Effects of Power Training on Muscle Thickness of Older Men

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Abstract
The present study aimed at comparing the effects of traditional resistance training (TRT) and power training (PT) in inducing muscle hypertrophy in older men. Twenty older men (aged between 69 and 76 years) were divided in two groups: TRT training (n=9) and PT training (n=11). The volunteers trained twice a week, during 10 weeks. Both groups performed an equal work output and the same exercises with loads between 40% and 60% of 1 RM. Three sets of eight repetitions of each exercise were performed with rest intervals of 90s between sets. Muscle thickness was measured by ultrasound at the biceps brachii (BIC) and rectus femoris (RF), using a 12 MHz high resolution scanning probe. An ANCOVA was used to compare post training muscle thickness values between TRT and PT, using baseline values as covariates. According to the results, RF muscle thickness increased only in PT, while BIC muscle thickness increased in both groups, but with larger increases in PT. In conclusion, ten weeks of PT induced muscle hypertrophy of the upper and lower limb muscles in older men. PT training may yield better results in muscle hypertrophy when compared with TRT.

Introduction
Skeletal muscle mass and strength decline as much as 12–14% per decade after the fourth decade of life [33,36]. In consequence, it is estimated that at least one-third of the muscle mass is lost between the age of 20 and 80 years [35,41]. This loss of muscle has important functional consequences for older people, including declines in bone mineral density, impaired thermoregulation, increased incidence of bone fractures, higher insulin resistance, reduction in the performance of daily living activities, etc [9,19,25,26].

However, despite the reduced functional capacity, skeletal muscle trainability appears to be preserved in the older, as shown by studies reporting that muscles of older men and women present similar or greater hypertrophy when compared with young individuals, as a result of resistance training [4,13,18,22]. Thus resistance training is considered an important component of exercise programs for older adults [2,27], especially due to its capacity for restraining sarcopenia and functional capacity [10,13,14,18].

During the muscle loss that occurs with aging, type II fibers are more affected than type I [23], leading to a pronounced loss of muscle power [7,23] and compromising the functional independence of the older [21,31]. To counteract this, a resistance training with higher velocities of movement, also called power training (PT), has been used to promote increases in peak power, muscle strength and performance of daily living activities [3,8,15,20,21]. Studies comparing the performance of functional abilities have reported better results for PT than for low velocity resistance training [3,32,34]. Previous studies using concentric [6] and eccentric [12,38] isokinetic training suggested that high velocity training is more efficient than low velocity training in inducing muscle hypertrophy in young men. However, little is known about the effects of PT in muscle hypertrophy of older persons.

There is some evidence to suggest that the early detection of physical weakness and the design of an appropriate activity intervention can help to promote or at least offset the decline in muscle mass that occurs with aging. Furthermore, the identification of interventions that enable an older person to improve muscle mass is worthy...
of investigation. Therefore, the purpose of this study was to compare the effects of a 10-week high-velocity PT program versus traditional resistance training (TRT) with an equivalent work output, on muscle thickness in older men.

Methods

Subjects

Twenty-four inactive male subjects (60–76 years old) volunteered to participate in the study. The men were selected at random from responders to advertisements placed in health clubs, social clubs, public officers, and by word-of-mouth. The volunteers were randomly assigned to either a PT or TRT group. Four participants dropped out due to family or personal reasons, one in the PT group and three in the TRT group. Therefore, 11 participants in the PT (66.64 ± 5.68 years; 62.03 ± 8.01 kg; 171.73 ± 4.96 cm; 21.10 ± 3.05 kg/m²) and nine in the TRT (66.33 ± 4.53 years; 61.39 ± 8.69 kg; 169.56 ± 6.81 cm; 21.41 ± 3.45 kg/m²) successfully concluded the study. All participants were apparently healthy and satisfied the qualification criteria for entering the study, which included being weight stable for the last six months (variations of less than 2 kg), have normal weight (BMI between 18.5 and 24.9 kg/m²), the absence of an acute or terminal illness and musculoskeletal disease, an unstable cardiovascular condition, including a recent history of myocardial infarction, or any other medical contraindication to perform resistance training exercise. Additionally, participants were all sedentary and did not perform any kind of physical activity more than once a week for the past six months. A physician examined all participants to check if they were able to participate in the study, based on their health status. Before signing an informed consent details about the study were explained to the participants, which included a description of the associated risks and benefits of participation. An Institutional Review Board approved the study protocol.

Procedures

Height and body mass

A standardized protocol was used to measure weight and height of the participants at the beginning of the study [29]. Weight was measured twice to the nearest 0.1 kg on an electronic scale (Filizola®, model Personal Line, São Paulo, Brazil). Height was measured twice to the nearest 0.1 cm using a stadiometer (Country Technology®, model 67031, Gays Mills, WI). The average of the two measures was used in the analyses.

Assessment of upper and lower body strength

A one repetition maximum (1-RM) bench and leg press test (Technogym®, Biomedical Line, Gambettola, Italy) was conducted to determine maximal upper and lower body strength. Tests were done according to a previously described procedure [3].

Assessment of upper and lower body peak power

Once the 1RM was established for each subject, a leg press and chest press test of peak muscular power was performed using the Power Control resistance machines (Technogym®, Biomedical Line, Gambettola, Italy). Power Control is a standard feature on the Biostrength® machine’s integrated system, which displays current information regarding the speed, range of motion, number of sets and repetitions performed. Muscle power was calculated from the product of force and speed of contraction.

During the tests, average velocity (m/s) and mean power (W) were recorded by a rotary encoder. Power (W) was assessed at 60% of the 1RM. The subjects performed the lift as fast as possible through a full range. The highest power achieved in each set was recorded as the peak power [3].

Resistance training intervention

The participants began by performing four familiarization training sessions over a two-week period. This familiarization period was included to decrease risk of injury, as most weight training injuries occur during the first two weeks of training [37]. The exercise protocols were designed in accordance with published guidelines for resistance training in older adults [11,27]. The 10-week training regimen consisted of a total of 20 training sessions, which were divided into two consecutive training days per week. Except for one participant in the PT group, that completed 19 sessions, all participants completed 20 sessions. Participants trained alone or in doubles, and all sessions were directly supervised by experienced personal trainers at a maximum rate of two volunteers per supervisor. Participants were instructed to not change their diets throughout the study period.

The program incorporated the following exercises: horizontal leg press, knee extension, knee flexion, chest press, seated row, elbow extension, and elbow flexion (Technogym®, Biomedical line, Gambettola, Italy), which were interspersed by 90-s recovery intervals. Both groups performed all exercises with an equal load. The training involved three sets of 8–10 repetitions at 40 percent of the 1RM for the first two sessions, 50 percent of the 1RM for the third and fourth sessions, and 60 percent of the 1RM for the subsequent sessions. The 1RM were tested every two weeks, before the beginning of the training session, to adjust training intensity. The exercises were performed with rest intervals of 90 s between sets. The PT group performed all exercises moving the weights as fast as possible in the concentric phase and taking 2–3 s to complete the eccentric phase. The concentric action was performed in approximately 1 s. The TRT group performed 2–3 s in the concentric phase and 2–3 s in the eccentric phase. The contraction velocity was controlled by a metronome and supervised by an experienced exercise technologist.

Muscle thickness

Participants were tested before and after training for muscle thickness of the biceps brachii (BIC) and rectus femoris (RF) of the dominant limb. All tests were conducted at the same time of day and participants were instructed to hydrate normally 24 h before the tests. Measures were taken 3–5 days after the last training session to prevent any swelling from contributing to the muscle thickness measurement. During this time, participants were instructed to not participate in any other exercise sessions or intense activity. Muscle thickness was measured using B-Mode ultrasound (HDI 5000, Philips, New York, NY, USA). A water soluble transmission gel was applied to the measurement site and a 12 MHz ultrasound probe was placed perpendicular to the tissue interface while not depressing the skin. Probe positioning was the same adopted in previous studies [5]. Once the technician was satisfied with the quality of the image produced, the image on the monitor was frozen. With the image frozen, a cursor was used in order to measure thickness, which was taken as the distance from the subcutaneous adipose tissue-muscle interface to muscle-bone interface [1]. A trained physician per-
formed all analyses. Reproducibility of measurements of muscle thickness was determined on two separate days. The coefficients of variation for BIC and RF muscle thickness were less than 3%.

Statistical analysis
Normality of the distribution for outcome measures was tested using the Shapiro-Wilk test. The independent-samples T-test was used to detect initial differences between groups. Paired samples t-tests were used to compare pre and post training values of muscle thickness within groups. An analysis of covariance (ANCOVA) was used to compare post training muscle thickness values between TRT and PT, using baseline values as covariates. The probability level of statistical significance was set at \( P < 0.05 \) in all comparisons. Statistical power on muscle thickness effect was determined to be 0.78 for the sample sizes used at the 0.05 alpha level. Data were analyzed using the SPSS 14.0 (SPSS Inc., Chicago, IL, USA) statistical software package. Descriptive statistics were expressed as means ± standard deviation (SD).

Results

Absolute and percentage changes in strength and power values are reported in Table 1, 2. Training-induced gains in strength were similar between groups, however PT induced significantly greater development in muscle power.

Pre and post training results for RF and BIC muscle thickness are shown in Figs 1, 2, respectively. There were significant increases in RF muscle thickness for PT (11.3%, from 1.86 ± 0.17 to 2.07 ± 0.2 cm, \( p < 0.05 \)), but not for TRT (5.5%, from 1.9 ± 0.27 to 2 ± 0.26 cm, \( p > 0.05 \)). The results of ANCOVA did not reveal differences in the post training values of muscle thickness between groups (\( p > 0.05 \)).

BIC muscle thickness significantly increased for both PT (14.3%, from 2.13 ± 0.2 to 2.43 ± 0.32 cm, \( p < 0.05 \)) and TRT (6.7%, from 2.29 ± 0.29 to 2.44 ± 0.35 cm, \( p < 0.05 \)). ANCOVA revealed a significant difference between groups, with higher values for the PT group in post training (\( p < 0.05 \)).

Table 1  Absolute and percent change muscle strength after 10 weeks resistance training.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline</th>
<th>Week 10</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td>leg press (kg)</td>
<td>PT</td>
<td>174.32 ± 33.65</td>
<td>221.59 ± 41.96</td>
<td>27.12*</td>
</tr>
<tr>
<td></td>
<td>TRT</td>
<td>176.67 ± 26.10</td>
<td>223.89 ± 37.73</td>
<td>26.73*</td>
</tr>
<tr>
<td>chest press (kg)</td>
<td>PT</td>
<td>45.09 ± 6.54</td>
<td>57.82 ± 8.67</td>
<td>28.23*</td>
</tr>
<tr>
<td></td>
<td>TRT</td>
<td>50.17 ± 8.10</td>
<td>62.67 ± 8.48</td>
<td>24.92*</td>
</tr>
</tbody>
</table>

Values are expressed as mean (± SD), Δ% = percent change, PT = Power Training, TRT = traditional training. * \( p < 0.05 \) vs. Baseline

Table 2  Absolute and percent change muscle power after 10 weeks resistance training.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline</th>
<th>Week 10</th>
<th>Δ%</th>
</tr>
</thead>
<tbody>
<tr>
<td>leg press (watts)</td>
<td>PT</td>
<td>613.55 ± 137.94</td>
<td>803.73 ± 164.69</td>
<td>31 *†</td>
</tr>
<tr>
<td></td>
<td>TRT</td>
<td>573.78 ± 107.49</td>
<td>618.67 ± 121.91</td>
<td>7.82 *</td>
</tr>
<tr>
<td>chest press (watts)</td>
<td>PT</td>
<td>235.27 ± 57.90</td>
<td>322.18 ± 82.25</td>
<td>36.94 *†</td>
</tr>
<tr>
<td></td>
<td>TRT</td>
<td>233.89 ± 62.35</td>
<td>264.78 ± 59.16</td>
<td>13.21 *</td>
</tr>
</tbody>
</table>

Values are expressed as mean (± SD), Δ% = percent change, PT = Power Training, TRT = traditional training. * \( p < 0.05 \) vs. Baseline, † \( p < 0.05 \) vs. TRT

Fig. 1  Pre and post training values of rectus femoris muscle thickness for Traditional Resistance Training and Power Training groups. * \( p < 0.05 \) – Pre vs. Post.

Fig. 2  Pre and post training values of biceps brachii muscle thickness for Traditional Resistance Training and Power Training groups. * \( p < 0.05 \) – Pre vs. Post. * \( p < 0.05 \) – Traditional Resistance Training vs. Power Training.
The recom-

h hypertrophy of older people have been published during the last years. However, few have compared the effects of different protocols in muscle hypertrophy. To our knowledge, this is the first study to present an evaluation on the effects of training with different velocities in muscle mass of older men. The major finding of the present study was that PT was more effective than TRT for increasing muscle thickness. According to the results, both training regimens lead to significant increases in BIC muscle thickness, however, the results obtained by the PT group were greater than TRT. Additionally, only PT was effective in improving RF muscle thickness.

The major limitation of the present study is the lack of dietary control. Previous studies suggested that nutritional deficiency are an important cause of frailty in older people and reported that nutritional status may influence the muscle response to training [14,39]. However, it is important to note that these studies were conducted in frail elders with functional impairments, and the sample of the present study was composed of weight-stable, functionally independent persons.

Previously, Shepstone et al. [38] compared the effects of fast (3.66 rad/s) and slow (0.35 rad/s) isokinetic lengthening contractions on muscle fiber and whole muscle cross-sectional area (CSA) of the elbow flexors in young men. Twelve participants trained one arm at a fast velocity while the contralateral arm performed an equivalent number of contractions at a slow velocity. Types I, IIA and IIX muscle fibers sizes increased in both arms, but the increases in types IIA and IIX were greater in the fast- vs. the slow-trained arm. Additionally, elbow flexor CSA increased in fast and slow arms, with the increase in the fast arm showing a trend toward being greater, but did not achieve significance.

Similar findings were reported by Farthing and Chilibeck [12] when comparing the effects of training with 180 and 30°/s in muscle thickness of the elbow flexors, measured by ultrasound, in 36 young volunteers (13 males and 23 females), but the results did not achieve significance. In a previous study by Coyle et al. [6], 22 college aged males performed maximal two-legged isokinetic knee extensions three times per week for six weeks at either 60°/s (slow) or 300°/s (fast) or both 60 and 300°/s (mixed). According to the results, only the fast group demonstrated a significant enlargement (11.2%) of type II muscle fibers. Our results are in agreement with these findings.

Shepstone et al. [38] hypothesized that the tendency for greater hypertrophy with faster vs. slower contractions would be due to greater protein remodeling induced by fast contractions. In agreement with these suggestion, biopsies revealed that fast lengthening contractions resulted in more muscle fiber injury [38]. Additionally, the results of Coyle et al. [6] suggest type II fiber hypertrophy to be a plausible mechanism for the increase in muscle fitness in the PT group. Given that type II fibers are more susceptible to be damaged due to mechanical stimuli [16, 30, 40] it is possible that both explanations are complementary. Previously, Frontera et al. [17] demonstrated that muscle strength is closely associated with muscle cross sectional area. Therefore, it should be presumed that skeletal muscle hypertrophy would lead to increased functional capacity, and this may be especially valid for the quadriceps muscles [8, 21, 23, 24, 28, 34]. This is in agreement with the results of previous studies comparing training velocities [6,12,38] and may explain previous results reported by our group, where PT lead to greater improvement in functional capacity [3].

The protocols used in the present study involved the same resistance training exercises with an equal work output, and the only difference between the two methods was the speed with which the exercises were performed. It was demonstrated that a high velocity power training program appears to be more effective in improving muscular hypertrophy than traditional resistance training in older men using a protocol similar to this study. This seems to contradict the current practice of many trainers, specially bodybuilders, who typically employ low velocity contractions in their training, however, the present findings are in agreement with most of the literature reviewed, including studies in young subjects [6,38]. Finally, with the proportion of older adults steadily rising, this may be a practical form of exercise that will enable older people to more effectively perform activities of daily living and therefore improve their quality of life.

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References


