Archives of Gerontology and Geriatrics 68 (2017) 106–112

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

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

# Are resistance and aerobic exercise training equally effective at improving knee muscle strength and balance in older women?

Elisa A. Marques[a,b,*], Pedro Figueiredo[b,c], Tamara B. Harris[a], Flávia A. Wanderley[d], Joana Carvalho[e]

[a] National Institute on Aging, Intramural Research Program, Laboratory of Epidemiology and Population Sciences, Bethesda, MD, USA
[b] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, ISMAI, Portugal
[c] Department of Kinesiology, University of Maryland, College Park, USA
[d] Alagoas State University of Health Sciences– UNCISAL, Maceió, Brazil
[e] Research Centre in Physical Activity, Health and Leisure, CIAFEL, Faculty of Sport, University of Porto, Portugal

ARTICLE INFO

*Article history:*
Received 10 August 2016
Received in revised form 28 September 2016
Accepted 4 October 2016
Available online 11 October 2016

*Keywords:*
Muscle strength
Isokinetics
Postural control
Endurance training
Aging

ABSTRACT

This study aimed to compare the magnitude of knee muscle strength and static and dynamic balance change in response to 8 months of progressive RE and AE training in healthy community-dwelling older women. A secondary aim was to assess the relationship between muscle strength and balance changes (up and go test (UGT), one-leg stance test, and center of pressure measures). This study was a secondary analysis of longitudinal data from a randomized controlled trial, a three-arm intervention study in older women (n = 71, mean age 69.0 y). The results suggest that both interventions elicited *likely* to *almost certain* improvements (using magnitude-based inference) in balance performance. Leg strength was improved after RE whereas it was *unclear* following AE. Improvements in strength were *almost certainly moderate* after RE and *possibly trivial* after AE, with *very likely* greater improvements following RE compared to AE. A large and significant negative correlation (r = -0.5; CI 90%: −0.7 to −0.2) was found between ΔUGT and change in both knee extension and knee flexion strength after 8-month RE. In conclusion, our results showed that both types of training improve balance, but RE was also effective at improving leg strength. In addition, improvements in both knee extension and flexion strength after RE appear to make an important contribution to meaningful improvements in static and dynamic balance.


## 1. Introduction

Increase or at least maintenance of capacity above the threshold risk for falls is central to prevent serious fall injuries such as hip fractures that often result in long-term functional impairment, nursing home admission and increased mortality (Marks, Allegrante, Ronald MacKenzie, & Lane,2003). Extensive literature has suggested that lower extremity weakness and balance impairment are associated with an increased risk of falls (Moreland, Richardson, Goldsmith, & Clase, 2004), mobility limitations (Donoghue, Savva, Cronin, Kenny, & Horgan, 2014; Visser et al., 2005), and hospitalizations (Cawthon et al., 2009). Thus, researchers and clinicians are interested in identifying the best exercise programme that is effective in decreasing fall risk. Epidemiological studies have provided the hypotheses for subsequent interventional studies that have documented the efficacy of exercise interventions to prevent falls (Gillespie et al., 2012) and improve balance (Howe, Rochester, Neil, Skelton, & Ballinger, 2011). Among the general population of community-dwelling older adults, aerobic exercise (AE) training and resistance exercise (RE) training are commonly prescribed and widely accepted, based on the variety of favourable adaptations that AE and RE as single interventions can elicit in older adults (Chodzko-Zajko et al., 2009). Although balance improvements may occur after long-term exercise interventions, the physiological mechanisms associated with balance improvement may vary between different types of exercise, such as AE and RE. Epidemiological studies have shown that low muscle strength or age-related sarcopenia are associated with impaired balance control in older adults (Bijlsma et al., 2013; Orr, 2010). Thus, exercise training without a specific balance component may be effective in improving balance control due to a direct influence on muscle mass and strength. Considering the obvious specificity of RE to activate muscle skeletal contraction

* Corresponding author at: National Institute on Aging, National Institutes of Health, 7201 Wisconsin Avenue, Gateway Building, Suite 2N212, Bethesda, MD 20892−9205, USA.
*E-mail address:* elisa.marques@nih.gov (E.A. Marques).

http://dx.doi.org/10.1016/j.archger.2016.10.002
0167-4943/

and hypertrophy compared with AE, it is reasonable to expect a different influence of muscle strength change in balance improvements after RE and AE interventions. On the other hand, the benefits of strength may not transfer effectively to concomitant improvements in functional outcomes such as balance, functional tasks, or activities of daily living (Granacher, Gollhofer, Hortobagyi, Kressig, & Muehlbauer, 2013). The contradictory evidence may be due to differences in training intensity, frequency, type of resistance training, equipment (such as free weights, resistance machines, or elastic bands), and types of measurements Recently we investigated the effects of RE and AE on strength and balance in older women (Marques et al., 2011), but consistent with other studies (Alfieri et al., 2012; Orr et al., 2006) the relationship between change in strength and the change in balance was not investigated. Moreover, recent reports have emphasized the importance of using alternative statistical measures for data interpretation, instead of focusing on the P value (Halsey, Curran-Everett, Vowler, & Drummond, 2015). Specifically, when interpreting intervention-balance studies an approach for determining meaningful changes such as effect size estimates and their precision (confidence intervals) should be considered (Halsey et al., 2015; Hopkins, Marshall, Batterham, & Hanin, 2009). Thus, the aims of this study were to describe the magnitude of balance and strength changes after RE and AE interventions, and to examine the relation between muscle strength and balance changes after 8 months of training.

## 2. Methods

### 2.1. Data source

We used data from an 8-month randomized controlled trial examining the effects of RE and AE on physical function, bone mineral density, osteoprotegerin (OPG) and receptor activator of NF-κB ligand (RANKL). On completion of initial screening 71 sedentary older women aged 61 to 83 years were randomly assigned to one of three study arms: RE (n = 23), AE (n = 24), and wait-list control group (CON, n = 24). The study design, protocol, inclusion and exclusion criteria, the contents of RE and AE interventions, baseline characteristics of the subjects, and the primary outcomes were described in detail elsewhere (Marques et al., 2011). Briefly, exercise sessions were performed on nonconsecutive days, 3 days per week, and each session lasted approximately 60 min (including a dynamic warm-up (~10 min) specific (resistance or aerobic) training period (~40 min), and cool-down (~5 min) over a period of 32 weeks. The RE protocol aimed to develop muscle mass and strength in the following muscle groups: quadriceps, hamstrings, gluteal, trunk and arms, and abdominal muscles using variable resistance machines (Nautilus Sports/Medical Industries, Independence, VA). The intensity of the training stimulus was initially set at 50% to 60% of one-repetition maximum (1RM), and then progressed to 80% of 1RM. The other exercise group participated in a training programme design to improve aerobic capacity. The exercise intensity was initially set at 50% to 60% of the subject's heart rate reserve for the first two months, and after increased to 85%. All participants provided informed consent, and the study was carried out in full compliance with the Helsinki Declaration. All methods and procedures were approved by the institutional review board.

### 2.2. Measurements

Participants completed a self-report questionnaire and buccal swabs (to obtain DNA for genotyping of the C/T −13910 mutation) (only at baseline) and several procedures and measures including blood draw (to obtain serum for RANKL and OPG assay), anthropometry, body composition, measures of different domains of physical function (muscle strength, static and dynamic balance), accelerometer-measured physical activity, and current diet were assessed at baseline and at the end of the intervention (week 32). A more thorough description of the methodology and primary results has previously been published (Marques et al., 2011). A description of the measures relevant to this manuscript, collected at both occasions, is provided here.

#### 2.2.1. Strength measures

The baseline to 8-month changes in two strength measures were examined as predictors of balance performance improvement: peak torque knee extensor (KE) strength and peak torque knee flexor (KF) strength. Isokinetic knee extensor and flexor strength of the left leg at 60°/s (1.05 rad/s) was measured on an isokinetic dynamometer (Biodex System 4 Pro; Biodex, Shirley, NY) in accordance with the manufacturer's instructions. Each participant, after familiarisation with the equipment, performed three maximal efforts with two minutes of rest between tests.

#### 2.2.2. Outcome measures

Balance was assessed by the same rater, blinded to group assignment, in the same laboratory environment. Dynamic balance was assessed using the up and go test (UGT) and static balance was measured using the one-leg stance test (OLST). Before starting the tests, participants remained seated and rested for five minutes. In the UGT, the score corresponded to the shortest time to rise from a seated position, walk 2.44 m (8 feet), turn, and return to the seated position, measured to the nearest 1/10th s. For the OLST participants stood upright as still as possible in an unassisted unipedal stance (on the nondominant leg) on a 40–60 cm force platform (Force Plate AM 4060-15; Bertec, Columbus, OH) with eyes open, looking straight ahead, and arms by the side of the trunk. Data from horizontal forces (Fy and Fx) and COP time-series were low-pass filtered with a zero-lag, fourth-order Butterworth filter with a cut-off frequency of 10 Hz. The outcome variables were anterior-posterior (AP) and medial-lateral (ML) mean velocity (cm/s) of the COP; the elliptical area (EA) was calculated using the equation: $\sqrt{2\sigma y} \times \sqrt{2\sigma x}$. Mean velocity was determined by dividing the total distance along the signal trajectory by the total recording time. The EA/time ratio was also included in the analysis.

#### 2.2.3. Adjustment variables

Baseline adjustment variables considered for inclusion in our models were age, body mass index (BMI), total lean mass, total percentage body fat mass, and daily physical activity. Height and body mass were taken using standardized procedures and BMI was computed as the ratio mass/height$^2$ (kg/m$^2$). Whole-body DXA (Hologic QDR 4500, software, APEX v3.0 software; Bedford, MA) was used to assess total lean mass and total fat mass as described previously (Marques et al., 2011). A uniaxial accelerometer (ActiGraph GT1 M; ActiGraph, Pensacola, FL), secured with an adjustable belt on the hip was used to measure physical activity time during waking hours for 7 consecutive days as previously described (Marques et al., 2011). The average daily moderate to vigorous physical activity (MVPA) of at least 5 days of valid wear was included as covariates in this study.

### 2.3. Statistical analysis

All data were initially inspected using descriptive statistics and by visually reviewing a graphic display. Descriptive information was reported as means ± standard deviations unless otherwise stated. The absolute change (Δ) was calculated between week 32 and baseline values of all strength-related variables and the outcomes. The results were analysed on an intention-to-treat