The Effect of Moderate Resistance Strength Training and Detraining on Muscle Strength and Power in Older Men

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ABSTRACT

Purpose: The purpose of the present study was to evaluate the effects of 10 weeks of moderate resistance strength training followed by 6 weeks of detraining on muscle strength and jump performance in healthy, moderately active, older men, aged 61 – 75 years (mean age 68 ± 5 years). **Methods:** Subjects were randomly assigned to a moderate resistance strength training group (RT, n=9), or to a control group (C, n=9). The RT group trained upper and lower body muscle groups at 60% of 1-Repetition Maximum (1-RM), 3 times per week for 12 weeks. Both groups were evaluated in the 1-RM knee extension and flexion strength, squat jump (SJ), and countermovement jump (CMJ) height before and after the training period. In addition, the RT group was evaluated in the same measurements after 6 weeks of detraining. **Results:** After the training period, RT improved significantly ($p < 0.001$) the 1-RM knee extension (32%) and flexion (28%) strength, SJ (39%), and CMJ (31%) height. Significant reductions were observed in 1-RM lower body strength, SJ, and CMJ height by approximately 15%, after the detraining period. **Conclusions:** Muscle strength and vertical jump performance improved after short-term moderate resistance strength training. A short-term detraining period affects the muscle strength and power in older adults, but the neuromuscular function does not return to pretraining levels. This suggests that the continuation of a strength training program is essential for the maintenance of muscle strength, functional performance, and independence in older adults.

Key Words: aging, resistance training, muscle strength, vertical jump performance

INTRODUCTION

Aging is associated with reductions in muscle strength and power.[1,2] Muscle strength and power are essential factors for older adults to perform effectively activities of daily living, maintain independence, and general well being.[3,4] Previous studies have reported comparable improvements in muscle power, as assessed by vertical jump performance,[5] in older adults using heavy resistance strength training,[6] or heavy resistance strength training combined with explosive exercises[7] or strength training with progressively increased resistance.[8] However strength training with moderate resistance may relate to higher acceptability and compliance and lower incidence rates of injury in older adults.[9] Other studies have shown significant improvements in muscle strength and performance using a moderate resistance strength training program.[10-12] However little evidence exists in the literature about the effect of a moderate resistance strength training program in muscle power as measured by vertical jump performance in older adults.

Muscle strength gains dissipate when regular strength training is interrupted.[13-15] On contrary, in the one study that examined the effect of a 24 week detraining period on squat jump height in previously strength trained older adults no significant changes were found.[16] It is possible the magnitude of decline in muscle strength and power of older adults after a detraining period are related to their physical activity level, their age, and their frailty.[13-16] It is clear that more data are needed to determine the effects of detraining on muscle strength and vertical jump performance in older adults. These data are essential to determine the decline rates in muscle strength and power after short term detraining periods in order to design effective strategies to prevent functional decline.

The purpose of the present study was to investigate the effect of 10 weeks of moderate resistance strength training followed by 6 weeks of detraining on muscle strength and vertical jump performance, in healthy active older men.

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METHODS

Participants

Eighteen healthy older men (range: 61 – 75 years; mean age 68 ± 5 years) were recruited through telephone calls, individuals inviting friends to strength train, and through an advertisement placed in local newspapers and in recreational clubs to participate in the study. Volunteers signed a written consent form after being informed of all risks, discomforts, and benefits associated with the procedures followed in the present study. The research design and procedures of the present study were approved by the Investigational Review Committee of the investigator's university. Participants were generally free of medication, had no symptoms of cardiovascular disease, and obtained physicians clearance to participate in this study. Also, participants were moderately active with walking and gardening to be their main leisure activities[17] and had no previous experience with strength training. After the baseline, medical control subjects were randomly assigned to a moderate resistance training (RT; n=9; mean age: 68.4 ± 5.5 yrs; mean weight 81.1 ± 4.9 kg; mean height 173 ± 3.7 cm) group or to a control (C; n=9; mean age 67.5 ± 4.8 yrs; mean weight 78.6 ± 5.3 kg; mean height 170 ± 4.0 cm) group that did not participate in any training program.

Resistance Training Program

Before the start of the training period all subjects (RT and controls) performed 3 resistance training sessions with no or little resistance. These sessions familiarized the subjects with the equipment and the proper exercise techniques and controlled for the large increases in strength measurements during the initial phases of training.[18] The resistance training program took place over a period of 10 weeks, where a total of 30 workout sessions were completed. Training sessions were conducted 3 times per week in nonconsecutive days with each session lasting approximately 1 hr. The training sessions for the resistance training group included a warm-up period (10 min), an exercise period (45 min), and a cool down period (5 min). The warm up and cool down periods included stretching and cycling on a stationary bike (Monarch, Varberg, Sweden) at 50% of maximum heart rate. The training program consisted of 6 exercises for the upper and lower body: leg extension, chest press, leg curl, latissimus pull down, arm curls, and triceps extension performed on 6 Universal Gym Machines.[10] At each exercise the subjects performed 3 sets of 15 repetitions at 60% of 1-RM with 2 minutes of rest between sets. During the 6-week detraining period, the participants of RT group were instructed to continue their usual recreational activities as before the initial training program, and not to perform any strength exercises.

The control group did not take part in exercise but participated only in the pre- and postmeasurement procedures. Upon the completion of the initial training program, the control group did not participate at the detraining measurements.

Outcome Measures

Maximum strength

The maximal weight that could be lifted for one repetition only was used as the measure of dynamic concentric muscle strength 1-RM for knee extension and flexion at the beginning of the training program (pretest), the week after the end of the program (post-test), and the week after the end of the detraining period.[10] The lower body strength was the sum of knee extensors and flexors muscle strength.[10] Test-retest reliability of 1-RM strength-test was found to be high in our laboratory (I.C.C.: 0.95).

Vertical jump performance

Vertical jump performance was assessed with the squat jump (SJ) and the countermovement (CMJ) jump height with hands on hips. The SJ and CMJ heights were measured at the beginning and the end of the 10-week training program and the week after the 6 weeks of the detraining on a resistive platform connected to a digital timer (Ergojump, Psion XP, Rome, Italy).[19] Before the evaluation of vertical jump performance, subjects performed a warm-up session which involved 5 min cycling and 5 min stretching of the lower limbs. The initial position for the SJ was with the knee flexed at 90° and from this position the participants were instructed to perform a maximal vertical jump. The CMJ included a countermovement (with knees flexed down to approximately 90°), before performing a maximal vertical jump.[19] Participants performed two trials for each jump and the higher height was recorded.

Statistical Analysis

Descriptive statistics were determined on the physical characteristics of the participants. T-test for independent samples was used to examine if there were any initial differences between the RT and the C groups of each dependent variable (anthropometric characteristics, 1-RM of knee extension and flexion, 1-RM lower body strength, squat jump height, and countermovement jump height). An ANOVA with repeated measures on the second factor (2 x 2, group by time) was conducted to examine any differences in main effects and time by group interactions on each variable. Finally, one-way ANOVA with repeated measures was applied to examine any differences between pre-, post-, and detraining values of each dependent variable in RT group. When the F ratio was significant, post hoc comparisons of means were analysed with Tukey's multiple comparisons test. Statistical significance was accepted at $p < .05$.

RESULTS

Baseline characteristics

No significant differences were found between the RT and C groups in their anthropometric characteristics (age, weight, and height), 1-RM knee extension and flexion strength, squat jump, and countermovement height at the start of the study.

Training Outcomes

A significant interaction was found between the factors time (pre- and post-training) by group for 1-RM knee extension strength ($F_{1,16} = 53.6$, $p < 0.001$), 1-RM knee flexion strength ($F_{1,16} = 28.5$, $p < 0.001$), 1-RM lower body strength ($F_{1,16} = 52.6$, $p < 0.001$), squat jump height ($F_{1,16} = 104.6$, $p < 0.001$), and countermovement jump height ($F_{1,16} = 112.5$, $p < 0.001$). The RT group demonstrated significant increases in the 1-RM knee extension, flexion, and lower body strength, squat jump height, and countermovement jump height at the end of the training period (Table 1).

Detraining Outcomes

Significant decrements were observed in 1-RM knee extension (from 38.3± 7.8 to 33.2 ± 10.0 kg; $p < 0.001$), flexion (from 36.3 ± 7.0 to 31.1 ± 7.6 kg; $p < 0.001$), and lower body strength (from 74.6 ± 14.6 to 64.3 ± 17.4 kg; $p < 0.001$), squat jump height (from 14.3 ± 2.8 to 12.1 ± 2.6 cm; $p \leq 0.001$), and countermovement jump height (from 17.1 ± 2.2 to 14.4 ± 2.6 cm; $p < 0.001$)

Table 1. Physical Characteristics, and Pre- and Post-training Values in 1-RM Lower Body Strength, 1-RM of Knee Extensors and Flexors, SJ and CMJ Heights, and Chair Rising Time in the Resistance Training (RT) and Control (C) Groups

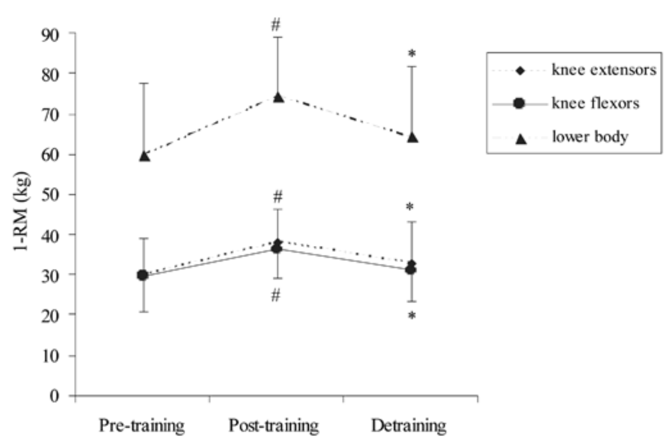
Measurements		RT (n =9)	C (n=9)
1-RM of lower body (kg)	Pre	60.0 ± 17.6	53.8 ± 10.6
	Post	74.6 ± 14.6*	53.9 ± 10.3
1-RM of knee extensors (kg)	Pre	30.3 ± 8.8	28 ± 6.6
	Post	38.3 ± 7.8*	28 ± 5.2
1-RM of knee flexors (kg)	Pre	29.7 ± 8.9	25.7 ± 5.3
	Post	36.3 ± 6.9*	26 ± 6.2
SJ height (cm)	Pre	10.3 ± 2.3	11.5 ± 1.5
	Post	14.3 ± 2.8*	11.6 ± 1.2
CMJ height (cm)	Pre	13.0 ± 2.8	12.6 ± 1.6
	Post	17.1 ± 2.2*	12.7 ± 1.5

1-RM indicates the 1-Repetition Maximum. SJ indicates the squat jump. CMJ indicates the countermovement jump.
* $p < 0.001$ significant differences between pre and post-training values

in RT group after 6 weeks of detraining period. However, the values at all parameters measured were still higher ($p < 0.05$) after the detraining period compared to the pretraining values, except for knee flexion strength (Figures 1 & 2).

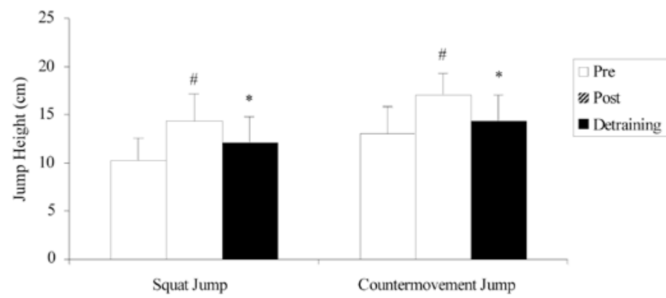
DISCUSSION

Muscle strength and power of the lower limbs contributes to several power daily activities, such as chair rising and stair climbing.[3,6,11,20] The results of the present study indicated that 10 weeks of strength training using moderate resistance improved significantly muscle strength and power, whereas 6 weeks of detraining caused significant reductions in the muscle strength and power in moderately active older men.



# $p < 0.001$ significant differences between pre and post-training values
* $p < 0.01$ significant differences between post and de-training values.

Figure. 1. Knee extensors, flexors and lower body strength (1-RM) in the experimental group during a 10 week resistance training followed by a 6 week detraining period.



# $p < 0.001$ significant differences between pre and post-training values
* $p < 0.01$ significant differences between post and de-training values.

Figure 2. Squat jump and countermovement jump height in the experimental group before (pre) and after (post) 10 weeks of moderate resistance strength training followed by a 6 week detraining period.

In previously inactive healthy older adults, a 12 week moderate resistance training program resulted in a 44% increment in 1-RM lower body strength and a 7% increment in midthigh CSA total muscle area.[10] A major methodological factor that may explain the different increments in 1-RM lower body strength between the present study (30%) and the above study (44%) is the different physical activity levels of the participants. Moritani & deVries[12] reported comparable increments in 1-RM elbow flexors strength (23%) following 8 week resistance training at 66% of 1-RM. Larger increase in muscle strength has been reported after a low resistance training program but the duration of the program was 52 weeks.[21] It seems that a moderate intensity resistance training (at 60% of 1-RM) is adequate to lead to neuromuscular adaptations in older adults. The mechanisms responsible for the improvement of neuromuscular function attributed mainly to the neural adaptations (motor unit activation, coordination) and secondary to muscle hypertrophy after short-term resistance training in older adults.[7,16]

The experimental group improved the vertical jump performance by 39% in SJ height and 31% in CMJ height. Previous studies[6-8] reported smaller increments in SJ and CMJ heights than the present study in spite of using resistances up to 80% of 1-RM. Especially in a study from our laboratory,[6] inactive older women improved the SJ height by 24.5% and CMJ height by 21.7% following 12 weeks of heavy resistance training. Additionally, a significant correlation among the change in squat and countermovement jump height and the change in chair rising time after the training period was observed.[6] It is possible this significant relationship between vertical jump performance and chair rising is due to the similar kinetic pattern and the same muscles groups involved in the tests. Hakkinen et al[7] showed that a 6 month heavy resistance training (including leg press exercise) combined with explosive exercises yielded 24% and 18% improvement in squat jump height, in habitually active older men and women, respectively. Roelants et al[8] reported significant increments in isokinetic knee extensors peak torque and countermovement jump height in older adults after 24 weeks of strength training for the knee extensors with progressively increased resistance. An important factor that can explain the increments in muscle strength and vertical jump performance of MRT group is their previous training status, with no strength training history. It has been observed that the gains in muscle strength and power following are larger in novice weight trainers than strength/power athletes.[22,23]

Another important finding of the present study is the decrements in 1-RM knee extensors and flexors strength, SJ height, and CMJ heights by approximately 15% after 6 weeks of detraining. Although a short term detraining period affected the neuromuscular function, the muscle strength and power did not return to pretraining values. Perhaps, the duration of the detraining period (6 week) and the physical activity level of the participants (moderately active) are factors related to the small magnitude of the neuromuscular decline.

Previous studies have reported various reductions in muscle strength after a detraining period,[13-15,24] while only one study determined the effect of detraining in vertical jump performance.[16] Lexell et al[24] have reported that older adults can maintain the gains in muscle strength for 27 weeks when training only once a week. Hakkinen et al[16] have reported small declines in concentric and isometric muscle strength (4% and 9%, respectively) after 24 weeks of detraining, whereas no significant changes occurred in SJ height in previously strength trained older adults. Taaffe and Marcus[14] reported a 40% increment in muscle strength after a 24 week resistance (at 75% of 1-RM) training period, but in muscle strength decline by 30% following a 12 week detraining period. Sforzo et al[15] have reported no significant declines in muscle strength after 5 weeks of detraining in older adults who had previously trained for 16 weeks of heavy resistance training. In the same study,[15] muscle strength returned to pretraining values after 10 weeks of detraining. On the other hand, Fiatarone et al[13] reported a significant decline in muscle strength after 4 weeks of detraining in frail older adults previously heavy resistance trained (at 80% of 1-RM) for 8 weeks. The magnitude of decline in muscle strength and power of older adults after a detraining period may be related to their recreational and daily activities during the detraining period,[16,24] their age,[13,25] and their frailty.[13,25] It seems that strength training in older adults, even with a reduced training frequency, must be performed during detraining periods in order to maintain muscle strength, mass, and functional performance gains that have been achieved following a regular strength training period.[16,24]

CONCLUSIONS

In conclusion, the findings of the present study indicated that a 10-week moderate resistance training improved the muscle strength and power of the lower limbs in moderately active older men. In addition, a 6 week detraining period caused significant declines in muscle strength and power. This suggests that a moderate resistance strength training program is an effective intervention to improve neuromuscular functions which contribute to the improvements of functional performance, maintaining independence, and the well being of older adults. During detraining periods, increased physical activity levels are essential for the maintenance of neuromuscular function and functional performance in older adults.

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