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High-speed resistance training is more effective than low-speed resistance training to increase functional capacity and muscle performance in older women

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ABSTRACT

Objective: To examine the effects of 12 weeks of high-speed resistance training (RT) versus low-speed RT on muscle strength [one repetition of maximum leg-press ($1RM_{LP}$) and bench-press ($1RM_{BP}$), plus dominant (HGd) and non-dominant maximum isometric handgrip], power [counter-movement jump (CMJ), ball throwing (BT) and 10-m walking sprint (S10)], functional performance [8-foot up-and-go test (UG) and sit-to-stand test (STS)], and perceived quality of life in older women.

Methods: 45 older women were divided into a high-speed RT group [EG, $n = 15$, $age = 66.3 \pm 3.7$ y], a low-speed RT group [SG, $n = 15$, $age = 68.7 \pm 6.4$ y] and a control group [CG, $n = 15$, $age = 66.7 \pm 4.9$ y]. The SG and EG were submitted to a similar 12-week RT program [3 sets of 8 reps at 40–75% of the one-repetition maximum ($1 < RM$), CMJ and BT] using slow, controlled (3 s) concentric muscle actions for the SG and using fast, explosive (<1 s) concentric muscle actions for the EG (20% less work per exercise without CMJ and BT).

Results: Over the 12-week training period, both RT groups showed small to large clinically significant improvements in the dependent variables; however, a significant difference was found between the EG and SG for the performance changes in BT, S10 and UG (20% vs. 11%, $p < 0.05$; 14% vs. 9%, $p < 0.05$; 18% vs. 10%, $p < 0.01$; respectively). No significant changes were observed for the CG.

Conclusion: Both RT interventions are effective in improving functional capacity, muscle performance and quality of life in older women, although a high-speed RT program induces greater improvements in muscle power and functional capacity.

1. Introduction

Maximal strength in older subjects is associated with the difficulty with which they perform activities of daily living (Ensrud et al., 1994), risk of all-cause mortality (Ruiz et al., 2008) and old-age disability (Rantanen et al., 1999). However, the performance of daily living activities and life-threatening risks, such as falling, that are particularly high in women (Eddy, 1972) may be more closely associated with muscle power than with muscle strength (Cadore and Izquierdo, 2013; Casas-Herrero et al., 2013; Foldvari et al., 2000; Hazell et al., 2007; Skelton et al., 2002; Suzuki et al., 2001), especially in this group (Suzuki et al., 2001). Further, muscle power declines at a faster rate with aging compared to muscle strength (Izquierdo et al., 1999) and older women exhibit lower muscle power levels when compared to older men (Caserotti et al., 2001), suggesting that, especially in older women, interventions with an impact on muscle power should be considered.

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The impact of traditional low-speed RT interventions on muscle power has been questioned (Izquierdo et al., 2001), especially for functional tasks (Keysor and Jette, 2001; Latham et al., 2004). In fact, it has been recommended that resistance training (RT) interventions for older adults should be more focused on muscle power than maximal strength (Porter, 2006). *Unconventional* high-speed RT may be an interesting approach to muscle power development in older women (Sayers, 2007); however, a few studies have led to questions about the impact of this training strategy on muscle strength, power and functional task performance in this age group (Cadore et al., 2014; Marques et al., 2013). Also, although it is relatively well know that exercise has a positive relation to quality of life (Bize et al., 2007; Schuch et al., 2014), relative to menopausal women, the limited evidence precludes a definitive statement. Because a small number of researchers have compared the effects and efficiency of different RT strategies on these variables, with some indicating similar results after low-speed vs. high-speed RT (Henwood et al., 2008; Wallerstein et al., 2012) and others showing higher training-related adaptations with high-speed RT (Katula et al., 2008; Sayers and Gibson, 2010), it is therefore necessary to have a better understanding of muscular, functional and quality of life adaptations in older women submitted to different RT strategies. Thus, the goal of this study was to compare the effects of a 12-week high-speed RT vs. a low-speed traditional RT program on muscle strength, power, ability to perform functional tasks and quality of life. We hypothesized that high-speed RT could be more *efficient* than traditional low-speed RT in promoting significant changes in muscular capacity, functional capacity and quality of life in older women.

2. Methods

2.1. Subjects

Initially, 60 older women of Hispanic descent fulfilled the inclusion criteria to participate in the study. Subjects with similar physical activity levels (Celis-Morales et al., 2012) were recruited. Older women fulfilled the following inclusion criteria: (a) healthy by self-report (i.e. completion of the revised physical activity readiness questionnaire for older adults — Cardinal et al., 1996), (b) free of a history of heart disease, osteoarthritis, severe visual impairment, neurological disease, pulmonary disease requiring the use of oxygen, uncontrolled hypertension, hip fracture or lower extremity joint replacement in the past 6 months and current participation in structured exercise or previous participation in RT in the past 6 months. Before inclusion in the study, all candidates were thoroughly screened by a physician, including assessment of the number of daily medications that the women were taking (3.0 ± 1.4, 3.8 ± 1.9 and 3.4 ± 2.2 for the EG, SG and CG, respectively). Women were randomly divided into three groups: a high-speed resistance training group (EG, n = 20, age = 66.3 ± 3.7 y), a low-speed resistance training group (SG, n = 20, age 68.7 ± 6.4 y) and a control group (CG, n = 20, age = 66.7 ± 4.9 y). To be included in the final analyses, participants were required to complete all of the familiarization sessions, training sessions and tests, which resulted in 45 older women being included for the final analyses. Apart from routine daily tasks, the EG and SG underwent a RT program of 3 sessions per week over 12 weeks. The CG did not undergo any specific type of physical activity. All subjects were carefully informed about the experimental procedures and about the possible risks and benefits associated with participation in the study and signed an informed consent document before any of the tests were performed. The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of the responsible department. The sample size was computed according to the changes observed in peak muscle power performance (d = 423 W; SD = 16) in a group of older adults submitted to the same high-speed RT program applied in this study (Henwood et al., 2008). A statistical power analysis revealed that a total of 8 participants per group would yield a power of 80% and $\alpha = 0.05$.

2.2. Testing procedures

The evaluation process selected protocols that were efficient and that had been previously used in several studies for the assessment of musculoskeletal function in older people (Hakkinen et al., 2000; Pereira et al., 2012a). All testing procedures were applied to both groups before the experimental period (T1) and after 12 weeks of training (T2). The subjects followed a familiarization session of 90 min before testing to reduce the effects of any differences in learning. The standardized tests were completed in two sessions separated by 48 h. The tests were performed at the same location and time and were supervised by the same researchers, before and immediately after the 12-week intervention period. On day 1, the subjects were assessed for body mass, standing height, resting heart rate, menopause-specific quality of life and the functional 8-foot up-and-go test and sit-to-stand test. In the second session, the subjects were assessed for maximum isometric handgrip strength, muscle power (maximum walking velocity, vertical jump and medicine ball throwing performance) and maximum dynamic strength (one-repetition maximum bench press and leg press). All tests were administered in the same order before and after training, with the subjects wearing athletic clothing. All participants were motivated to give their maximum effort during performance measurements.

2.3. Anthropometric and cardiovascular measures

Standing height (m) and body mass (kg) were assessed according to international standards for anthropometric assessment (Marfell-Jones et al., 2006). To evaluate height and body mass, a stadiometer/mechanical scale (SECA, model 220, Germany) with precisions of 0.1 cm and 0.1 kg, respectively, was used. These parameters were assessed prior to any physical performance test. Subjects were tested while wearing light clothing (shoes were removed). The body mass index (BMI) was calculated (kg/m^2). Before resting heart rate measurements, the women rested quietly for 10 min in the supine position, then two measures were made with an automatic heart rate measuring device (Omron Healthcare Inc., Vernon Hills, IL), with 1 min between measures, following a previously described protocol for older women (Rossow et al., 2014).

2.4. Strength tests

2.4.1. One repetition maximum leg-press and bench press

Each subject was tested for maximal bilateral concentric one-repetition leg-press ($1RM_{LP}$) and bench-press ($1RM_{BP}$) following a previously described protocol (Izquierdo et al., 2001). Briefly, the $1RM_{LP}$ subjects had their shoulders in contact with the machine and the starting knee angle was 100°. On command, the subject performed a concentric extension (as fast as possible) of the leg muscles (hip, knee and ankle extensor muscles) starting from the flexed position, to reach the full extension of 180° against the resistance determined by the weight plates. In the $1RM_{BP}$, the bar was positioned 1 cm above the subject's chest and was supported by the bottom stops of the measurement device. The subject was instructed to perform, from the starting position, a purely concentric action as fast as possible. Warm-up consisted of a set of five repetitions at 40–60% of the perceived maximum load. Thereafter, four to five separate, single attempts were performed until the subject was unable to extend her legs or arms to the required position. The last acceptable extension with the highest possible load was determined as 1RM.

2.4.2. Maximum isometric handgrip

Maximum isometric strength of the forearm muscles (handgrip test) was measured in both hands (dominant, HGd; and non-dominant, HGnd), using an adjustable digital hand dynamometer (Baseline, Irvington, NY), according to a previously described protocol (Desrosiers et al., 1995). Briefly, women were instructed to exert a maximal grip while seated on a chair in an erect position, with a 90° hip, knee and elbow flexion position, with the shoulder adducted and neutrally rotated, the forearm in a neutral position and the wrist in a slight extension (0° to 30°). Three grip-strength measures of each hand were taken, with the best result chosen for analysis.

2.5. Power tests

2.5.1. Vertical jump

To assess the maximum height in a counter-movement jump (CMJ), all trials were performed on a mobile contact mat (Ergojump; Globus, Codogne, Italy) with arms akimbo. Take-off and landing were standardized to full knee and ankle extension on the same spot. The test was performed three times, each separated by a 2-minute rest period. The average maximum height of three trials was adopted and expressed in centimeters (cm).

2.5.2. Medicine ball throwing

Ball throwing performance (BT) was tested with a 2 kg medicine ball according to previous recommendations (Pereira et al., 2012a). Briefly, women sat on a chair with the posterior trunk region positioned against the chair back and held the ball to the front with both hands and then they were instructed to throw the medicine ball as far and fast as possible. Three approved attempts were made with one-minute rest intervals between each attempt. Only the best attempt was used for further analysis.

2.5.3. 10-m walking sprint

Subjects were instructed to perform three maximum effort walking sprints of 10 m (S10). The sprint time was measured to the nearest 0.01 s using single beam infrared photoelectric cells (Globus Italia, Codogne, Italy). The starting position was standardized to a still split standing position with the toe of the preferred foot forward and behind the starting line. Sprint start was given by a random sound, which triggered timing. The photoelectric signal was positioned at 10 m and set ~0.7 m above the floor (i.e., hip level) to capture the trunk movement rather than a false trigger from a limb. Subjects performed trial sprints, separated by 3 min of rest, on an indoor wooden track.

2.6. Functional tasks

2.6.1. 8-foot up-and-go test (UG)

The test consisted of standing up from a chair, walking 2.44 m, and turning and returning to the initial seated position. The test was administered according to previously described instructions (Pereira et al., 2012a).

2.6.2. Sit-to-stand test (STS)

The test consisted of standing up from a chair and returning to the initial seated position, completing as many repetitions as possible in 30 s. The test was administered according to previously described instructions (Hallage et al., 2010).

2.7. Quality of Life

2.7.1. The Menopause-specific Quality of Life Questionnaire (MENQOL)

Subjects complete the MENQOL during a structured interview, with the Spanish version of the questionnaire validated for Chilean women (Blumel et al., 2000). The MENQOL has 29 questions, divided into four areas of well-being: vasomotor, psychosocial, physical and sexual. Each question explores the intensity of a perceived symptom, quantified with an integer rating scale between 0 (no discomfort) and 6 (great discomfort). For scoring purposes, if the subject had no symptom for a question, her score was 1. If the subject had the symptom with a rating of 1, her score was 2 and so on, for a maximum score of 8 where subjects declared a symptom with a rating of 6. The mean score for each area was used for analysis.

2.8. High-speed resistance training and traditional low-speed resistance training protocols

Training was undertaken 3 times per week, based on previous interventions (Henwood et al., 2008; Pereira et al., 2012a). Briefly, training consisted of a 10-minute warm-up that included stretching, six resistance training exercises (bench press, standing upper row, biceps curl, leg press, prone leg curl and leg extension) and concluded with a cool-down of abdominal crunches and the prone *superman* exercise to target core stabilizers. Training sessions for both groups lasted approximately 70 min, were separated by a minimum of 48 h and were performed under the direct supervision of an exercise instructor to ensure safety and the maintenance of the exercise protocol. Participants in the SG completed 3 sets of each exercise performing 8 repetitions at 75% of their baseline 1RM, with 1-minute rest between sets. All of the repetitions were completed within 3 s for the concentric muscle action and another 3 s for the eccentric muscle action. Participants in the EG completed three sets (at 45, 60 and 75% of their baseline 1RM) of each exercise, based on the proposal that optimal muscle power is achieved using maximal movement velocity at 40%–75% of 1RM (Siegel et al., 2002), with 8 repetitions for each set and 1 min of rest between sets. The EG completed all repetitions using a concentric muscle action as fast as possible and used 3 s for the eccentric muscle action. The EG completed approximately 20% less work per exercise in comparison with the SG. To accomplish the training principle of overload, the resistance was increased for both RT groups when the number of repetitions that a participant could complete was >8 in their final set, as described previously (Henwood et al., 2008; Jozsi et al., 1999). In this case, both RT groups increased the resistance approximately 1% to 5% for the 3 sets performed. Additionally, the EG completed 2 sets of 5 repetitions of ball throwing with a 2 kg medicine ball and 2 sets of 3 repetitions of countermovement jumps. A detailed description of the RT program applied during intervention to the EG and SG is depicted in Table 1.

2.9. Statistical analysis

All values are reported as the mean ± standard deviation (SD). Relative changes (%) in the dependent variables and effect sizes (ESs) are expressed with 90% confidence limits (CL). Normality and homoscedasticity assumptions for all data before and after intervention were checked, respectively with the Shapiro–Wilk and Levene's tests. The training-related effects were assessed using a two-way ANOVA with repeated measures (groups × time). When a significant F value was

Table 1
Twelve weeks high-speed resistance training protocol and traditional low-speed resistance training protocol.

	EG	SG[b]
Exercises[a]	Bench press Standing upper row Biceps curl Leg press Prone leg curl Leg extension	
Sets × reps	3 × 8	3 × 8
Intensity (%1RM)	45–75	75
Eccentric velocity (s)	3	3
Concentric velocity (s)	1 (or less)	3
Rest between sets (min)	1	1

EG: high-speed resistance training protocol. Both groups trained 3 times per week.

[a] Additionally, both groups completed 3 sets of 10–12 reps for abdominal crunches and the prone superman exercise at the end of each session.

[b] SG: traditional low-speed resistance training protocol (the EG also completed 2 sets of 5 repetitions of ball throwing with a 2 kg medicine ball and 2 sets of 3 repetitions of countermovement jumps).

achieved across time or between groups, Tukey's post hoc procedures were performed to locate the pairwise differences between the mean values. The α level was set at $p \leq 0.05$ for statistical significance. All statistical calculations were performed using the STATISTICA statistical package (Version 8.0; StatSoft Inc., Tulsa, OK, USA). In addition to this null hypothesis testing, these data were also assessed for clinical significance using an approach based on the magnitudes of change. Threshold values for assessing magnitudes of ESs (changes as a fraction or multiple of baseline SD) were 0.20, 0.60, 1.2 and 2.0 for small, moderate, large and very large, respectively (Hopkins et al., 2009). We obtained high intra-class correlation coefficients for the different performance measurements, varying between 0.81 and 0.96.

3. Results

No significant differences ($p > 0.05$) were observed among the groups for the descriptive and dependent variables at baseline (Tables 2, 3, 4).

No significant changes ($p > 0.05$) in height, body mass or BMI were observed (Table 2) between T1 and T2 in either group. Similarly, no significant changes ($p > 0.05$) in resting heart rate were observed between T1 and T2 in either group (Table 2).

From the pre- to post-training period, relative to muscle performance, the EG shows a clinically significant ($p < 0.05$) increase in $1RM_{BP}$ (51%, 1.2 ES), $1RM_{LP}$ (36%, 1.3 ES), HGd (9%, 0.4 ES) and HGnd (11%, 0.4 ES) as also did the SG in the same tests (46%, 1.2 ES; 29%, 0.8 ES; 9%, 0.3 ES; 10%, 0.4 ES; respectively). Nevertheless, no significant differences were found between the EG and SG for the performance changes in strength measures (Table 3).

After the training period, significant ($p < 0.05$) improvements in the power variables were observed in the EG in CMJ (23%, 0.8 ES), BT (20%, 1.0 ES) and S10 (−14%, −0.8 ES) performance, similar to the SG in the same tests (13%, 0.3 ES; 11%, 0.7 ES; 9%, 0.5 ES; respectively). Specifically, the performance changes in CMJ, BT and S10 for the EG and SG were significantly ($p < 0.05$) higher compared to the CG (Table 3). Relative to the SG, the EG achieved significantly higher performance changes in the BT and S10 tests (Table 3).

In both functional tasks, the EG shows a clinically significant ($p < 0.05$) improvement in UG (−18%, −1.0 ES) and STS (21%, 0.8 ES) performance, as also did the SG (10%, 0.5 ES; 19%, 0.4 ES; respectively). The performance changes in UG and STS for the EG and SG were significantly ($p < 0.05$) higher compared to the CG (Table 3). Compared with the SG, the EG achieved a significantly higher performance change in the UG test (Table 3). Significant group × time interactions were noted for all measures ($p < 0.05$), with the EG making significantly greater improvements in all testing performance parameters than the SG. Between T1 and T2, no significant changes were observed for the CG for all RT groups in muscle performance, cardiovascular variables and functional tasks ($p > 0.05$).

From T1 to T2, the EG shows a clinically significant ($p < 0.05$) improvement in their psychosocial (−33%, −1.0 ES) and physical (−25%, −1.0 ES) quality of life, as also did the SG (−28%, −0.5 ES; −23%, −0.7 ES; respectively), whereas no clinically significant changes were observed for the CG (Table 4). The changes (%) in the psychosocial and physical subscales for the EG (but not for the SG) were significantly ($p < 0.05$) higher vs. the CG (Table 4). No significant differences were found between the EG and SG for the changes (%) in quality of life (Table 4).

A significant relationship was observed between performance changes in the HGnd, UG and STS tests, with the changes in psychosocial quality of life ($r = -0.47$, $p < 0.01$; $r = 0.33$, $p < 0.05$; $r = -0.33$, $p < 0.05$; respectively) and between the S10 test and physical quality of life ($r = 0.33$, $p < 0.05$).

4. Discussion

The aim of this study was to compare the effects of a 12-week high-speed RT vs. a low-speed traditional RT program on muscle strength, power, ability to perform functional tasks and quality in older women. This study indicated that 12 weeks of high-speed and low-speed RT induced significant and small-to-large improvements in $1RM_{LP}$, $1RM_{BP}$, HGd, HGnd, CMJ, BT, S10 walking test time and UG functional test and STS performances, together with clinically significant improvements in the psychosocial and physical quality of life. However, the high-speed RT program induced significantly higher changes in BT, S10 walking test time and UG functional test performance vs. the traditional low-speed RT protocol. These results are unique and provide interesting data showing that a high-speed RT optimizes muscle power and functional task performance in older women.

The EG and SG showed similar clinically significant improvements in $1RM_{BP}$ (51%, 1.2 ES; 46%, 1.2 ES; respectively), $1RM_{LP}$ (36%, 1.3 ES; 29%, 0.8 ES; respectively), HGd (9%, 0.4 ES; 9%, 0.3 ES; respectively) and HGnd (11%, 0.4 ES; 10%, 0.4 ES; respectively), while the CG did not modify their performance in these strength measures. Our results indicate a similarly positive effect of high-speed and low-speed RT on maximal strength of upper-body and lower-body muscles of older women.

Table 2
Training effects (with 90% confidence limits) for the anthropometric and cardiovascular variables between groups.

	T1 Mean ± SD	T2 Mean ± SD	Change (%)	Effect size
Body mass (kg)				
EG (n = 15)	72.3 ± 13.1	72.4 ± 12.9	0.2 (−0.1, 0.5)	0.01 (0.0, 0.02)
SG (n = 15)	71.1 ± 15.5	70.8 ± 15.3	−0.4 (−1.1, 0.3)	−0.02 (−0.05, 0.01)
CG (n = 15)	65.2 ± 7.2	65.3 ± 7.1	0.2 (−0.2, 0.6)	0.02 (−0.01, 0.05)
Height (cm)				
EG	150.8 ± 5.4	150.8 ± 5.5	0.0 (−0.1, 0.0)	−0.01 (−0.03, 0.01)
SG	151.6 ± 5.9	151.5 ± 5.9	−0.1 (−0.2, 0.0)	−0.02 (−0.04, −0.01)
CG	148.6 ± 5.0	148.5 ± 5.1	−0.1 (−0.1, 0.0)	−0.02 (−0.04, 0.00)
Body mass index (kg/m^2)				
EG	31.7 ± 5.0	31.8 ± 5.0	0.3 (0.0, 0.6)	0.01 (0.00, 0.03)
SG	31.0 ± 6.5	30.9 ± 6.4	−0.2 (−1.0, 0.5)	−0.01 (−0.05, 0.03)
CG	29.5 ± 3.0	29.6 ± 3.0	0.4 (0.0, 0.7)	0.03 (0.00, 0.07)
Resting heart rate (beats/min)				
EG	68.5 ± 8.4	68.3 ± 8.1	−0.2 (−1.6, 1.1)	−0.02 (−0.13, 0.09)
SG	72.8 ± 10.3	72.7 ± 9.2	0.1 (−1.3, 1.6)	0.01 (−0.09, 0.11)
CG	75.1 ± 10.4	75.1 ± 9.1	0.2 (−1.5, 1.5)	0.01 (−0.09, 0.11)

T1: before experimental period; T2: after 12 weeks of resistance training. Values in brackets represent 90% confidence limits.

Table 3
Training effects (with 90% confidence limits) for the physical performance variables between groups.

	T1 Mean ± SD	T2 Mean ± SD	Performance change (%)	Effect size
One repetition maximum leg-press (kg)				
EG	74.3 ± 16.5	100.3 ± 18.8[c]	36.2 (25.6, 47.8)[i]	1.34 (0.99, 1.70)***
SG	81.0 ± 23.1	102.3 ± 22.9[c]	29.2 (20.6, 38.6)[h]	0.79 (0.57, 1.00)**
CG	80.3 ± 23.3	80.3 ± 20.1	2.1 (−4.7, 9.4)	0.06 (−0.14, 0.26)
One repetition maximum bench-press (kg)				
EG	14.5 ± 4.5	21.1 ± 4.3[c,e]	50.6 (39.8, 62.3)[i]	1.21 (0.99, 1.43)***
SG	16.3 ± 4.5	23.1 ± 4.4[c,f]	45.5 (34.5, 57.4)[i]	1.23 (0.98, 1.49)***
CG	15.7 ± 3.6	15.5 ± 3.3	−0.2 (−5.1, 4.9)	−0.01 (−0.18, 0.17)
Dominant maximum isometric handgrip (kg)				
EG	24.3 ± 5.2	26.3 ± 5.0[c]	9.1 (5.9, 12.4)[i]	0.38 (0.25, 0.51)*
SG	24.9 ± 5.2	27.0 ± 5.6[c]	8.6 (6.3, 11.0)[i]	0.32 (0.24, 0.40)*
CG	23.0 ± 3.8	22.8 ± 3.1	−0.4 (−2.6, 1.9)	−0.02 (−0.15, 0.11)
Non-dominant maximum isometric handgrip (kg)				
EG	22.3 ± 4.8	24.5 ± 4.8[c]	10.5 (7.8, 13.2)[i]	0.40 (0.30, 0.50)*
SG	24.4 ± 4.9	26.7 ± 4.7[c,d]	9.9 (7.1, 12.8)[i]	0.41 (0.30, 0.52)*
CG	21.9 ± 2.4	21.7 ± 2.2	−0.9 (−3.8, 2.2)	−0.08 (−0.34, 0.18)
Counter-movement jump (cm)				
EG	7.8 ± 2.2	9.5 ± 2.0[c]	23.3 (13.1, 34.3)[h]	0.79 (0.46, 1.11)**
SG	9.2 ± 3.4	10.1 ± 3.3[b]	13.3 (5.1, 22.1)	0.30 (0.12, 0.48)*
CG	8.1 ± 2.2	8.2 ± 2.1	1.4 (−2.0, 4.9)	0.05 (−0.07, 0.16)
Ball throwing (cm)				
EG	2.4 ± 0.4	2.9 ± 0.5[c]	19.9 (14.4, 25.6)[i,j]	1.01 (0.75, 1.27)**
SG	2.5 ± 0.4	2.8 ± 0.4[b]	10.7 (6.0, 15.6)[h]	0.66 (0.38, 0.93)**
CG	2.5 ± 0.5	2.5 ± 0.5	−0.8 (−3.7, 2.3)	−0.04 (−0.18, 0.11)
10-m walking sprint (s)				
EG	5.0 ± 0.9	4.3 ± 0.8[c]	−14.1 (−17.0, −11.2)[i,j]	−0.80 (−0.97, −0.62)**
SG	5.0 ± 0.8	4.6 ± 0.7[c]	−8.7 (−10.8, −6.4)[i]	−0.52 (−0.66, −0.38)*
CG	4.8 ± 0.6	4.9 ± 0.7	3.3 (0.8, 5.9)	0.23 (0.05, 0.49)*
8-foot up-and-go test (s)				
EG	7.7 ± 1.4	6.3 ± 1.1[c,d]	−17.6 (−18.5, −16.7)[i,k]	−1.01 (−1.07, −0,96)**
SG	7.8 ± 1.4	7.0 ± 1.3[c]	−9.7 (−12.2, −7.1)[h]	−0.51 (−0.65, −0.37)*
CG	7.8 ± 1.4	7.9 ± 1.3	1.2 (−1.3, 3.8)	0.07 (−0.07, 0.20)
Sit-to-stand test (repetitions)				
EG	11.8 ± 2.3	14.4 ± 3.3[c,d]	21.3 (16.8, 25.9)[h]	0.79 (0.64, 0.94)**
SG	11.3 ± 3.5	13.0 ± 3.3[c]	18.8 (10.3, 27.8)[h]	0.38 (0.22, 0.54)*
CG	11.2 ± 2.1	11.1 ± 2.2	−1.6 (−7.6, 4.8)	−0.08 (−0.39, 0.23)

T1: before experimental period; T2: after 12 weeks of resistance training; values in brackets represent 90% confidence limits.

* Small.

** Moderate.

*** Large.

[a] Denotes significant difference from pre- to post training ($p < 0.05$).

[b] Denotes significant difference from pre- to post training ($p < 0.01$).

[c] Denotes significant difference from pre- to post training ($p < 0.001$).

[d] Denotes significant difference with the CG post training ($p < 0.05$).

[e] Denotes significant difference with the CG post training ($p < 0.01$).

[f] Denotes significant difference with the CG post training ($p < 0.001$).

[g] Denotes significant difference with the CG ($p < 0.05$).

[h] Denotes significant difference with the CG ($p < 0.01$).

[i] Denotes significant difference with the CG ($p < 0.001$).

[j] Denotes significant difference with the SG ($p < 0.05$).

[k] Denotes significant difference with the SG ($p < 0.01$).

These results are similar to those previously reported for older subjects submitted to high-speed and low-speed RT programs (Henwood et al., 2008; Sayers and Gibson, 2010; Wallerstein et al., 2012). Maximal strength measures can be associated with the difficulty experienced by older subjects to perform activities of daily living (Ensrud et al., 1994) and with their quality of life (Benton et al., 2014), an observation that agrees with our result showing a relationship between maximal strength and psychosocial quality of life. Even more, maximal strength can be a useful predictor of all-cause mortality (Ruiz et al., 2008) and old age disability (Rantanen et al., 1999). Because maximal strength measures are relatively easy to be completed (especially handgrip strength), this variable can be used as a convenient tool for prognosis in the elderly population.

Although we use high rigor to include subjects in the final analyses (i.e., completion of all training session), compared with previous interventions in older women (Pereira et al., 2012a; Sáez Sáez de Villarreal, 2010) the magnitude change in CMJ for the SG (13%, 0.3 ES) in this study was smaller after RT using an intervention of similar duration. However, this discrepancy in training effect can be attributed to the training specificity, as the previous studies mentioned above used CMJ or similar exercises as a training strategy. Although, the EG achieves a training effect (23%, 0.8 ES) similar to that observed previously in 60–70 y older women (Sáez Sáez de Villarreal, 2010) and sex-mixed groups (Hakkinen et al., 2000) submitted to explosive strength training. In fact, our results show that only the EG achieves a significantly higher training effect in CMJ performance compared to the CG. Similarly, we observe a

Table 4
Training effects (with 90% confidence limits) for the responses to the Menopause-specific Quality of Life Questionnaire (MENQOL) between groups.

	T1 Mean ± SD	T2 Mean ± SD	Change (%)	Effect size
Vasomotor				
EG	1.8 ± 1.3	1.4 ± 1.1	−20.4 (−27.8, −12.2)	−0.55 (−0.78, −0.31)*
SG	1.5 ± 2.1	1.2 ± 1.6	−18.0 (−28.7, −5.6)	−0.29 (−0.50, −0.08)*
CG	1.9 ± 1.8	2.0 ± 1.9	−5.1 (−21.8, 15.2)	−0.07 (−0.33, 0.19)
Psychosocial				
EG	1.7 ± 0.9	1.1 ± 0.7[a]	−33.3 (−45.5, −18.4)[b]	−1.04 (−1.56, −0.52)**
SG	1.7 ± 1.6	1.1 ± 1.0[a]	−28.4 (−41.0, −13.2)[b]	−0.47 (−0.74, −0.20)*
CG	1.5 ± 1.1	1.6 ± 1.0	14.9 (−13.3, 52.4)	0.22 (−0.23, 0.67)*
Physical				
EG	2.5 ± 0.7	1.9 ± 0.4[a]	−24.8 (−36.1, −11.4)	−1.02 (−1.6, −0.43)**
SG	2.4 ± 1.1	1.8 ± 0.6[a]	−22.6 (−33.8, −9.4)	−0.65 (−1.06, −0.25)**
CG	2.2 ± 1.1	2.1 ± 0.8	2.4 (−15.3, 23.8)	0.05 (−0.33, 0.42)
Sexual				
EG	3.7 ± 2.1	3.3 ± 1.9	−8.6 (−22.1, 7.4)	−0.14 (−0.40, 0.11)
SG	3.4 ± 2.0	3.2 ± 1.8	0.2 (−21.3, 27.5)	0.00 (−0.27, 0.27)
CG	4.1 ± 1.4	3.9 ± 1.2	−2.6 (−9.9, 5−3)	−0.08 (−0.30, 0.15)

T1: before experimental period; T2: after 12 weeks of resistance training; values in brackets represent 90% confidence limits.
* Small.
** Moderate.
[a] Denotes significant difference from pre- to post training ($p < 0.05$).
[b] Denotes significant difference with the CG ($p < 0.05$).

significantly higher increase in BT performance only for the EG (20%, 1.0 ES; SG: 11%, 0.7 ES), similar to that previously reported for older women submitted to high-speed RT (Pereira et al., 2012a,b). These results suggest that, compared to a traditional low-speed RT, high-speed RT may offer a higher muscle power training effect for the lower-body and upper-body muscles. Because muscle power is more closely associated with the performance of activities of daily living than muscle strength (Hazell et al., 2007), training for muscle power with a high-speed RT program might be a more optimal means of training for older women leading to more beneficial results in functional performance in everyday tasks.

Both, the EG (−14%, −0.8 ES) and the SG (−9%, −0.5 ES) achieve a significant performance increase in the S10 test, although the performance change in the EG was significantly ($p < 0.05$) higher. Walking is an essential part of daily living and even a performance increase of 0.1 m/s may be associated with a survival increase in older adults, especially in women (Studenski et al., 2011). A significant improvement in this functional task with RT may reduce the difficulty with which older women perform it, giving them the possibility for better walking habits, improved health (Mosallanezhad et al., 2014) and greater enjoyment of daily activities. In fact, we observe a significant increase in the physical and psychosocial quality of life of RT women. Moreover, we observe a significant correlation ($r = 0.33$, $P < 0.05$) between the performance change in the S10 test and the change in physical quality of life. This result suggests that high-speed RT is a more optimal training strategy to increase a fundamental functional task that may be related with an improvement in critical aspects of quality of life. Gains in walking performance can be maintained during prolonged periods of time (i.e., 24 weeks), even if RT is discontinued (Hakkinen et al., 2000), thus the benefits of RT (especially from high-speed RT) can be maintained for long periods of detraining. This is especially important for older women enrolled in training programs that are discontinued during some time period (i.e., summer time or disease).

In the UG test time, the EG and SG achieve a significant reduction (−18%, −1.0 ES; and −10%, −0.5 ES, respectively), however the performance change was significantly higher in the EG, similar to that previously reported for older adults submitted to traditional low-speed RT (Fragala et al., 2014) and high-speed RT (Pereira et al., 2012a), respectively, supporting the fact that high-speed RT may be a more optimal RT strategy to increase functional performance in older women. In maximal strength, the EG and SG achieve similar increases but better performance was achieved in the EG in upper-body (i.e., BT) and lower-body (i.e., CMJ) muscle power. Because muscle power is more closely associated with functional task performance and risk of falling than maximal strength in older women (Foldvari et al., 2000; Skelton et al., 2002; Suzuki et al., 2001), these observations may help explain the higher UG test performance change observed in the EG.

Difficulty with rising from a chair can be related to aging-associated neuromuscular wasting, which may lower the quality of life in the elderly (Tseng et al., 1995). In the functional status assessment of older women through the STS test, both the EG and the SG achieve a significant and similar performance change (21%, 0.8 ES; and 19%, 0.4 ES, respectively). In older women, performance changes in the STS test may be related to neuromuscular and morphological changes resulting from ST in the lower limbs (Pinto et al., 2014). In fact, low-speed and high-speed RT protocols may induce significant increases in morphological and neuromuscular lower limb adaptations (Wallerstein et al., 2012). Changes in muscle strength and power may help explain the performance increase observed in both RT groups, although only muscle power is independently correlated with the ability to repeatedly stand and sit in a chair (Suzuki et al., 2001), suggesting that muscle power plays a more important role in the functional tasks that older women perform daily. This agrees with our results, as we observe that only the EG achieves a significantly ($p < 0.05$) higher performance change in the STS test vs. the CG and also the clinical significance analysis for assessing magnitudes of ES indicates a moderate clinical significance for the EG and only a small significance for the SG. Therefore, our results may reinforce the notion that RT can be useful to counteract the neural and morphological aging-associated wasting processes and that a key daily living functional performance task such a sitting and rising from a chair can be markedly increased with RT in older women, helping them to develop more independence, with the advantage of high-speed RT inducing higher clinically relevant results.

A possible limitation of the present study was the absence of more physiological measurements, to better understand the underlying mechanism of training-induced adaptations to both, high-speed RT and low-speed RT.

In conclusion, both low-speed and high-speed RT interventions are effective for improving functional capacity, muscle performance and quality of life in older women, although a high-speed RT program induces greater improvements in muscle power and functional task performance.

4.1. Practical applications

A high-speed RT intervention is an effective, safe and efficient strategy to achieve significant and clinically relevant improvements in neuromuscular and functional task performance relevant to daily life activities of older women, together with significant improvements in their quality of life. These results should be considered for designing appropriate RT programs for older adults.

Conflict of interest

The authors have no conflicts of interests.

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