Experimental Gerontology 58 (2014) 51–57

Contents lists available at ScienceDirect

Experimental Gerontology

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

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

Rodrigo Ramírez-Campillo [a], Angélica Castillo [a], Carlos I. de la Fuente [b], Christian Campos-Jara [b], David C. Andrade [c], Cristian Álvarez [d], Cristian Martínez [e], Mauricio Castro-Sepúlveda [f], Ana Pereira [g,h], Mário C. Marques [h,i], Mikel Izquierdo [j,*]

[a] Department of Physical Activity Sciences, Universidad de Los Lagos, Osorno, Chile
[b] School of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile
[c] Laboratory of Exercise Sciences, MEDS Clinic, Santiago, Chile
[d] Family Health Center, Los Lagos, Chile
[e] Department of Physical Education, Sport and Recreation, Universidad de La Frontera, Temuco, Chile
[f] School of Health, Duoc UC, Santiago, Chile
[g] Department of Sport Sciences, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal
[h] Research Centre in Sports, Health and Human Development, Vila Real, Portugal
[i] Department of Sport Sciences, University of Beira Interior, Covilhã, Portugal
[j] Department of Health Sciences, Public University of Navarre, Navarre, Spain

ARTICLE INFO

Article history:
Received 25 April 2014
Received in revised form 3 July 2014
Accepted 8 July 2014
Available online 9 July 2014

Section Editor: Christiaan Leeuwenburgh

Keywords:
Resistance training
Aging
Women
Power output
Adaptation

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 ± 3.7 y], a low-speed RT group [SG, n = 15, age = 68.7 ± 6.4 y] and a control group [CG, n = 15, age = 66.7 ± 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.

* Corresponding author at: Department of Health Sciences, Public University of Navarra, Campus of Tudela, Av. de Tarazona s/n. 31500 Tudela, Navarra, Spain.
E-mail address: mikel.izquierdo@gmail.com (M. Izquierdo).

http://dx.doi.org/10.1016/j.exger.2014.07.001
0531-5565/

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 $= 66.3 \pm 3.7$ y), a low-speed resistance training group (SG, $n = 20$, age 68.7 ± 6.4 y) and a control group (CG, $n = 20$, age $= 66.7 \pm 4.9$ 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