Resistance Exercise Intensity Progression in Older Men

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Abstract

Our purpose was to examine possible influences of age on resistance exercise (RE) intensity progression in men. Twenty-four men, divided in young sedentary (YS; n=10; 25.9±3.7 years), older sedentary (OS; n=7; 67.4±5.2 years), and older runners (OR; n=7; 71.3±3.0 years), underwent a 2-times-a-week RE program for 13 weeks. Muscle strength was assessed before and after training by 1-repetition maximum test. RE workloads were recorded for each exercise session, and increases of 5–10% were made whenever adaptation occurred. Muscle strength improved similarly in all groups after RE (P<0.001). Relative RE intensity progression was not significantly different between YS and OS, except for a greater increase in calf raise relative workload observed in YS (P<0.05). In contrast, OR displayed greater relative workload increase in 7 and 6 exercises than YS and OS, respectively (P<0.05). The RE was safe as no injuries or major muscle pain were observed in either group. These results suggest that healthy sedentary older men are capable to exercise and increase RE intensity in the same way as young men, while physically active older men are capable to increase RE intensity in greater way than sedentary young and older men.

Introduction

Regular participation in physical activity or exercise programs can minimize the changes associated with typical aging in sedentary society and may contribute towards psychological health and well-being [1, 3]. Physical exercise programs have shown to improve muscle strength [7], balance [18], aerobic capacity [14], metabolism [4, 21], glucose tolerance [4, 17], blood pressure [5, 6], activities of daily living [25] and psychological health [26] in older people including those frail and in their eighties and nineties [1, 3, 10].

Exercise recommendation for both older and young people includes aerobic, resistance, and stretching exercises. However, resistance exercise has shown to be the most effective exercise for reducing and reverting sarcopenia [1, 3, 10], the loss of muscle mass with advancing age. Moreover, resistance exercise has also shown to reduce the decline in functional abilities and health status associated with sarcopenia [1, 3, 10].

Aging appears not to affect the ability to improving physical capacity through exercise training [1, 10]. Resistance training has shown to increase muscle strength in older people in the same way, or even to a greater extent, than in young people [7, 15, 20]. Despite preserved capacity for muscle strength improvement, recommendations of resistance exercise prescription for older adults have emphasized that exercise intensity increase should be slower and at lower rate of progression than in young people [1, 2, 19]. However, there is a lack of studies comparing resistance exercise intensity progression between older and young subjects. The only study we know that compared resistance and aerobic exercise progression between young and older women displayed that older women can safely increase exercise intensity in the same way as young women [7]. To our knowledge, studies analyzing resistance exercise intensity progression in older men (sedentary or physically active) have not been published.

The aim of the present study was to compare resistance exercise intensity progression and muscle strength response in older (sedentary or physically active) and young men undergoing the same resistance training program. We hypothesized that healthy older men may safely increase exercise intensity and muscle strength in the same way as healthy young men.
Methods

Study design
The study utilized a 3-group repeated measures design. All volunteers had their muscle strength tested (of all muscle groups trained) prior to and following a 13-week exercise training. Exercise training workload was monitored and recorded at each session, in order to measure exercise intensity progression throughout the study period. The exercise sessions consisted of warm-up, resistance exercise and cool-down. This study was approved by the ethics committee at our institution and is in accordance with the ethical standards of the International Journal of Sports Medicine [11]. All volunteers read a detailed description of the protocol and provided their written informed consent.

Subjects
The study population consisted of fourteen physically inactive men, divided into young sedentary (YS; 20–30 years) and older sedentary (OS; 64–78 years) group, and seven older trained runners (OR; 67–77 years; training frequency 4.7 ± 0.8 days wk⁻¹; training volume 5.7 ± 0.7 h wk⁻¹), which underwent physical exercise screening and exercise testing for beginning participation in the Cardiovascular and Muscular Fitness Program of the Laboratory of Kinesiology at the Institute of Orthopedics and Traumatology, Medical School, University of Sao Paulo, Brazil. Only those men who had not been practicing resistance training during the 12 months preceding the study were allowed to participate.

Before exercise testing, a structured history, medical record review, and physical evaluation of all volunteers were performed to document symptoms, history of chronic diseases, current medication, cardiac risk factors, and cardiac events and procedures. All volunteers with musculoskeletal limitations to physical exercise, uncontrolled cardiovascular or metabolic diseases, insulin-dependent diabetes, chronic psychological disorders and/or cardiac disease (defined as those with a history of myocardial infarction, angiographically documented coronary artery disease, coronary angioplasty, coronary bypass surgery or chronic heart failure) were excluded from the study. A symptom limited exercise testing (Heck modified protocol) was carried out to further rule out presence of any coronary artery disease.

Only those men who completed at least 75% of the exercise sessions and had less than three consecutive absences during the training period were included in the analysis. In all, thirty-three volunteers were screened but only twenty-seven men were found to be eligible. The reasons for ineligibility included coronary artery disease (1 OS), knee osteoarthritis (2 OS and 1 OR), and currently physically active (2 YS). Of all the eligible volunteers, three did not complete the thirteen weeks of follow-up (1 of each group) for reasons that were not related to the exercise program, and thus were not included in the analysis.

The demographic characteristics of the men included in the study are summarized in Table 1. None of the YS men were taking any medication. In the OS group, some men were taking diuretics (n = 6), angiotensin-converting enzyme inhibitors (n = 5), beta-blocker (n = 1), and atorvastatin (n = 1) to control arterial hypertension and dyslipidemia. In the OR group, only two men were taking diuretics and angiotensin-converting enzyme inhibitors to control arterial hypertension.

Strength test
To determine muscle strength and the initial workload for each resistance exercise, the 1-repetition maximum (1-RM) test was performed after four familiarization bouts and 2–5 days after the last exercise session as previously described [7]. In brief, the 1-RM test was performed using bench press, leg press, seated row, knee curl, shoulder press, calf raise, biceps curl, triceps push-down and abdominal using the same weight-lifting machines and free-weight dumbbells that were used for training. The tests were conducted following the exercise order described above (after proper warm-up), and the 1-RM workload was defined as the maximum weight that could be moved once through the full range of motion with proper form and without performing Valsalva maneuver. All tests were conducted by the same investigator before and after the exercise training period. In our laboratory, the intraclass correlation for 1-RM test-retest measures was 0.983 (95% confidence interval = 0.964–0.997).

Exercise program
The exercise training program, designed to develop muscle mass and strength, was performed twice a week for 13 weeks. Each

Table 1 Subjects’ characteristics at baseline.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Young Sedentary</th>
<th>Older Sedentary</th>
<th>Older Runners</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>10</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>age (years)</td>
<td>27.1 ± 3.2†††</td>
<td>67.4 ± 5.2</td>
<td>71.6 ± 4.0**</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.2 ± 4.8</td>
<td>26.5 ± 4.4</td>
<td>22.8 ± 0.6†</td>
</tr>
<tr>
<td>waist circumference (cm)</td>
<td>86.6 ± 10.7†</td>
<td>96.5 ± 13.5</td>
<td>78.9 ± 3.8†††</td>
</tr>
<tr>
<td>blood pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>resting systolic</td>
<td>114.0 ± 11.7††</td>
<td>136.7 ± 10.4</td>
<td>131.6 ± 12.4*</td>
</tr>
<tr>
<td>diastolic</td>
<td>70.7 ± 11.8†</td>
<td>86.6 ± 10.8</td>
<td>78.0 ± 4.5**</td>
</tr>
<tr>
<td>peak systolic</td>
<td>172.3 ± 16.3††</td>
<td>193.6 ± 16.4</td>
<td>190.0 ± 14.2*</td>
</tr>
<tr>
<td>diastolic</td>
<td>60.6 ± 10.8††</td>
<td>88.3 ± 12.5</td>
<td>75.5 ± 5.5*</td>
</tr>
<tr>
<td>heart rate (bpm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>resting</td>
<td>80.1 ± 6.9</td>
<td>81.7 ± 8.2</td>
<td>62.4 ± 8.8†††</td>
</tr>
<tr>
<td>peak</td>
<td>198.2 ± 19.4††</td>
<td>162.7 ± 16.2</td>
<td>166.0 ± 13.9**</td>
</tr>
<tr>
<td>exercise time (min)</td>
<td>12.7 ± 2.1†††</td>
<td>8.3 ± 2.1</td>
<td>14.8 ± 2.4†††</td>
</tr>
</tbody>
</table>

N: number of subjects; BMI: body mass index. Different from older sedentary: † = P < 0.05; †† = P < 0.01; ††† = P < 0.001.
exercise session was monitored by an exercise specialist and lasted for approximately 50 min, including warm-up and cool-down (5 min each).

The resistance exercise consisted of two sets of 8–12 repetitions each, of the same nine exercises described in the 1-RM test. The initial workload for the resistance exercise was 60% of 1-RM, and subjects were encouraged to perform the maximum they could during the sets of 8–12 repetitions prescribed, with proper form and avoiding Valsalva maneuver. All subjects were instructed to take a 30 to 60 s rest between sets.

Exercise intensity progression

To promote sufficient workload to produce improvements throughout the 13 weeks of training, the exercise intensity was increased by 0.5–10 kg (5–10%) whenever the subjects had adapted to the exercise workload. Exercise adaptation was considered as achieved when two sets of 12 repetitions with the proper form and avoiding Valsalva maneuver were performed for two consecutive exercise sessions.

Statistical methods

All data are reported as mean ± standard deviation. Statistical program SigmaStat 3.5 for Windows (Systat Software Inc., Chicago, IL, USA) was used for statistical analysis. Kolmogorov–Smirnov test was applied to ensure a Gaussian distribution of the data. Differences in subjects’ characteristics and post-exercise muscle strength were analyzed by one-way ANOVA. Two-way ANOVA (group vs. time) with repeated measurements was used to analyze the 1-RM strength test data. Bonferroni post-hoc analysis was used to determine significant data indicated by ANOVA. Because of its nonparametric distribution, exercise intensity progression was analyzed by Kruskal-Wallis test, and Dunn’s post-hoc test was used to determine significant data indicated by Kruskal-Wallis. The significance level was set at P < 0.05.

To obtain an estimate of size effect expected for the variables in our sample, we relied on the results of exercise training studies similar to ours [7, 15, 20]. Considering that the results of those studies produced a 17–49% increase in muscle strength, with no difference between young and older adults, we estimated that an overall sample of 8 subjects for each age group would be required to provide a power of 85% to detect a muscle strength change of 20% with a two-sided alpha of < 0.05.

Results

Muscle strength

Data from 1-RM strength test are displayed in Table 2. Pre- and post-exercise muscle strength was lower in OS and OR than in YG (P < 0.05) for almost all exercises tested. Resistance training promoted a 17–40% increase in 1-RM test (P < 0.05), with no significant differences among groups. These increases were enough for the OS and OR groups to show post-exercise muscle strength similar to the YS pre-exercise muscle strength.

Exercise intensity progression

As OS and OR groups showed lower muscle strength at baseline, they started the exercise training program with lower absolute workload (P < 0.05) in almost all exercises (kilograms weighted), although the initial relative workload was the same for the three groups (60% of 1-RM). Only the calf raise exercise did not show significant difference in the initial absolute exercise training workload among groups. Resistance exercise relative workload increase curves are displayed in Fig. 1. Despite the lower muscle strength of the OS in comparison with YS, the resistance exercise relative workload increase was not significantly different between YS and OS for eight exercises trained. The only exception was a greater increase in calf raise relative workload observed in the OS group (P < 0.05). In contrast, OR displayed greater relative workload increase than YS and OS in the leg press, seated row, knee curl, calf raise, biceps curl and abdominal exercises (P < 0.05). OR also displayed greater shoulder press relative workload increase than YS (P < 0.05), but not than OS. With these increases, relative workloads used in last exercise session were greater in OR (78.4 ± 2.2% of 1-RM) than in OS (69.5 ± 2.8% of 1-RM) and YS (71.1 ± 5.3% of 1-RM) in the nine exercises performed (P < 0.01).

The exercise intensity progression method utilized in this study was found to be safe since no injuries, muscle damage or major muscle pain were observed in the three groups during the study period.

Discussion

The primary finding of the present investigation was that the relative exercise intensity progression was similar in sedentary young and older men during 13 weeks of training. In addition, older male runners displayed greater exercise intensity progression than sedentary young and older men during the same training period.

### Table 2

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Young Sedentary (n = 10)</th>
<th>Older Sedentary (n = 7)</th>
<th>Older Runners (n = 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre (kg)</td>
<td>Post (kg)</td>
<td>Δ (%)</td>
</tr>
<tr>
<td>bench press</td>
<td>40.0 ± 10.1</td>
<td>52.7 ± 12.5°</td>
<td>39.4 ± 13.0°</td>
</tr>
<tr>
<td>leg press</td>
<td>108.7 ± 12.5</td>
<td>127.7 ± 14.7°</td>
<td>113.0 ± 13.4°</td>
</tr>
<tr>
<td>seated row</td>
<td>64.5 ± 11.9</td>
<td>79.0 ± 14.0°</td>
<td>64.0 ± 14.4°</td>
</tr>
<tr>
<td>knee curl</td>
<td>56.0 ± 17.4</td>
<td>75.2 ± 20.0°</td>
<td>45.5 ± 18.1°</td>
</tr>
<tr>
<td>shoulder press</td>
<td>32.7 ± 12.7</td>
<td>41.2 ± 14.1°</td>
<td>39.8 ± 13.9°</td>
</tr>
<tr>
<td>calf raise</td>
<td>139.0 ± 34.1</td>
<td>162.5 ± 35.2°</td>
<td>141.3 ± 55.4°</td>
</tr>
<tr>
<td>triceps</td>
<td>39.5 ± 10.4</td>
<td>50.1 ± 13.0°</td>
<td>38.0 ± 9.4°</td>
</tr>
<tr>
<td>biceps curl</td>
<td>25.9 ± 7.0</td>
<td>30.3 ± 8.3°</td>
<td>24.5 ± 5.0°</td>
</tr>
<tr>
<td>abdominal</td>
<td>84.0 ± 14.3</td>
<td>109.5 ± 19.0°</td>
<td>92.0 ± 17.8°</td>
</tr>
</tbody>
</table>

Δ: increase of muscle strength after the training period. *: difference from young sedentary at same period (P < 0.05). **: difference from pre-exercise at same group (P < 0.05)
Although resistance exercise recommendations for both young and older people include 1–3 sets of 8–12 repetitions in 8–10 exercises for 2–3 days/week [1, 10, 12], generally it has been suggested that exercise intensity should have a slower and decreased rate of progression in healthy older than in young adults to prevent injuries and muscle damage because of a greater adaptation time [1, 2, 19]. However, our findings do not support this recommendation. In the present study, the three groups started exercise training at the same relative intensity as recommended for young men [2, 12], and no significant differences were observed in almost all relative workload increase curves between sedentary young and older men during the training period (Fig. 1). The only difference was a greater calf raise workload increase curve, which was observed in the OS group. Moreover, older runners displayed higher relative workload increase than sedentary older and young men in six and seven exercises performed, respectively. In the two remaining exercises (bench press and triceps push-down), older runners also displayed higher workload increase than sedentary older and young men; however this greater increase failed to show statistical significance. The present study further suggests that healthy older men can safely perform and progress through resistance exercise at the same level (or even at a greater level when they are endurance trained) as young men, since no orthopedic injuries, muscle damage or major muscle pain were observed using resistance exercise protocol and criteria for increasing the exercise intensity standardized for all subjects.

To the best of our knowledge, this study is the first investigation to compare the exercise intensity progression between young and older men. The present findings are in line with a previous study of our group which reported that healthy older women without previous training can exercise safely and increase their resistance exercise intensity similar to young women [7]. Other studies have also demonstrated that healthy as well as frail elderly individuals do not show major orthopedic injuries or muscle damage when performing resistance exercises at the same intensity recommended for young adults [9, 13, 15, 18, 20, 21, 25]

A recent review suggested that healthy older adults may exercise at similar volume and intensity as recommended for healthy young adults, however information about how exercise intensity should be increased was not provided [10]. Our findings support the above recommendation and suggest that healthy older men can safely exercise at similar intensity and increase intensity as recommended for healthy young men.

The 1-RM strength improvement shown in this study was unaffected by age, with strength gains from 17.4 to 37.6% for the young sedentary, 18.7 to 39.8% for the older sedentary and 22.5 to 31.8% for the older male runners in all nine movements tested. Strength gains in the sedentary and older runners matched pre-training strength levels in the young men. In agreement with our

Fig. 1 Relative workload increase curves. †: Different from young sedentary and older sedentary groups (P<0.05). ◊: Different from young sedentary group (P<0.05).

findings, other studies analyzing age effects on muscle strength gain in response to resistance training demonstrated improvements of 17 to 49%, with no differences between young and older adults, and with post-training strength in older reaching the pre-training levels of young individuals [7,15,20]. It is important to emphasize that older runners displayed a higher relative workload increase than sedentary older and young men in six and seven exercises performed, respectively. These increases resulted in a greater relative workload used by older runners in the last exercise session (see results). A possible explanation for this greater adaptation observed in the older runner may be a lesser metabolic disturbance and an up-regulation of mechanisms that protect muscle tissue from oxidative and mechanical damage [27,29].

Experimental studies have shown slower muscle fiber repair/regeneration in older vs. young adult animals [8,16,28], and a remodeling study showed increased muscle damage after a high-intensity resistance training in older compared with young women [23]. In the present study, we used a 2 days/wk moderate volume (2 sets of resistance and 20 min of aerobic exercise).

In the present study, we used a 2 days/wk moderate volume (2 sets of resistance and 20 min of aerobic exercise). A higher relative workload increase than sedentary older and young adults, and with post-training strength in older reaching the pre-training levels of young individuals [7,15,20].

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References