training program over the 3-year detraining period.

MEASUREMENT OF DYNAMIC STRENGTH

The subjects' 1-RM, determined as being the heaviest weight that could be lifted once through a full range of movement with correct form, was measured for unilateral arm curl (AC), unilateral leg press (LP), and bilateral supine bench press (BP). Single arm curl 1-RM was tested on a custom built apparatus specifically designed for the study (Rubicon Industries, Stoney Creek, ON). Leg press and bench press 1-RM strength was determined using a multistation weightlifting machine (model 4141-162; Global Gym and Fitness Equipment Ltd, Weston, ON). The testing after 5 years was done by a trained assessor, but not the same person who had done the evaluations during the first 2 years.

TREADMILL TESTING

Subjects performed an incremental treadmill (Quinton Q55xt) walking test until they: (a) reported a Borg (1982) rating (1–10 scale) of perceived exertion (RPE) of 7 (very severe) for leg discomfort or dypsnea (n = 19); (b) reached their age-predicted maximum heart rate (MHR) as determined by electrocardiographic monitoring (V5) (n = 1); or (c) felt they could not continue (n = 10), at which time the attending investigator terminated the test. Subjects were unaware of the criteria for ending the test. The treadmill protocol was as follows: during the first 2 minutes the treadmill walking speed was 2.0 mph at an elevation of 10%; this was increased to 2.5 mph and 12% grade for Minutes 2 to 4, and in each additional 2-min interval the speed remained constant and the elevation increased by 2% to a maximum of 24%. Symptoms of leg effort and dypsnea were rated separately at the end of every minute, and heart rate was monitored continuously.

STATISTICAL ANALYSES

Data were analyzed using a Group × Time mixed analysis of variance (ANOVA) with repeated measures for Time, using the Statistica (StatSoft Inc.) software program. The Tukey HSD method was used as a post-hoc test to determine specific differences between groups. The interaction of greatest interest was Group × Time, to evaluate the effects of training and detraining. The absolute and relative changes were assessed separately, and error bars have been left off the figures for clarity. A probability level of $p \leq 0.05$ was considered statistically significant. All values are expressed as mean ± standard deviation unless otherwise stated.

Results

Subject characteristics at the 5-year follow-up time are summarized in Table 1. There were no significant differences between the groups with respect to age, gender, height, weight, or level of habitual physical activity (PAH-Q). All subjects completed each test.

DYNAMIC STRENGTH

Men were significantly stronger than women for each measure of dynamic strength (AC, LP, and BP, all $p < 0.001$). This finding was consistent across all groups, but since there was no significant difference in the pattern of change over time between men and women, the data are presented as men and women combined. Furthermore, as there were no significant differences in the pattern of strength gain between the two limbs for arm curl or leg press, values represent the sum of both limbs.

Table 1 Subject Characteristics (mean ± *SD*)

Group	Age (yrs)	Height (cm)	Weight (kg)	Mod. Baecke Questionnaire for Older Adults (PAH-Q)
Training	74.9 ± 4.2	164.4 ± 8.0	67.6 ± 12.0	14.8 ± 7.7
Detraining	72.3 ± 3.5	165.5 ± 9.0	76.1 ± 13.0	12.7 ± 9.2
Control	70.2 ± 3.1	162.6 ± 11.0	76.7 ± 14.0	15.0 ± 8.1

Table 2 Dynamic Strength (1-RM) After Resistance Training, Detraining, or Control (mean ± *SD*)

	Baseline	2 years	5 years
Arm Curl 1-RM			
Training	17.3 ± 6.6	39.4 ± 24.8 †‡	33.0 ± 21.6 †‡
Detraining	23.1 ± 17.6	39.3 ± 23.9 †‡	28.4 ± 19.6 ‡
Control	22.1 ± 10.0	21.6 ± 10.9	17.7 ± 8.0
Leg Press 1-RM			
Training	129.0 ± 36.0	163.8 ± 46.9 †‡	150.1 ± 42.2 †
Detraining	135.2 ± 35.8	178.8 ± 52.8 †‡	153.6 ± 41.5 ‡
Control	155.8 ± 50.0 *	148.8 ± 137.4	137.4 ± 40.0
Bench Press 1-RM			
Training	31.5 ± 14.4	48.1 ± 21.4 †	39.8 ± 19.7 †
Detraining	36.4 ± 17.1	54.5 ± 23.4 †‡	37.7 ± 17.1
Control	39.5 ± 14.5	41.7 ± 12.8	36.0 ± 11.2

Note: Dynamic strength was measured as one-repetition maximum (1-RM; kg). *Significant difference at baseline between groups; †Significant change from baseline; ‡Significant difference from Con. All values significant at $p \leq 0.02$.

Absolute Dynamic Strength (1-RM). As the Con group demonstrated a greater leg press 1-RM than both the Tr and Detr at baseline, analysis of covariance was used to assess changes in this outcome measure. Following 2 years of high-intensity resistance training (Table 2), dynamic strength in the Tr and Detr groups increased significantly above pretraining values in all exercises (AC = 22.1 ± 19.4 kg and 16.1 ± 16.8 kg; LP = 35.2 ± 18 kg and 43.2 ± 24 kg; BP = 16.6 ± 10 kg and 18.2 ± 11 kg, respectively). The Con group demonstrated a slight decline over this period in arm curl (–4.4 ± 3 kg) and leg press (–18.3 ± 19 kg) strength, and a slight increase in bench press (2.7 ± 3.5 kg) strength, although none of the changes were significant (Table 2). At 2 years, the Tr and Detr groups were significantly elevated above the Con in arm curl and leg press 1-RM. The Detr group was significantly stronger than the Con in bench press 1-RM (Table 2).

After 3 years of maintenance training, the 1-RM in the Tr group remained significantly elevated above baseline values for arm curl (15.72 ± 17.0 kg, p = 0.003), leg press (21.6 ± 16.7 kg, p = 0.01), and bench press (8.3 ± 11.8 kg, p = 0.02). Arm curl 1-RM in the Tr group was also significantly greater than in the Con after 5 years (p = 0.005). The difference in leg press 1-RM between the Tr and Con groups at 5 years approached significance (p = 0.07).

The Detr group demonstrated a general decline in dynamic strength from Years 2–5, although values remained elevated, but not significantly, above pretraining in arm curl (5.3 ± 4.9 kg), leg press (18.4 ± 22 kg, p = 0.056), and bench press (1.4 ± 13 kg) exercises. Despite the reductions in 1-RM strength, the Detr group remained significantly elevated above the Con group in both arm curl and leg press (Table 2). The Con group demonstrated further reductions from baseline in arm curl (–4.4 ± 2.9 kg), leg press (–18.3 ± 18 kg, p = 0.057), and bench press (–3.5 ± 6.9 kg) 1-RM, but the changes were not statistically significant.

Relative (%) Change in Dynamic Strength. Two years of high-intensity resistance training elicited increases in arm curl dynamic strength of 113.9 ± 76.9% in the Tr group and 81.9 ± 52.1% in the Detr group (both p = 0.0001). Both groups were significantly different from Con (–3.63 ± 19.8%; Figure 1). Similar patterns were noted in both leg press (27.9 ± 13.1% and 31.9 ± 15.7%, p = 0.001) and bench press (57.8 ± 28.3% and 55.6 ± 33.9%, p = 0.001) 1-RM in the Tr and Detr

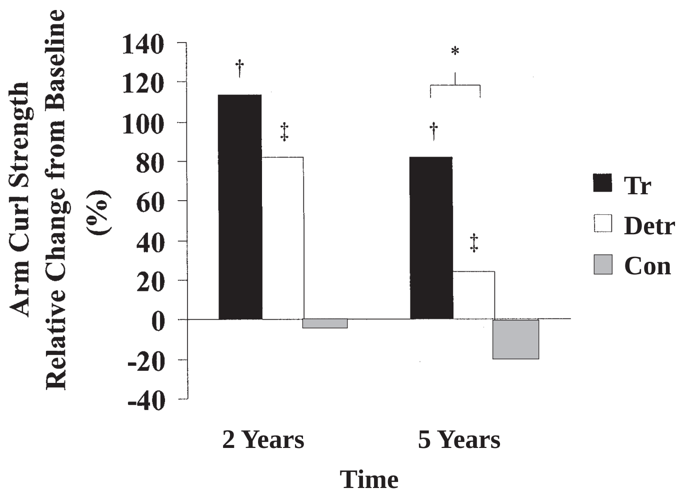

Figure 1. Arm curl strength, relative change from baseline. †Significant difference between Tr and Con, $p < 0.0002$. ‡Significant difference between Detr and Con, $p < 0.0002$. *Significant difference between Tr and Detr, $p = 0.02$.

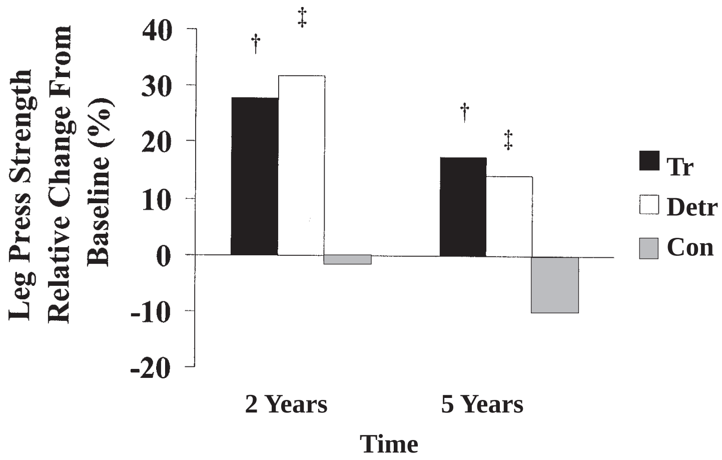

Figure 2. Leg press strength, relative change from baseline. †Significant difference between Tr and Con, $p < 0.001$. ‡Significant difference between Detr and Con, $p < 0.003$. No significant differences were noted between Tr and Detr groups.

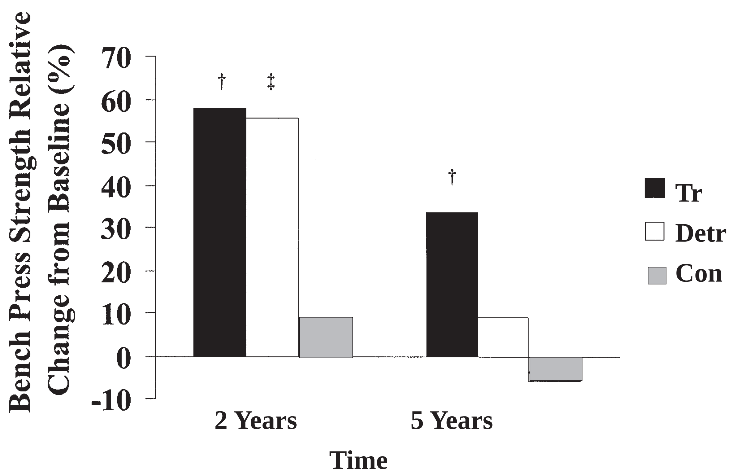

Figure 3. Bench press strength, relative change from baseline. †Significant difference between Tr and Con, $p < 0.006$. ‡Significant difference between Detr and Con, $p = 0.0001$.

groups, respectively (Figures 2 and 3), and both groups differed significantly from the Con ($p = 0.0001$).

At the 5-year follow-up, the change in arm curl 1-RM from baseline was significantly different between the Tr (82.2 ± 68.9%) and Detr (24.2 ± 17.9%, $p = 0.02$) groups, and the changes in both the Tr and Detr groups were significantly different from Con (Figure 1). In leg press there were no significant differences between the change in the Tr (17.4 ± 10.9%) and Detr (14.2 ± 16.0%) groups, yet both were significantly different from the Con (–9.7 ± 14.5%) (Figure 2). After 5 years the relative change in bench press 1-RM in the Tr group was significantly different from the Con, but there were no differences between the Tr and Detr or the Detr and Con (Figure 3). The relative decline in muscular strength between Years 2 and 5 were not significantly different between the Tr and Con groups.

TREADMILL PERFORMANCE

There were no significant differences between the three groups at baseline in treadmill endurance. After 2 years of resistance training, both the Tr and Detr groups demonstrated an increase in time to exhaustion, with a general decline noted in the Con. This was similar for both relative changes from baseline in treadmill endurance and absolute change in treadmill performance. Following a moderate-intensity resistance training or detraining period, there was a general decline, not significant, in mean time to exhaustion for all groups. There was a significant correlation between the level of habitual physical activity (PAH-Q) and treadmill time to exhaustion ($r = 0.37$, $p = 0.0003$) at 5 years only. A similar relationship was noted for leg press dynamic strength and treadmill endurance at baseline ($r = 0.41$, $p = 0.02$); however, this relationship was not found at 2 or 5 years.

Discussion

DYNAMIC MUSCULAR STRENGTH

The major purpose of the present study was to compare the dynamic muscle strength among three groups of older men and women over a 5-year period. The first group had done twice-weekly resistance training continuously for 5 years. The second group had done 2 years of continuous training followed by 3 years of detraining, and the third group served as controls throughout.

Training. Two years of high intensity resistance training in older men and women resulted in significant increases in dynamic muscular strength ranging from 27% to 114% above pretraining values. These increases in dynamic strength are similar to values reported from other studies of short-term (Fiatarone et al., 1990; 1994; Nichols et al., 1995a; 1995b) and long-term (Lexell et al., 1995; Pyka et al., 1994) resistance training, and further demonstrate that muscle retains the capacity to adapt to overload training, even into the 9th decade of life.

To distinguish between the effects of continuing training at a more moderate intensity with those of ceasing training altogether, half of our resistance-trained subjects persisted in a maintenance program (Tr) for a further 3 years and the other half stopped training altogether (Detr). The results indicated that maintenance training attenuated the reduction in strength experienced by the detraining group (Figures 1–3). Another interesting observation was that the relative reduction in muscular strength between Years 2 and 5 was not significantly different between the Tr and Con, which might suggest that the decline in the training group was a consequence of the aging process itself. On the other hand, the reduction in training intensity from 80% of 1-RM to 60–70% of 1-RM in the final 3 years may not have provided a sufficient stimulus to prevent strength loss and to maintain the neuromuscular adaptations resulting from the 2 years of high-intensity training.

Graves and colleagues (1988) and Lexell and colleagues (1995) reported that a reduction in training frequency from 3 times per week to just once per week resulted in the preservation, or even a slight improvement, of dynamic strength over 12 and 26 weeks, respectively, as long as the intensity of the training stimulus was maintained. Perhaps a more appropriate method for maintaining muscular strength gains in the elderly would be to maintain the training stimulus intensity and reduce the frequency. Evidently, the mechanisms and training principles for the maintenance of strength in the elderly need to be evaluated further.

Detraining. The effect of detraining on the retention of muscle strength in the elderly has not been adequately addressed. In the present study, after 3 years of detraining there was a modest decline in dynamic strength from posttraining values, ranging from 13% in lower body exercises to 29% in upper body lifting. Lexell and colleagues (1995) reported that 26 weeks of detraining resulted in a 5% reduction in dynamic knee extension and arm flexion 1-RM, but the values remained significantly above baseline. In another study, Fiatarone and colleagues (1990) demonstrated a more pronounced 32% decline in dynamic muscular strength from just 4 weeks of detraining in the institutionalized frail elderly, but once again the 1-RM remained significantly above pretraining values. Ivey et al. (2000) reported that after a 9-week strength training program there was a 14% decline in knee extensor strength following 31 weeks of detraining. Knee extensor strength remained significantly above baseline for men, yet this trend did not remain for elderly women. In the present study, as in those by Lexell et al. and Ivey et al., the subjects were generally much more active (community dwelling vs. institutionalized elderly) and also relatively younger than in Fiatarone's study (mean age of 72.5, 71, and 68.5 yrs vs. 90 yrs). Thus, age may partially account for the rapid strength decline in the latter investigation.

The duration of both the strength training periods and the length of detraining differ quite substantially between the present study and those by Ivey et al. (2000), Lexell et al. (1995), and Fiatarone et al. (1994). The present study employed a 2-year resistance-training program with a 3-year follow-up period. The longest detraining period in the literature to date is 31 weeks (Ivey et al). It is possible that the relative preservation of dynamic strength over 3 years of detraining in our study may have resulted from the long duration of the initial resistance training program, suggesting that the duration of training could be an important contributing factor to the retention of neuromuscular adaptations once training ceases (Hortobagyi et al., 1993).

Given that training-induced increases in muscle strength result from a combination of hypertrophy and neural adaptations, it is interesting to speculate on the mechanisms responsible for the maintenance of muscular strength so long after the stimulus was withdrawn. In the study by Lexell and colleagues (1995), maximum strength testing took place on four separate occasions during the detraining period (26 weeks). Perhaps even this small degree of intervention may have been enough to attenuate the strength decline after training, most likely due to neural adaptations such as improved “learning” and coordination (Rutherford and Jones, 1986). Since it is unlikely that muscular hypertrophy resulting from 2 years of resistance training would remain 3 years following the cessation of training, we propose that neural adaptations were likely responsible for the relative preservation of dynamic strength among our subjects. The results from Ivey et al. (2000) support the hypothesis that strength is better preserved than muscle mass after a prolonged period of detraining.

Aging. The control subjects, who did not strength train throughout the 5-year study, consistently lost upper- and lower-body dynamic strength (Figures 1–3; Table 2). The relative decline in strength was slightly, although not significantly, greater for the upper body than for the lower body (mean of 12% vs. 10%) exercises over the 5 years. This trend is consistent with cross-sectional studies which suggest that the age-related decline in muscle strength will accelerate with increasing age, and that there are systematic differences in the magnitude and rate of strength loss in different muscle groups (Aoyagi and Shephard, 1992).

Nevertheless, the decline in muscular strength demonstrated by the Con group in this study is much greater than expected from the results of cross-sectional studies which have reported declines in muscular strength ranging from 24% to 45% between 50 and 80 years of age (8–15% per decade) in the quadriceps muscles (Hurley et al., 1995; Larsson et al., 1979; Lexell, 1995). In contrast, longitudinal studies have demonstrated greater losses of muscular strength over short periods (Aniansson et al., 1983; 1986; 1992; Winegard et al., 1996) in elderly men and women.

TREADMILL PERFORMANCE

Enhanced functional capacity after resistance training in older persons has been documented in several studies and may contribute to improved performance of activities of daily living and prolonged independence (Brown et al., 1990; Fiatarone et al., 1990; 1994; McCartney et al., 1995; 1996; Nichols et al., 1995a; Sforzo et al., 1995; Trappe et al., 1995). In this study, training at a high intensity was associated with greater treadmill walking endurance, with no respective increase in those subjects who did not train. Moreover, following 3 years of detraining, the decline in treadmill endurance was similar to the relative decline in leg press strength. This supports Nichols et al.’s (1995b) suggestion that the age-associated decline in functional capacity is strongly related to muscle weakness, and that strength training of moderate to high intensity may result in notable increases in mobility and balance. Thus, any change in functional capacity resulting from resistance training may be significant in both a practical and clinical sense.

In agreement with others, our data confirm that long-term resistance training in the elderly is feasible and yields strength and performance benefits well into the 8th decade of life. The major finding was that although 3 years of detraining resulted in a decline in dynamic strength and treadmill endurance capacity, the training-induced gains were not completely lost. We speculate that the 2-year training period may have effected improvements in learning and coordination that endured over this protracted time period.

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