Detraining and Retraining in Older Adults Following Long-Term Muscle Power or Muscle Strength Specific Training

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**Background.** Training cessation among older adults is associated with the loss of functional ability. However, exercise programs undertaken prior to activity cessation may offer functional protection. In the present study, the residual effects of muscle power or muscle strength training were investigated following extended detraining and subsequent retraining.

**Methods.** Thirty-eight healthy independent older adults (65–84 years) entered a 24-week detraining period subsequent to 24 weeks of training. Following detraining, participants recommenced training using either the high-velocity muscle power (HV) or muscle strength (ST) protocol, as undertaken during the initial training period, twice weekly for 12 weeks. Isometric and dynamic muscle strength, muscle power, movement velocity, muscle endurance, electromyographic activity, and the results of a battery of functional performance tasks were assessed.

**Results.** Muscle function and functional performance increased following initial training, however, no group differences were observed. Detraining resulted in similar declines in muscle power and muscle strength for both groups \( (p < .05) \) (power, HV 17.8 ± 1.8%, ST 15.5 ± 2.2%; and strength, HV 17.1 ± 2.2%, ST 16.5 ± 1.8%), with comparable accrual following retraining. No significant changes in functional ability were observed following detraining (average change; HV 3.1 ± 3.5% and ST 2.1 ± 3.5%) or retraining. No group differences emerged in this study.

**Conclusion.** Cessation of training resulted in only a modest loss of muscle power and strength that was recouped following 12 weeks of retraining. Importantly, training-induced gains in functional performance were preserved during detraining. The residual effects of power or strength training appear comparable, and both may be suitable exercise modes prior to a period of activity cessation to promote physical independence.

**Key Words:** Resistance training—Functional performance—Muscle function—Detraining—Retraining.

The decreasing capacity of an older individual to undertake activities of daily living is associated with the age-related loss of muscle mass and compromises independent living (1,2). Undertaking resistance training in later life has proven a reliable strategy to counter the physiological and functional losses that accompany normal aging (3,4). However, the availability of the older adult to take extended holidays, coupled with volunteering or family commitments, may lead to periods of voluntary training cessation. In contrast, those with advanced morbidity may be subject to enforced inactivity. Whether voluntary or enforced, the functional well-being of an individual prior to extended cessation of activity may play an important role in prolonging independence or in physiological recovery (5,6).

Research indicates that, in older adults, the loss of muscle strength during training cessation is dependent on the intensity and duration of the initial exercise protocol and the frequency of retesting (6,7), yet little is known about the relationship between training intensity and functional loss. Recent work suggests that power-orientated high-velocity varied resistance training is more effective at increasing functional ability in older adults than is strength training alone (8). However, no data are available investigating the impact of detraining on functional performance in previously muscle power-trained older adults. Moreover, although studies indicate that resumption of training will result in rapid accrual of the muscle strength lost during detraining (6), no data are available investigating the effect of retraining on muscle power or functional ability.

With the recent interest in power training for older adults (9) and work suggesting that greater physiological gains may be possible compared to those achieved with strength training (10), investigations directly comparing muscle power- and strength-oriented training are warranted. Moreover, examining muscle and physical function following cessation and resumption of training will help to disclose which form of training provides the greatest protection for maintaining functional independence in older adults anticipating periods of extended inactivity. Therefore, the purpose of the present study was to assess the effect of detraining and retraining on muscle function and functional performance in older adults who have undergone either muscle strength or muscle power specific resistance training. It is hypothesized that greater detraining loss will be experienced in the muscle parameters related to that specific form of training. Therefore, power-training individuals will experience a greater loss in muscle power, and the strength training group will lose a greater percentage of their muscle strength when compared to the alternate training regimen. Furthermore, it is hypothesized that individuals will regain lost muscle function and functional ability during an abbreviated period of retraining.
METHODS

Participants
Independently living, community-dwelling adults aged 65–84 years were recruited from the Brisbane city area by newspaper advertisement to participate in a 24-week resistance training intervention comparing muscle power and muscle strength training to a nontraining control group. Following the completion of the initial intervention, training participants were offered the opportunity to continue in an extension study examining the effects of detraining and retraining, whereas the control group was offered a short-term resistance training program (11). The initial participant recruitment has been described previously (12). Briefly, potential participants meeting the selection criteria, which included no acute or terminal illness, cardiovascular, respiratory, neurological or muscular disease, or resistance training in the previous 12 months, were sent an information pack detailing the study and requesting that they obtain their general practitioner’s approval for participation. Having obtained this, participants were invited to attend familiarization and baseline testing sessions. Following baseline assessment, 67 participants were randomized to the high-velocity varied resistance muscle power training (HV = 23), strength training (ST = 22), or nontraining control (CO = 22) group. At the completion of the 24-week intervention, 38 participants entered the detraining and retraining program (HV = 19, ST = 19). The University of Queensland Medical Research Ethics Committee approved the study, and all participants gave informed consent.

Study Design
This study examined the effects of a 24-week period of detraining and 12 weeks of retaining in a group of previously high-velocity varied resistance muscle power or conventional strength-trained older adults (Figure 1). Details of the substantial increases in muscle function and functional performance that occurred for both training groups following 24 weeks training have been presented previously (12). During detraining, participants were instructed to continue with their customary physical activity but not to engage in any new activities, and given strict instructions to avoid any resistance-based exercise.

Retraining Protocol
Retraining, during which participants resumed training using the protocol undertaken during the initial training phase, was undertaken twice weekly and consisted of six upper- and lower-body resistance exercises (chest press, supported row, biceps curls, leg press, leg curls, and leg extensions) using Extek resistance equipment (Extek Pty. Ltd., Brisbane, Australia). Each session commenced with a warm-up of stretching activities and concluded with a cool-down comprising abdominal and lower back exercises. All training sessions lasted approximately 1 hour, were separated by a minimum of 2 days, and were conducted under direct supervision of an exercise instructor to ensure safety.

Retraining was divided into conditioning, to better prepare participants to re-enter training (13), and retraining. The four conditioning sessions consisted of participants...
completing three sets of eight repetitions for each exercise at 65% of their postdetraining 1 repetition maximum (1RM) for the first two sessions, and 70% 1RM for the third and fourth sessions. Concentric and eccentric movements were performed at a rate of ~3 seconds. New 1RM measures, used to calculate the retraining commencement weights, were collected following conditioning. Due to the strenuous nature of 1RM testing, this session was included as the first of the remaining 20 retraining sessions.

**ST Protocol**

Following conditioning, the ST group maintained the 3-second movement speed, completing three sets of eight repetitions at 75% 1RM.

**HV Training Protocol**

In contrast to the ST group, the HV group performed ~20% less work per exercise using two lighter sets at 45% and 60% 1RM in addition to one high-intensity set at 75% 1RM, and were instructed to produce the concentric portion of each repetition as explosively as possible.

To ensure that the program was progressive for both groups during the retraining period, the resistance was increased when the number of repetitions that a participant could complete in the final set was more than eight (14). Specifically, when participants could complete 10 or 11 repetitions in their final set, the 1RM was increased by 5%; when they could complete ≥12 repetitions, the 1RM was increased by 10%. Resistance adjustments were made following the final session of each week.

**Measures**

All tests of muscle function were conducted on the same equipment used by participants during training. Data collection for all variables occurred at commencement of detraining (week 0), postdetraining (week 24), and post-retraining (week 36).

**Muscle Function**

Dynamic muscle strength and muscle endurance.—Dynamic concentric muscle strength for all exercises was measured using the 1RM method (11). Briefly, an individual's 1RM is the maximum weight that can be moved through the full range of motion once with correct technique. Leg press and chest press muscle endurance was determined from the maximum number of repetitions performed at 70% 1RM (15). The coefficient of variation (CV) for repeated 1RM measures in our laboratory ranged from 2.5% to 8.8%, and was 4.4% and 6.4% for leg press and chest press endurance, respectively.

Isometric muscle strength and electromyographic activity.—Isometric leg extension and biceps curl strength data collection has been described previously (12). Briefly, data were calculated following a maximal contraction at a predetermined angle, 135° for the leg extension (where full knee extension is 180°) and 90° for the biceps curl (16). Participants were given a “go” command, instructed to undertake the contraction explosively and to maintain maximal torque for 3 seconds. Three attempts were carried out with each attempt separated by 30 seconds.

The electromyographic (EMG) activity of the right biceps brachii and right rectus femoris were collected during the respective isometric assessment. Bipolar surface EMG recording was used (QANTEC EMG Preamplifier 820; University of Queensland (UQ), Brisbane, Australia), and the signal amplified (QANTEC Isolated EMG Amplifier 810; UQ, Australia) by a sensitivity factor of 1 Kv for the biceps brachii and 500 v for the rectus femoris. Pre-amplified surface electrodes were fixed directly to the skin with adhesive tape. Skin preparation entailed shaving and cleaning prior to electrode attachment. The EMG attachment sites for the rectus femoris was half the distance from the superior surface of the patella to the anterior superior iliac spine, and one third the distance from the cubital fossa to the medial acromion for the biceps brachii (17).

Unilateral EMG data were full wave rectified and time normalized against a maximal bilateral voluntary isometric contraction. Mean and maximal isometric strength and EMG data were analyzed using the Spike2 program (Cambridge Electronic Design Limited, Cambridge, U.K.) for the initial 500 ms from the onset of torque activity, to investigate variations in the instantaneous contractual habits of muscle (18), and subsequent 500–1500 ms to ensure that the maximal peak torque phase of the contraction was incorporated (19). Only data coinciding with the peak isometric torque were retained for analysis. The CV for mean and maximal biceps curl and leg extension isometric muscle strength in our laboratory ranged from 5.3% to 13.8%, and for mean and maximal EMG activity from 6.8% to 11.4%.

Muscle power and movement velocity.—Data collection for peak and average muscle power and movement velocity for five exercises (chest press, biceps curl, leg press, leg extension, leg curl) were calculated from electronic measures of force, excursion, and duration of movement (20), and were collected through the DATAQ acquisition program (version 2.46; DATAQ Instruments Inc., Akron, OH). For conversion and movement analysis, all electronic data were forwarded to the LabView 7 Express program (National Instruments Corporation, Austin, TX). After all force and velocity data were finalized, files were forwarded to MatLab (The Mathworks Inc, Natick, MA) for calculation.

Participants were informed of the importance of the rate of movement as a component of muscle power and were encouraged to move against each resistance as rapidly as possible. For all exercises, the mean of three resistances (45%, 60%, and 75% 1RM) was calculated for analysis. Participants were given three attempts at each resistance, and repetitions were separated by 30 seconds. The CV for peak and average muscle power ranged from 2.0% to 8.2%, and for maximal and average movement velocity from 1.6% to 8.3%.

**Functional Performance**

All participants undertook a battery of eight functional performance tests. These tests were the floor rise to standing; stair climb; usual, fast, and backward 6-meter
walk; repeated chair rise to standing (five times); 400 m walk; and the functional reach test to measure static balance. These tests have been previously described in detail (11). Tests were performed in triplicate, except for the 400 m walk (only one trial was performed), with the best of the three trials used in the analysis. For each test, equipment was standardized, directions pre-scripted, and participants were closely supervised. Participants were instructed to move as fast as they could safely manage, except for the usual 6 m walk and functional reach test. The CV for functional performance tasks in our laboratory ranged from 2.0% to 7.5%.

Body Composition and Bone Mineral Density

Height and body mass were obtained using a stadiometer and electronic scale, respectively. Whole-body bone mineral-free lean mass, fat mass, percent body fat, and total body bone mineral density (BMD) (g/cm²) were determined by dual x-ray absorptiometry (DXA) (Hologic Discovery W, Hologic Inc., Beford, MA). The CVs for repeated body composition and BMD measures are < 1.0%.

Lifestyle Questionnaires

The physical activity of participants, assessed for the week prior to detraining, retraining, and at the studies conclusion, was measured using the Physical Activity Scale for the Elderly (21). In addition, the Activities-specific, Balance Confidence questionnaire was used to assess falls self-efficacy (22), and the University of Queensland Quality of Life questionnaire was administered to participants to assess health-related quality of life. All questionnaires were self-administered. The CV for lifestyle questionnaires in this study was 2.3% – 5.1%.

Statistical Analysis

Data were analyzed using the SPSS (SPSS Inc., Chicago, IL) statistical software package. Student t tests were used to examine differences between groups before detraining, and Group × Time repeated-measures analysis of covariance (ANCOVA) adjusted for sex was used to investigate differences between groups over the three time points (predetraining, detraining, and retraining). To examine within-group changes, repeated-measures analysis of variance (ANOVA) was used and, where appropriate, the Bonferroni post hoc procedure was performed to identify the source of difference. Percent change was calculated on individual data as the difference between the present and previous measure, relative to the previous, for example [(retraining – detraining)/detraining] × 100. All tests were two-tailed, and an alpha level of 0.05 was required for significance. All values are expressed as the mean ± standard error.

RESULTS

Participants

Prior to the end of detraining, 4 of the 38 participants withdrew from the study and a further 7 prior to the end of the retraining period. This resulted in 27 participants completing the intervention: HV = 15 (5 men and 10 women; age 72.1 ± 1.5 years, height 1.6 ± 0.2 m, weight 70.2 ± 3.1 kg, body fat 33.3 ± 2.2%, number of medications 1.3 ± 0.3) and ST = 12 (7 men and 5 women; age 69.3 ± 1.0 years, height 1.7 ± 0.2 m, weight 75.8 ± 2.3 kg, body fat 30.6 ± 2.2%, number of medications 2.0 ± 0.5). There was no significant difference for any participant characteristic or study variable (p > .05) between groups. In addition, participants who left the study were not distinguished from those that completed the study.

A significant time effect was observed for lean mass (p = .01); however, there were no Group × Time interactions. Within-group analysis revealed that HV and ST had a significant decrease in lean mass from 44.2 ± 2.3 kg to 43.3 ± 2.4 kg and from 49.3 ± 2.8 kg to 48.3 ± 2.9 kg, respectively, following detraining (p < .05). No changes in BMD, self-assessed physical activity, balance confidence, or quality of life were observed following detraining or retraining.

Muscle Function

Dynamic muscle strength and muscle endurance.—There was a significant time effect (p < .001) for all muscle strength exercises following detraining and retraining; however, no Group × Time interactions emerged (Figure 2). Muscle strength decreased 17.1 ± 2.2% following detraining and increased 20.6 ± 3.5% following retraining in the HV group. In comparison, the ST group experienced a 16.5 ± 1.8% decrease and a 21.4 ± 3.4% increase following detraining and retraining, respectively. No significant changes in chest press or leg press muscle endurance were observed.

Isometric muscle strength and EMG activity.—For isometric strength, the HV and ST groups experienced a 16.5 ± 2.3% and 17.8 ± 3.0% decrease, respectively, following detraining, that was recouped with retraining. However, no significant time effects or Group × Time interactions emerged. No Group × Time interactions emerged for any EMG measures with only the mean rectus femoris measures, 500–1500 ms from onset of force, displaying a significant effect for time (p < .05) with both groups having a reduced EMG activity following detraining.

Muscle power and movement velocity.—The HV group experienced a 17.8 ± 1.8% loss and 25.6 ± 2.4% gain, and the ST group a 15.5 ± 2.2% loss and 24.9 ± 1.9% gain in peak muscle power following detraining and retraining, respectively. Although a significant time effect (p < .05) emerged for all muscle power variables except the average leg curl and leg press, there were no Group × Time interactions (Table 1). There was little change in movement velocity during the course of the study, with the only substantial effect following detraining, after which the HV group was slower than the ST group (p < .05) for chest press velocity.

Functional Performance

No Group × Time interactions or time effects emerged for any functional performance task (Table 2).
DISCUSSION

This is the first study to compare change in muscle function and physical performance following detraining and retraining in previously power- or strength-trained older adults. Comparable declines in strength and power were noted in both groups following 24 weeks detraining, but these were recouped following 12 weeks retraining. Importantly, we found that gains in functional ability derived from specific power or strength training were preserved during the detraining period.

Although research among well-functioning older adults has examined the use of resistance-based exercise programs to attenuate or reverse the loss of muscle mass and functional ability, less attention has been given to changes incurred following cessation of activity. Recently, Carli and Zavorsky (5) investigated enforced inactivity in older adults preparing for elective surgery and extended hospitalization. The results showed that those who undertook moderate- to high-intensity exercise prior to hospitalization (prehabilitation) increased their quality of life during recovery, decreased their length of hospitalization and postoperative associated complications, and reduced functional loss during immobilization. Other studies investigating voluntary detraining suggest significant loss in functional ability following periods as short as 2 weeks in previously resistance-trained older adults (23).

Although it would be expected that enforced inactivity would have greater impact on functional loss than that experienced by individuals undertaking voluntary activity cessation (24), it has been suggested that functional losses during these periods are closely linked to strength loss and that resistance training does not confer sufficient protection to complex motor tasks involved in activities of daily living (25). In contrast, we found minimal change in functional ability following a prolonged period of detraining, even in the presence of significant losses in muscle strength and power. The intensity and duration of training we prescribed was greater than that undertaken in previous detraining.

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Figure 2. Detraining (0–24 weeks) and retraining (24–36 weeks) changes in muscle strength in older adults undertaking varied resistance training, adjusted for sex.

A. Bench press; B. supported row; C. biceps curl; D. leg press; E. leg curl; F. leg extension. HV = high-velocity varied resistance training; ST = strength training. Within-group comparisons are presented above each exercise for week 0 (predetraining), 24 (detraining), and 36 (retraining). *p < .05. Values shown are adjusted mean ± standard error.
investigations (23,25,26). Moreover, we did not undertake regular maximal testing during the detraining period which may attenuate the loss of muscle strength (6), suggesting that daily activities, as undertaken by individuals during detraining, was sufficient to maintain functional capacity. However, it is more likely that the reserve capacity (27) of the participants was sufficiently enhanced as a result of the initial 24-week training period, such that it was not severely depleted during detraining and, as a result, participants remained at or near their functional ceiling for the tasks examined. The suggestion that participants were at or near their functional ceiling is further supported by the lack of change in functional performance with detraining, even though muscle strength and power increased. Studies examining the association between muscle strength and walking speed and/or lower extremity performance support the role of a reserve capacity threshold (28–30), and we have previously reported that further gains in strength in well-functioning older adults engaged in resistance training did not translate into additional gains in physical performance (31).

### Table 1. Peak (P) and Average (A) Muscle Power (W) in Resistance-Trained Older Adults Following 24 Weeks of Detraining and 12 Weeks of Retraining, Adjusted for Sex

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predetraining* (Week 0)</th>
<th>Detertraining (Week 24)</th>
<th>Retraining (Week 36)</th>
<th>Predetraining* (Week 0)</th>
<th>Detertraining (Week 24)</th>
<th>Retraining (Week 36)</th>
<th>p Value</th>
<th>Time</th>
<th>Group × Time</th>
<th>Comparison†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest pr.†</td>
<td>266.5 ± 16.6</td>
<td>217.1 ± 15.9</td>
<td>243.5 ± 14.3</td>
<td>247.7 ± 19.4</td>
<td>211.8 ± 18.7</td>
<td>252.4 ± 16.8</td>
<td>.003</td>
<td>.151</td>
<td>ST: 0 &gt; 24</td>
<td>HV: 0, 36 &gt; 24, ST: 0 &gt; 24</td>
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<tr>
<td>Biceps curl</td>
<td>104.4 ± 6.7</td>
<td>84.2 ± 6.7</td>
<td>100.2 ± 6.3</td>
<td>92.3 ± 7.9</td>
<td>88.0 ± 7.9</td>
<td>99.0 ± 7.4</td>
<td>.038</td>
<td>.057</td>
<td>HV: 0 &gt; 36 &gt; 24</td>
<td>HV: 0, 36 &gt; 24, ST: 0 &gt; 24</td>
</tr>
<tr>
<td>Leg press</td>
<td>421.4 ± 23.5</td>
<td>335.4 ± 19.4</td>
<td>421.7 ± 22.7</td>
<td>360.8 ± 27.5</td>
<td>322.6 ± 22.7</td>
<td>388.3 ± 26.5</td>
<td>.049</td>
<td>.223</td>
<td>HV: 0 &gt; 36 &gt; 24, ST: 36 &gt; 24</td>
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</tr>
<tr>
<td>Leg curls†</td>
<td>149.5 ± 9.6</td>
<td>122.9 ± 6.4</td>
<td>155.6 ± 9.7</td>
<td>137.8 ± 11.3</td>
<td>117.6 ± 7.5</td>
<td>145.8 ± 11.4</td>
<td>.070</td>
<td>.862</td>
<td>HV &amp; ST: 36 &gt; 24</td>
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<tr>
<td>Leg ext.</td>
<td>192.8 ± 13.8</td>
<td>160.7 ± 10.7</td>
<td>197.3 ± 11.6</td>
<td>182.3 ± 16.2</td>
<td>163.8 ± 12.6</td>
<td>198.3 ± 13.6</td>
<td>.015</td>
<td>.347</td>
<td>HV &amp; ST: 36 &gt; 24</td>
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</tr>
<tr>
<td></td>
<td>52.1 ± 6.5</td>
<td>46.5 ± 3.8</td>
<td>48.7 ± 4.5</td>
<td>46.0 ± 7.6</td>
<td>43.8 ± 4.4</td>
<td>49.8 ± 5.3</td>
<td>.486</td>
<td>.571</td>
<td>HV &amp; ST: 36 &gt; 24</td>
<td></td>
</tr>
<tr>
<td>Floor-rise, s</td>
<td>361.9 ± 20.6</td>
<td>321.8 ± 19.5</td>
<td>416.3 ± 24.9</td>
<td>381.7 ± 24.2</td>
<td>318.9 ± 22.8</td>
<td>430.9 ± 29.2</td>
<td>&lt;.001</td>
<td>.511</td>
<td>HV &amp; ST: 36 &gt; 24</td>
<td></td>
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<tr>
<td>Stair-climb, s</td>
<td>165.5 ± 11.7</td>
<td>154.2 ± 8.6</td>
<td>195.9 ± 10.6</td>
<td>175.8 ± 13.7</td>
<td>157.3 ± 10.1</td>
<td>197.1 ± 12.4</td>
<td>.003</td>
<td>.809</td>
<td>HV: 36 &gt; 0, 24, ST: 36 &gt; 24</td>
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</table>

Notes: *Data collected following 24 weeks training prior to detraining. **Within-group comparisons for weeks 0 (predetraining), 24 (detertraining), and 36 (retraining); p < .05. Values shown are adjusted mean ± standard errors. **ST, n = 11. 
HV = High-velocity varied resistance training; ST = strength training; Chest pr = chest press; Leg ext. = leg extension.

### Table 2. Functional Performance in Resistance-Trained Older Adults Following 24 Weeks of Detraining and 12 Weeks of Retraining, Adjusted for Sex

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predetraining* (Week 0)</th>
<th>Detertraining (Week 24)</th>
<th>Retraining (Week 36)</th>
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<th>Detertraining (Week 24)</th>
<th>Retraining (Week 36)</th>
<th>p Value</th>
<th>Time</th>
<th>Group × Time</th>
<th>Comparison†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor-rise, s</td>
<td>3.6 ± 0.2</td>
<td>4.0 ± 0.3</td>
<td>3.9 ± 0.3</td>
<td>3.3 ± 0.2</td>
<td>3.6 ± 0.3</td>
<td>3.4 ± 0.3</td>
<td>.366</td>
<td>.959</td>
<td></td>
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</tr>
<tr>
<td>Stair-climb, s</td>
<td>4.5 ± 0.2</td>
<td>4.6 ± 0.2</td>
<td>4.4 ± 0.2</td>
<td>4.7 ± 0.2</td>
<td>4.8 ± 0.2</td>
<td>4.6 ± 0.2</td>
<td>.467</td>
<td>.908</td>
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<tr>
<td>6 m walk, s</td>
<td>4.0 ± 0.1</td>
<td>4.0 ± 0.1</td>
<td>3.9 ± 0.1</td>
<td>3.8 ± 0.1</td>
<td>3.9 ± 0.1</td>
<td>3.9 ± 0.1</td>
<td>.184</td>
<td>.581</td>
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</tr>
<tr>
<td>Resistance</td>
<td>3.0 ± 0.1</td>
<td>2.9 ± 0.1</td>
<td>2.9 ± 0.1</td>
<td>2.8 ± 0.1</td>
<td>2.8 ± 0.1</td>
<td>2.9 ± 0.1</td>
<td>.142</td>
<td>.402</td>
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<tr>
<td>Backward</td>
<td>16.4 ± 1.2</td>
<td>16.8 ± 1.2</td>
<td>15.4 ± 1.1</td>
<td>15.4 ± 1.3</td>
<td>16.0 ± 1.3</td>
<td>14.7 ± 1.2</td>
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<td>.969</td>
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<tr>
<td>Chair-rise, s</td>
<td>10.4 ± 0.5</td>
<td>10.5 ± 0.4</td>
<td>9.7 ± 0.3</td>
<td>10.7 ± 0.5</td>
<td>11.2 ± 0.4</td>
<td>10.1 ± 0.4</td>
<td>.304</td>
<td>.696</td>
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<tr>
<td>Functional reach, cm</td>
<td>33.7 ± 1.2</td>
<td>31.8 ± 0.9</td>
<td>34.5 ± 1.0</td>
<td>34.1 ± 1.3</td>
<td>33.1 ± 1.0</td>
<td>36.4 ± 1.1</td>
<td>.656</td>
<td>.570</td>
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<tr>
<td>400 m walk, s</td>
<td>233.8 ± 5.9</td>
<td>238.3 ± 8.0</td>
<td>238.0 ± 7.8</td>
<td>234.0 ± 6.6</td>
<td>232.0 ± 8.9</td>
<td>224.5 ± 8.7</td>
<td>.619</td>
<td>.340</td>
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</table>

Notes: *Data collected following 24 weeks training prior to detraining. Values shown are adjusted mean ± standard error. **HV (n = 14). 
HV = High-velocity power training; ST = strength training.
In contrast to functional performance, the dynamic muscle strength decreases that followed detraining were similar to those reported previously (32,33). Although a paucity of studies addressing subsequent resumption of training among older adults exist, our results are in agreement with previous work, suggesting that muscle strength accrual during retraining will increase to predetraining levels and requires only a relatively short retraining period (6,34). Importantly, these training and retraining gains were achieved in the HV group using a reduced total workload per training session, supporting previous work from our laboratory suggesting that only one set of high-intensity work, complimented by two lower-intensity sets, are required for substantial muscle strength gains in older persons (12).

In the present study, the muscle power decreases and increases experienced during detraining and retraining, respectively, occurred independent of change in movement velocity. This finding indicates that the force component of muscle power had the greatest impact on power loss during detraining. In younger adults, high-velocity varied resistance training has been used to optimize muscle power and movement velocity (35,36). Although previous studies report an association between increased muscle power and motor-unit output (37), to our knowledge this is the first study to report significant change in muscle power without substantial enhancement of EMG activity. Maximal EMG underwent nonsignificant decreases and increases following detraining and retraining, respectively, suggesting that the noteworthy muscle strength and power changes reported here are likely associated with alternative physiological mechanisms such as decreased antagonist activation or improved motor unit synchronization (38). However, it should be noted that the CV for EMG activity was considerably larger than that of the other outcome measures, and there was substantial variation among participants in their EMG response following detraining and retraining.

In contrast to previous studies, we collected data at pretraining and postdetraining only. Although regular maximal testing during these periods would have allowed us to report progressive change, it would also have influenced muscle function (6,34). Therefore, it is suggested that the changes reported here are an accurate reflection of those that will be experienced during training cessation in previously muscle strength- or power-trained older adults. However, although we have no reason to suspect that participants did not adhere to our instructions to avoid resistance-based training, we were unable to police individuals during the detraining period. Nevertheless, the comprehensive battery of tests used and similarity of change experienced among participants suggests that the data presented reflect change in muscle and physical function experienced in community-dwelling older adults following detraining.

Although this study supports the benefits of resistance training among older adults, several limitations must be considered. The participants in this study were healthy, community-dwelling older adults and may not be representative of all older persons, particularly frail or institutionalized individuals. In addition, we cannot assume that the impact of detraining in these individuals can be generalized to conditions that require extended bed rest or hospitalization, where losses in function may be quite substantial. Finally, the study was undertaken in the absence of a control group, the inclusion of which would have allowed comparative data from a group of nontraining healthy individuals. We cannot discount that a well-functioning group without prior resistance training exposure would also experience a lack of functional performance loss over a 6-month period. Nevertheless, functional performance gains were derived from the initial 24-week training period (12), and these gains were maintained throughout the detraining period.

**Summary**

A prolonged period of cessation of training resulted in a significant decrease in muscle function among older adults who previously undertook muscle power or strength training. However, these changes were not accompanied by alterations in functional performance. Twelve weeks retraining resulted in a reversal of these muscle function losses. Consequently, it may be a worthwhile strategy to prescribe high-intensity resistance exercise using either a strength-training or power-training protocol to older adults expecting a period of activity cessation. Given the outcomes of this study, it is possible that high-intensity prehabilitation programs may assist in the enhancement and preservation of physical function in older persons at the levels required to prolong functional independence.

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**References**

8. Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in...

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