Experimental Gerontology 97 (2017) 80–88

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

Effect of resistance training volume on walking speed performance in postmenopausal women: A randomized controlled trial

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ARTICLE INFO

Section Editor: Emanuele Marzetti

Keywords:
Aging
Gait speed
Weight lifting
Abdominal fat

ABSTRACT

Low muscle strength and high abdominal fatness play an important role in fast and usual walking speeds decrement in postmenopausal women (PW). Low-volume resistance training (RT) improves muscle strength. However, high-volume RT has shown to improve muscle strength and abdominal fatness in PW. Thus, high-volume RT would elicit greater improvement in fast and usual walking speeds than low-volume RT.

Objective: To confirm whether the high-volume RT is better than the low-volume RT, we performed a randomized controlled trial (clinical trial registration: RBR-8SBBVP) study to investigated the effects of two different RT volumes (three sets vs. six sets) on fast and usual walking speed performances (fast: one-mile walk test and usual: four-meter walk), muscle strength (1 RM test), and abdominal fatness (WC – waist circumference; WC/W waist circumference-to-weight ratio; WHtR – waist-to-height ratio; ABSI – A body shape index; BRI – body roundness index; CI – conicity index) in PW.

Methods: Thirty-three PW were randomized (simple randomization) in three groups: control group (CT – no exercise), low-volume RT (LV) and high-volume RT (HV). The RT consisted of eight total body exercises at 70% of one repetition maximum for 16 weeks performed three times a week.

Results: The fast walking speed (6.1% [CI 95% 2.3–9.9]), WC (− 4.1% [CI 95% − 6.9 to − 1.4]), WHtR (− 4.2% [CI 95% − 7.0 to − 1.4]) and BRI (− 10.3% [CI 95% − 17.3 to − 3.4]) improved in the HV when compared to the LV and CT. The WC/W (− 3.7% [CI 95% − 6.5 to − 0.93]), ABSI (− 3.8% [CI 95% − 6.5 to − 1.2]) and CI (− 3.9% [CI 95% − 6.6 to − 1.3]) improved in the HV when compared to the CT. Muscle strength improved similarly in trained groups (LV: 49.1% [CI 95% 42.5–55.6] and HV: 43.7% [CI 95% 33.0–54.5]) when compared with the CT. No differences were observed in usual walking speed.

Conclusion: Our results suggest that high-volume RT (six sets) at 70% of 1 RM is necessary to promote an improved fast walking speed performance and abdominal fatness in PW.

1. Introduction

Menopause period is accompanied by increased levels of body fatness, particularly at the abdomen, and progressive reduction in muscle strength and fast and usual walking speed (LaRoche et al., 2011; McLeod et al., 2016; Sirola and Rikkonen, 2005; Straight et al., 2015). Fast and usual walking speeds are a simple, reliable, and valid measure of physical performance (Cruz-Jentoft et al., 2010; Dobkin, 2006). Fast and usual walking speeds have been shown to be strongly correlated with falls, hospitalizations, cardio and cerebrovascular diseases and mortality in older adults (Guralnik et al., 1995; McGinn et al., 2008). According to the disablement model, impairment (e.g. loss or abnormality of the muscle tissue) precedes the functional limitation and disability (Buchner et al., 1996; Rantanen et al., 1999; Reid and Fielding, 2012). Thus, low maximum muscle strength is established as an early determinant of reduced fast and usual walking speed performances and disability (Buchner et al., 1996; Clark and Manini, 2012; Rantanen et al., 1999; Rantanen et al., 2001; Reid and Fielding, 2012). However, greater levels of body fatness are predictive of declines in fast and usual walking speed performances in older adults, particularly in older women (PW) (Bouchard et al., 2007; Chen and Guo, 2008; LaRoche et al., 2011; Straight et al., 2015; Tseng et al., 2013; Vincent et al., 2010). Interestingly, previous studies have demonstrated that older women have significantly greater fat mass and lesser lean mass,

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http://dx.doi.org/10.1016/j.exger.2017.08.011
Received 12 May 2017; Received in revised form 4 August 2017; Accepted 8 August 2017
Available online 10 August 2017
0531-5565/

lower leg extension power, lesser muscle quality, and slower fast and usual walking speeds compared with older men (Bouchard et al., 2007; Straight et al., 2015). As the change in body composition commonly occur concomitantly with the change muscle strength after menopause period, there is an interaction between low muscle strength and excess of body fatness on physical function performance (e.g. fast and usual walking speeds) (LaRoche et al., 2011; Straight et al., 2015). This interaction may be due, at least in part, to the fact that the capacity of body musculature to transfer body weight (i.e. walk) is affected by low muscle strength (Clark and Manini, 2012) and also by body fat excess (i.e. abdominal fatness excess), such as an interaction strength-to-weight (i.e. abdominal fat weight) ratio (Bouchard and Janssen, 2009; LaRoche et al., 2011; Straight et al., 2015). For these reasons, it is possible that intervention strategies that increase muscle strength and reduce body fatness (i.e. abdominal fatness) concomitantly are more efficient to improve walking speed than interventions that aim solely to increase muscle strength in PW.

The American College of Sports Medicine (ACSM) recommends resistance training (RT) to improve muscle mass and function. It is assumed that a RT protocol with one-three sets of 8–15 repetitions at 60–80% of one repetition maximum (1 RM), two-three times a week and eight to ten exercises is necessary to induce significant increases in muscle strength and mass and fast and usual walking speeds (American College of Sports, 2009). To the authors' knowledge, one study conducted in older subjects has compared fast and usual walking speed gains when the subjects performed one versus three sets RT (> 75% of 1 RM; two times a week) (Galvao and Taaffe, 2005). Galvao and Taaffe (2005) demonstrated that the three-set RT protocol improved more the fast walking speed performance and muscle strength than single-set RT protocol (Galvao and Taaffe, 2005). Although no difference was observed in body fatness in this study, the results indicate a dose-response of RT volume for walking speed in older people due to muscle strength improvements.

It has been consistently demonstrated that RT protocol (three sets, > 75% of 1 RM and two-three times a week) exhibits modest to no effect on indicators of obesity in PW (Brochu et al., 2009; Maesta et al., 2007; Phillips et al., 2012; Sénéchal et al., 2012), probably due to the low energy expenditure of recommended RT (American College of Sports et al., 2009; Haddock and Wilkin, 2006; Orsatti et al., 2014; Phillips and Ziuraitis, 2004). Hence, we have demonstrated recently that is necessary a higher RT volume (i.e. six sets) than the recommended RT (i.e. three sets) to reduce abdominal fatness in PW (Nunes et al., 2016). Thus, due to an interaction strength-to-abdominal fat on walking speed, it would seem reasonable to assume that high volume RT (i.e. six set) is more efficient to improve walking speed than low volume RT (i.e. three sets). However, no studies have compared the effect of RT volume beyond three sets on walking speed performances (fast and usual) in PW.

In our view, the efficacy of a high-volume RT protocol should be measured by the high-volume RT protocol's ability to improve physical function. This can be done by comparing the effect of high-volume RT protocol with the effect of the protocol recommended by ACSM (three-set protocol) and of a control group (no exercise). Therefore, to confirm whether the high-volume RT (i.e. six sets) protocol is better than the low-volume RT (i.e. three-set), we performed a randomized controlled trial (RCT) study to investigated the effects of two different RT volumes (three sets vs. six sets) on fast and usual walking speed performances, muscle strength, and abdominal fatness in PW. We hypothesized that the six-set RT protocol would elicit greater improvement in fast and usual walking speed performances due to reducing in abdominal fatness when compared to the three-set RT protocol.

2. Methods

2.1. Study design

This study was conducted to evaluate the effect (16 weeks) of RT volume on fast and usual walking speed performances in PW. Therefore, a randomized, controlled and parallel study (trial registration: RBR-8SBBVP, http://www.ensaiosclinicos.gov.br) was performed. Before the study began, the sample size required for a statistical power of 80% was calculated based on the meaningful fast and usual walking speed performances outcome (RT vs. control group) from a previous study (Hortobágyi et al., 2015). Thus, improvements of 0.1 m/s (meaningful walking speed performances) (Hortobágyi et al., 2015) would be detected with nine women per group. However, our sample size was increased to about 35% per group at the beginning of the intervention due to possible participants lost to follow-up. The groups were randomized on a single sequence (simple randomization) of random assignments by the same examiner after the completion of the inclusion criteria. Before the study began and during the follow-up, the groups were unknown to each other. All outcomes were assessed at the baseline and at the end of the RT intervention. First, the secondary outcomes were assessed in the following order: nutritional (questionnaire), body composition (anthropometric evaluation), physical functioning test (SPPB) and maximum strength (1 RM test/body weight ratio). Afterward, the primary outcomes (the usual and fast walking speed performances) were assessed with the four-meter walk test and the one-mile track walk test. The sample consisted of 33 PW divided into three groups: control (CT, $n = 11$), low volume (LV, $n = 10$) and high volume (HV, $n = 12$). The LV group performed a total body RT protocol (eight exercises) with three sets of 8–12 repetitions at 70% 1 RM with a 1.5-minute rest interval between sets and exercises, three times a week. The HV group performed the same RT as the LV group, except for the number of sets that were six. The total training volume was calculated by multiplying the load by sets by repetitions. The CT group did not participate in the RT routine; they only did stretching exercises twice a week. After the RT period, the assessments were performed 72 h after the last session of training to avoid workout side effects.

2.2. Subjects

All the volunteers were housewives and reported no history of physical training practice prior to the study and aged between 50 and 79 years old whose amenorrhea had occurred at least 12 months prior to the study and were selected at a neighborhood association near the local University. Basal follicle-stimulating hormone (FSH) and basal estradiol (E_2) values were > 40 mIU/mL and ≤ 54.7 pg/mL, respectively, to determine the menopause status. The inclusion criteria consisted of: no hormone therapy or phytoestrogens; controlled blood pressure and glycemia; absence of myopathies, arthropathies, and neuropathies; absence of muscle, thromboembolic and gastrointestinal disorders; absence of cardiovascular and infection; non-drinker (no alcohol intake whatsoever in their diet) and non-smoker. Prior to the study, basal thyroid stimulator hormone (TSH) and basal free thyroxine (T4) levels were measured to exclude thyroid dysfunctions that could interfere with the symptoms. A CONSORT diagram is shown in Fig. 1. Thus, the 33 volunteers who participated in the study demonstrated E_2 and FSH values within the normal range for PW (Table 1).

All PW were clear on the objectives and procedures of the study and gave us their written informed consent. The study was approved by the University Review Board for the Use of Human Subjects (local Ethics Committee) and was written in accordance with the standards set by the Declaration of Helsinki.

2.3. Nutritional assessments

All women were submitted to a three-day food record (two days in the middle of a week and one on the weekend) (Thompson and Byers, 1994). Energy and macronutrients (carbohydrates, proteins, and fats) were quantified. Macronutrients data were corrected for body weight to reduce the inter-individual differences. Data were calculated by a software “Dietpro” 5i version. The women were advised to maintain the