AGE DOES NOT AFFECT EXERCISE INTENSITY PROGRESSION AMONG WOMEN

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ABSTRACT

Ciolac, EG, Brech, GC, and Greve, JMD. Age does not affect exercise intensity progression among women. J Strength Cond Res 24(11): 3023–3031, 2010—It has been recommended that the intensity of exercise training (ET) should progress slowly with lower increments in older than in young people. However, scientific evidence supporting this recommendation is lacking. Our aim was to examine possible influences of age on exercise intensity progression in healthy women. Seventeen young (29.1 ± 5.7 years) and 16 older women (64.5 ± 4.5 years) underwent 13 weeks of ET consisting of cycle ergometry (CE, 65–75% of reserve heart rate), whole-body resistance exercise (RE, 60% of 1 repetition maximum [1RM]), and stretching. Muscle strength was assessed before and after ET by the 1RM. Cycle ergometry and RE workloads were recorded for each exercise session, and increases of 5–10% were made whenever adaptation occurred. Absolute muscle strength after ET improved (p < 0.001) in both groups, and there were no significant differences between groups. Relative exercise intensity progression was not significantly different between groups for RE (Pearson’s correlation = 0.98 ± 0.01), but it was greater in older women for CE (p = 0.047). The ET was safe because no injuries or major muscle pain was observed in either group. These results suggest that healthy older women are capable of exercising and increasing exercise intensity in the same way as young women.

KEY WORDS aging, aerobic endurance, muscle strength, older

INTRODUCTION

Regular participation in physical activity or exercise programs can minimize the changes associated with typical aging in sedentary society and may contribute toward psychological health and well-being (1,8,11). Physical exercise programs improve muscle strength (1,8,11,14), balance (19,23), aerobic capacity (17), metabolism (27), glucose tolerance (22), activities of daily living (31), and psychological health (32) in older people including those frail and in their eighties and nineties (6,10).

Exercise recommendations for older and young people include aerobic, resistance, and stretching exercises, but there are some differences between the 2 age groups (1,3,11). The primary difference relates to progression of exercise intensity; it is emphasized that it should increase slowly and at a lower rate of progression in older than in young people (1,3,11). On the other hand, aging has been shown not affect the ability to improve physical capacity through exercise training (ET) (1). Aerobic and resistance training can safely improve aerobic capacity and muscle strength in older people in the same way or to a greater extent than in young people (1,6,10,14,28). However, no data are available regarding exercise intensity progression in older people. Thus, it is difficult to know whether older populations, even when healthy, can safely increase their exercise intensity as in young people.

The world elderly population is expected to double by the year 2025. Low levels of physical conditioning can have significant negative impact on health, quality of life, and independence of older people (1,8,25). The loss of muscle mass with advancing age (sarcopenia) is associated with a decline in functional abilities and health status (8,11). On the other hand, ET has been shown to reverse this process in both older men and women (1,8,11). Therefore, based on these studies, it is imperative to know the capacity of older persons to increase their exercise intensity. A knowledge of whether older adults are capable of exercising and progressing at the same intensity as young adults could help in designing more efficient exercise programs to optimize health- and fitness-related outcomes.

The aim of the present study was to compare exercise intensity progression and muscle strength response in older and young women undergoing an ET program. We
hypothesized that healthy older women may safely increase exercise intensity and muscle strength in the same way as healthy young women.

**METHODS**

**Experimental Approach to the Problem**

The study used a 2-group repeated-measures design. All volunteers had their muscle strength tested (of all muscle groups trained), before and after the 13 weeks of ET. The ET workload was monitored and recorded at each session, to measure the exercise intensity progression throughout the study period. The exercise sessions consisted of aerobic, resistance, and stretching exercises. This study was approved by the local ethics committee for research protocols analysis. All volunteers read a detailed description of the protocol and provided their written informed consent.

**Subjects**

The study population consisted of 33 physically inactive women, divided into a young group (YG; 20–35 years) and older group (OG; 61–75 years), 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, School of Medicine, University of São Paulo.

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 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. Smokers and subjects taking any drug that could potentially influence the cardiovascular response to exercise (e.g., β-blockers) were also excluded from the study. A symptom limited cardiopulmonary exercise testing was carried out to further rule out the presence of any coronary artery disease and to determine their initial aerobic exercise workload. Only those women who had not been practicing regular physical activity during the 12 months preceding the study were allowed to participate. During the follow-up, women that did not complete at least 75% of the exercise sessions or had more than 3 consecutive absences during the training period were also excluded from the study.

In all, 45 volunteers were screened (23 young), but only 38 women (20 young) were found to be eligible. The reasons for ineligibility included chronic low-back pain (1 young), coronary artery disease (1 older), knee osteoarthritis (2 older) or arthroplasty (1 older), and currently physically active (2 young). Of all the eligible volunteers, 3 young and 2 older women did not complete the 13 weeks of follow-up for reasons that were not related to the exercise program and were thus not included in the analysis.

The demographic characteristics of YG and OG included in the study are summarized in Table 1. Lower levels of body mass index and waist circumference, and higher levels of cardiorespiratory fitness were observed in the YG. None of the YG women were taking any medications. In the OG, some were taking diuretics (n = 6), angiotensin-converting enzyme inhibitors (n = 3) or metformin (n = 2), to control arterial hypertension or type-2 diabetes, respectively.

**Strength Test**

To determine muscle strength and the initial workload for each resistance exercise (RE), the 1 repetition maximum (1RM) test was performed after 4 familiarization bouts and 2–5 days after the last exercise session. The familiarization consisted of completing the RE program with little or no workload, with the subjects being instructed about proper warm-up, stretching, and exercise techniques to avoid strength gains because of motor learning and to reduce the risk of injury. The 1RM 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 resistance training machines and free-weight dumbbells that were used for training.

After proper warm-up, 1RM tests were performed in the

<table>
<thead>
<tr>
<th>Table 1. Subjects’ characteristics of both groups at the beginning of the study.*†</th>
<th>Young group</th>
<th>Older group</th>
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<tbody>
<tr>
<td>Characteristics</td>
<td></td>
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<tr>
<td>N</td>
<td>17</td>
<td>16</td>
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<tr>
<td>Age (y)</td>
<td>29.1 ± 5.7</td>
<td>64.5 ± 4.5</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>23 ± 3.9</td>
<td>26.7 ± 4.5‡</td>
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<tr>
<td>Waist circumference (cm)</td>
<td>80.5 ± 8.7</td>
<td>94 ± 10.6§</td>
</tr>
<tr>
<td>Exercise test</td>
<td></td>
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<tr>
<td>Peak speed (km·h⁻¹)</td>
<td>11.3 ± 0.79</td>
<td>8.4 ± 1.5§</td>
</tr>
<tr>
<td>Time to exhaustion (min)</td>
<td>10.69 ± 0.99</td>
<td>7.53 ± 2.02§</td>
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*Values are given as mean ± SD.
†Significantly different from the young group (p < 0.05).
‡Significantly different from the young group (p ≤ 0.001).
exercise order described above. The 1RM 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 1RM tests were conducted by the same investigator before and after the ET period, paying special attention to consistency of the machine adjustment, body position, isolation of targeted muscle groups, use of Valsalva maneuver, and level of vocal encouragement. In our laboratory, the intraclass correlation for 1RM test–retest measures were 0.983 (95% confidence interval = 0.964–0.997).

**Exercise Program**

The ET program, designed to develop aerobic capacity, muscle mass and strength, and flexibility, was performed twice a week for 13 weeks. Each exercise session was monitored by an exercise specialist and lasted for approximately 70 minutes.

Aerobic exercise was performed at the beginning of each exercise session and consisted of 20 minutes of cycle ergometer at 65–75% of reserve heart rate (RHR). The RHR was calculated as the difference between peak and resting heart rate (HR), multiplied by the intensity of the exercise and summed with the resting HR, in accordance with the Karvonen method (15). Peak and resting HR were obtained from the graded exercise test. The subject's HR was controlled during each exercise session.

The RE consisted of 2 sets of 8–12 repetitions each, of the same 9 exercises described in the 1RM test. The initial workload for the RE was 60% of 1RM, and subjects were encouraged to perform the maximum they could during the
Exercise Intensity Progression among Women

| Table 2. Muscle strength increase after 13 weeks of exercise training.* |
|--------------------------|--------------------------|
| Exercise             | Young group (n = 17)     | Older group (n = 16)     |
| Bench press           | 31.5 ± 8.3               | 33.9 ± 9.7               |
| Leg press             | 17.2 ± 6.5               | 19.9 ± 8.2               |
| Seated row            | 23.7 ± 7.7               | 20.1 ± 9.3               |
| Knee curl             | 27.8 ± 9.9               | 41.9 ± 16.6†             |
| Shoulder press        | 36.4 ± 10.3              | 31.0 ± 12.2              |
| Calf raise            | 30.5 ± 10.3              | 27.1 ± 9.0               |
| Triceps              | 29.7 ± 7.5               | 34.3 ± 10.6              |
| Biceps curl           | 16.7 ± 6.4               | 16.1 ± 8.3               |
| Abdominal            | 29.7 ± 10.0              | 29.6 ± 9.4               |

*Values are given as mean ± SD(%).†Tendency to be different from the young group (p = 0.07).

sets of 8–12 repetitions prescribed, with proper form and avoiding Valsalva maneuver. All subjects were instructed to take a 30- to 60-seconds rest between sets.

Stretching consisted of 10 exercises designed to target major muscle groups, were performed between the aerobic and REs and at the end of each exercise session. The subjects were instructed to reach the maximum range of motion and sustain it for 20 seconds.

Exercise Intensity Progression

To promote sufficient workload to produce improvements throughout the 13 weeks of training, the exercise intensity of the aerobic and REs was increased by 5% and 1–5 kg (5–10%) in the cycle ergometer and RE, respectively, whenever the subjects had adapted to the exercise workload. Aerobic exercise adaptation was considered as achieved when the exercise HR was less than 65% of the subjects’ RHR for 1 exercise session. Resistance exercise adaptation was considered as achieved when 2 sets of 12 repetitions with the proper form and avoiding Valsalva maneuver were performed for 2 consecutive exercise sessions.

Statistical Analyses

All data are reported as mean ± SD. Statistical program SPSS 12.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Kolmogorov–Smirnov test was applied to ensure a Gaussian distribution of the results. Student’s t test was used to analyze the differences in subjects’ characteristics at baseline. Two-way ANOVA (group vs. time) with repeated measurements was used to analyze the IRM strength test data. Bonferroni post hoc analysis was used to determine significant data that was indicated by 2-way ANOVA. Unpaired t test was used to compare the postexercise muscle strength improvements and exercise intensity progression between groups. Pearson’s correlation test was used to analyze the curves of exercise intensity progression between groups. The significance level was set at p ≤ 0.05.

RESULTS

Physical Capacity

Pre and postexercise muscle strength was lower in OG than in YG (Figure 1). Thirteen weeks of ET promoted a 15–38% increase in the IRM test, with no significant differences between the YG and OG, except for a tendency (p = 0.07) to a greater increase in the knee curl IRM test for the OG (Table 2). These increases were enough for the OG to show postexercise muscle strength similar to the YG pre-exercise muscle strength.

Although the maximum graded exercise test was not performed after the ET, the differences between the cycle-ergometer workloads from the first and last exercise sessions may be indicative of endurance improvement. A significantly greater workload increase in the OG than in the YG (71.7 ± 36.8% vs. 49.3 ± 21.1%; p = 0.05) was observed.

Exercise Intensity Progression

Because the OG showed lower physical capacity at baseline, they started the ET program with lower absolute workload in almost all exercises (kg and W for resistance and aerobic exercise, respectively), although the initial relative workload was the same for both groups (60% of IRM and 65–75% of RHR for resistance and aerobic exercise, respectively). Only the biceps curl exercise did not show significant difference in the initial absolute ET workload.

Despite the lower physical capacity of the OG, absolute workload increases were not significantly different between OG and YG with regard to leg press, seated row, knee curl, biceps curl, or cycle-ergometer exercise during the 13 weeks of training. The YG displayed higher absolute workload increase only for the bench press (p = 0.005), shoulder press (p = 0.008), calf raise (p = 0.001), and abdominal (p = 0.003). A tendency toward a higher absolute workload increase for the triceps push-down (p = 0.06) was also observed in the YG (Figure 2).

The RE relative workload increase was not significantly different between YG and OG during the training period,
Figure 2. Absolute workload increase curves for aerobic and resistance exercises. *Workload increase value in watts. †Tendency to be different from the younger group ($p = 0.06$). ††Significantly different from younger group ($p < 0.01$).
Figure 3. Relative workload increase curves for aerobic and resistance exercises. †Tendency to be different from younger group (p = 0.061). ††Significantly different from the younger group (p = 0.047).
except for a tendency ($p = 0.06$) toward a greater increase in shoulder press relative workload in the YG. The increase in cycle-ergometer relative workload was different ($p = 0.047$) between groups, with OG displaying a greater increase during the 13 weeks of training (Figure 3).

The exercise intensity progression method used in this study was found to be safe because no injuries, muscle damage or major muscle pain were observed in the YG and OG during the study period.

**Discussion**

The primary finding of this study was that the relative exercise intensity progression was similar in healthy young and older women during 13 weeks of training. Furthermore, our exercise program also promoted improvements in muscle strength and aerobic capacity that were similar between the 2 groups.

Although exercise recommendations for both young and older people include aerobic, resistance and stretching exercises (12,4,12), generally it has been suggested that older people begin ET at lower intensity than young people. The RE recommendations for older people are to perform 1–3 sets of 10–15 repetitions for 2–3 d wk$^{-1}$, whereas for young adults, they include 1–3 sets of 8–12 repetitions at greater workload (4,12). Moreover, 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 time to adaptation (3,4,12). However, our findings do not support this recommendation. In the present study, young and older women started ET at the same relative intensity as recommended for young women (2,4,12), although the absolute workload was greater in aerobic and 6 REs. In addition, the relative workload increase curves were not significantly different between the young and older women during the training period. The present study further suggests that healthy older women can safely perform and progress through physical exercises at the same level as the young women, because no orthopedic injuries, muscle damage or major muscle pain were observed using physical exercise protocol and criteria for increasing the exercise intensity standardized for all subjects.

To the best of our knowledge, this study is the first in comparing the exercise intensity progression between young and older women. However, other studies have also demonstrated that healthy and frail elderly individuals do not show major orthopedic injuries or muscle damage when performing REs at the same intensity recommended for young adults (10,13,16,24,29). 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 (11). Our findings support the above recommendation and suggest that healthy older women can safely exercise at similar intensity and increase intensity as recommended for healthy young women.

The 1RM strength improvement shown in this study was unaffected by age, with strength gains from 16.7 to 36.4% for the young and 16.1 to 41.9% for the older women in all 9 movements tested. Strength gains in the older women matched pretraining strength levels in the young women. In agreement with our findings, other studies analyzing age effects on muscle strength gain in response to resistance training demonstrated 17–49%, improvements with no differences between young and older adults, and with postraining strength in older reaching the pretraining levels of young individuals (16,18,24).

It is important to emphasize that the relative workload increase curve for aerobic exercise was greater for OG than YG. There are at least 2 hypotheses that explain this finding. First, OG could acquire increased biomechanical efficiency during training period. Oxygen uptake and cardiovascular response to exercise correlates with biomechanical efficiency and the quantity of muscle recruited (7,26). Poor cycle ergometry (CE) and neuromuscular recruitment at the beginning of the study, because of the longer periods of physical inactivity (11), could yield greater cardiovascular response to exercise in older women; thus, a greater improvement in the neuromuscular recruitment in older women may occur during the training period and likely resulting in the increased cardiovascular adaptation to the CE observed in OG.

The second hypothesis is based on the blood lactate response to exercise. It has been shown that maximum steady-state lactate levels decline with aging (21). On the other hand, it is known that aerobic ET performed at higher blood lactate levels is associated with greater improvements in aerobic performance (5,34). According to this, older women probably exercised closer to the maximum steady-state lactate than the young women, and this may have promoted a faster cardiovascular adaptation to the CE.

Experimental studies have shown slower muscle fiber repair or regeneration in older vs. young adult animals (9,20,33). A clinical study showed increased muscle damage after a high-intensity resistance training in older compared with young women (29). In the present study, we used a 2 d wk$^{-1}$ moderate volume (2 sets of resistance and 20 minutes of aerobic exercise). Thus, it is possible that the similar exercise intensity progression between young and older women found in the present study was influenced by the volume and frequency of the exercise program. It is however not known whether these results would be observed with greater volume and frequency of training. Further investigations addressing this issue are necessary.

An important limitation of this study was the inclusion of only older women without orthopedic or cardiovascular limitations to exercise, although some of them displayed well-controlled arterial hypertension and type-2 diabetes. This limitation makes it difficult to extrapolate present findings for older women with

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other limitations or poorly controlled chronic diseases, especially chronic orthopedic diseases. Thus, other studies for evaluating exercise intensity progression among physically limited older adults become necessary.

In summary, this study suggests that healthy older women without previous training can exercise safely and increase their resistance and aerobic exercise intensity similar to young women. This similar exercise intensity and workload progression does not promoted greater risk of injuries, muscle damage or cardiovascular incidence in our study population. The study further suggests that age does not affect musculoskeletal and cardiovascular response to resistance and aerobic training in women. In this regard, this study underscores the role of resistance and aerobic ET on reverting the musculoskeletal system and cardiovascular function that changes that are associated with typical aging in a sedentary society.

**PRACTICAL APPLICATIONS**

Loss of physical condition associated with inactivity because of aging, particularly the decreases in musculoskeletal function and muscle mass (sarcopenia), may lead to functional impairment and physical disability (8,30), and increased rates of cardiovascular and metabolic diseases (11,25). Resistance and aerobic training improves body fat, muscle mass, and strength, and demonstrates a potential role in the prevention of diabetes, functional dependency, chronic diseases, falls, and fractures in older subjects (8,11,19,23). However, it has been generally suggested that exercise intensity progression for healthy older adults should be slow and with lower increases than for young adults to prevent injuries and muscle damage because of a greater adaptation (3,4). Our data do not support this recommendation, instead suggesting that healthy older women can exercise and make exercise progression at the same intensity as young women. Information about what exercise intensity older adults can really tolerate, and how it can progress to avoid ET plateau, is imperative for prescribing more efficient exercise programs that may optimize health- and fitness-related outcomes outlined above. Results of our study were obtained using ET progression models in resistance training.

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**REFERENCES**


