Experimental Gerontology 53 (2014) 1–6

Contents lists available at ScienceDirect

Experimental Gerontology

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

Short report

Muscle quality index improves with resistance exercise training in older adults

Maren S. Fragala *, David H. Fukuda, Jeffrey R. Stout, Jeremy R. Townsend, Nadia S. Emerson, Carleigh H. Boone, Kyle S. Beyer, Leonardo P. Oliveira, Jay R. Hoffman

Institute of Exercise Physiology and Wellness, University of Central Florida, Orlando, FL, USA

ARTICLE INFO

Article history:
Received 21 October 2013
Received in revised form 2 January 2014
Accepted 29 January 2014
Available online 6 February 2014

Section Editor: Christiaan Leeuwenburgh

Keywords:
Sarcopenia
Power
Intervention
Aging
Elderly
Strength
Resistance training

ABSTRACT

Introduction: Sarcopenia is currently best described as an age-related decline in skeletal muscle mass and function. However, no consensus exists as to how to best quantify muscle function in older adults. The muscle quality index (MQI) was recently recommended as an ideal evidence-based assessment of functional status in older adults. Nevertheless, the usefulness of MQI to assess physical function is limited by whether it is reflective of muscle qualitative changes to an intervention. Thus, the purpose of this investigation was to determine whether MQI changes in response to resistance exercise training and detraining and how such changes correspond to other recommended measures of physical function proposed by suggested definitions of sarcopenia.

Methods: Twenty-five older adults (70.6 ± 6.1 y; BMI $= 28.1 \pm 5.4$ kg $\cdot$ m^{-2}) completed a 6-week resistance training program in a wait-list controlled, cross-over design. MQI was determined as power output from timed sit to stand (STS), body mass, and leg length. Gait speed, hand grip strength, get-up-and-go and lean body mass (LBM) were evaluated before and after exercise training and detraining. MQI and functional changes to training and detraining were evaluated with repeated measures ANOVA and clinical interpretations of magnitude based inferences.

Results: Short term resistance training significantly and clinically improved MQI (203.4 ± 64.31 to 244.3 ± 82.92 W), gait time (1.85 ± 0.36 to 1.66 ± 0.27 s) and sit to stand performance (13.21 ± 2.51 to 11.05 ± 1.58 s). Changes in LBM and hand grip strength were not significant or clinically meaningful. De-training for 6-weeks did not result in significant changes in any measure from post-training performance.

1. Introduction

Sarcopenia, the age-related loss in skeletal muscle mass is closely related to mobility and functional impairments common with advanced age (Fiatarone et al., 1994; Foldvari et al., 2000; Janssen, 2006).The relative importance of muscle function for sarcopenic outcomes has led to more recent approaches to define sarcopenia incorporating muscle function into the diagnostic criteria (Cruz-Jentoft et al., 2010; Lauretani et al., 2003). However, the ability to diagnose sarcopenia and develop meaningful treatments has been complicated by the complexities of muscle function and differing rates of age-related changes. In particular, the rate that muscle strength declines is faster than the rate that muscle mass declines (Goodpaster et al., 2006). Similarly, the rate at which muscle power declines is even more rapid than the concomitant loss of muscle strength and mass (Frontera et al., 1991; Goodpaster et al., 2006; Hakkinen et al., 1996). Such temporal discrepancies reveal more intricate musculoskeletal changes associated with sarcopenia and aging than simply a loss of muscle tissue. Such changes are likely attributed to the quality of the muscle tissue (Goodpaster et al., 2001).

Skeletal muscle quality has been described in many ways ranging from muscle composition and density to muscle function per muscle mass to muscle's metabolic processes (Barbat-Artigas et al., 2012). Muscle quality is often assessed indirectly as a relative performance indicator defined as muscle strength per muscle mass (Moritani and deVries, 1979). When defined in this way, muscle quality declines are associated with advanced age (Lindle et al., 1997; Lynch et al., 1999). While aging attenuates muscle's hypertrophic responses to resistance training (Welle et al., 1996), it does not appear to impair muscle quality adaptations to resistance exercise in older adults (Welle et al., 1996). Hence, muscle quality may present a meaningful, informative, and sensitive target to monitor sarcopenia status and treatment efficacy, beyond routine measures of muscle mass. In particular, a simple muscle qualitative assessment that can be conducted feasibly during routine clinical examinations may have the broadest impact for assessment and evaluation. Functional measures, by way of muscle quality estimation, may allow for clinicians to account for the interaction between declining muscularity and intramuscular fat infiltration which may be

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Abbreviations: AED, Automatic external defibrillator; BMI, Body mass index; CPR, Cardio-pulmonary resuscitation; DEXA, Dual energy X-ray absorptiometry; ICC, Intra-class correlation coefficients; LBM, Lean body mass; MQI, Muscle quality index; STS, Sit to stand; SEM, Standard error of measurement; SWC, Smallest worthwhile change.

* Corresponding author at: Sport and Exercise Science, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816, USA. Tel.: +1 407 823 3877.

E-mail address: Maren.fragala@ucf.edu (M.S. Fragala).

0531-5565/$ – see front matter © 2014 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.exger.2014.01.027

misinterpreted or neglected for by standard sarcopenic evaluation involving only muscle mass in aging adults.

Recently, Barbat-Artigas et al. (2012) reviewed and recommended the muscle quality index (MQI) as a "clinical screening tool to detect individuals at risk of physical incapacities based on muscle quality." The MQI calculates muscle power from anthropometric measures (e.g. leg length and body mass) and timed chair rises (Takai et al., 2009). The MQI assessment is particularly informative in comparison to other measures because it evaluates specific lower extremity function that is related to ambulation, as opposed to non-muscle group specific measures of handgrip strength. In addition, the MQI is a more complete index of muscle quality than relative strength since it incorporates the velocity at which muscle shortens (i.e. muscle power), which is reflective of the neuromuscular component. Furthermore, the assessment is clinically relevant, since it is calculated from the common sit to stand test. Utilizing the familiar timed sit to stand test, the assessment is appropriate for older persons who may have physical limitations, safety concerns and/or sarcopenia. Moreover, prior research has shown that the ability to rise from a chair is related to functional independence in older adults (Corrigan and Bohannon, 2001). MQI can be distinguished from the common sit to stand test as, as it incorporates anthropometric measures of body mass and leg length to which have previously been shown to alter the relationship between chair rise performance and leg strength (Takai et al., 2009). The MQI has been shown to be strongly correlated to the cross-sectional area of the knee extensors ($r = 0.801$) and force of the knee extensors ($r = 0.730$) in older adults, while timed sit to stand was not (Takai et al., 2009).

While the MQI has been recommended as the "best clinical measure to assess muscle power" (Barbat-Artigas et al., 2012), no proposed definitions of sarcopenia have incorporated the potentially more sensitive muscle quality measure of muscle power into the proposed criteria. For muscle quality to become an appropriate target of treatment strategies for sarcopenia, we need to generate a better understanding of the adaptability of aspects of muscle quality at the clinical level. Hence, the purpose of the present investigation was to examine if and how MQI changes in response to a resistance training and detraining intervention in older adults and how such changes compare to other measures of physical function commonly measured in older adults.

2. Materials and methods

2.1. Experimental approach to the problem

To determine the effects of resistance training and detraining on muscle quality index (MQI), older adult volunteers completed two phases of the experimental protocol, both of which included a 6-week resistance training program, in a wait-list controlled, cross-over design (Fig. 1). Volunteers were randomized into exercise group 1 or exercise group 2. Exercise group 1 completed 6-weeks of resistance training in Phase 1 and 6-weeks of detraining (no resistance training) in Phase 2. Exercise group 2 completed a 6-week control period of no resistance exercise intervention where they were instructed to maintain their normal daily activities in Phase 1 followed by 6-weeks of resistance exercise training in Phase 2. All participants were tested at 3 time points separated by 6-weeks of resistance exercise training either proceeded by detraining (Phase 1) or preceded by a control condition (Phase 2). MQI and functional measures were determined before and after Phase 1 and Phase 2 at weeks 0, 6, and 12. Reliability intra-class correlation coefficients (ICC) and standard error of measurements (SEM) were computed from 11 participants in the control group.

2.2. Participants

Twenty-five older adults volunteered for the study (70.5 ± 6.2 y; 168.4 ± 9.4 cm; 81.4 ± 19.0 kg). Participants were recruited from a variety of sources including word of mouth, flyers, and informational presentations. Participants were required to be over age 60 y and physically cleared for exercise participation according to a health history questionnaire or physicians clearance. Physician clearance was required for any participant over age 70 y or any potentially positive risk factor as indicated on the medical history questionnaire. Individuals classified as "high risk" for exercise by having a cardiovascular, pulmonary, or metabolic disease, or one or more cardiovascular signs and symptoms were excluded from participation. Participants were randomly assigned to either group 1 ($n = 13$) or group 2 ($n = 12$). Participants were recruited so that an equal number of men and women was randomized to each group. During both phases of the protocol, all participants were instructed to follow their normal diets. Two women completed pretesting but did not complete all time points due to personal reasons not associated with the study. One man chose not to complete the week 12 DEXA test. Thus, 23 individuals were included in the final analysis, with $n = 22$ for the body composition analysis. Participants were informed of study procedures, and provided written informed consent prior to enrolling in the study. All study procedures were reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at the University of Central Florida.

2.3. Measures

2.3.1. Anthropometrics

Body mass and stature were measured following standardized anthropometric protocols on a digital scale and an upright standiometer during each testing occasion. Body mass index was calculated from these measures as $\mathrm{kg} \cdot \mathrm{m}^{-2}$.

2.3.2. Dual-energy X-ray absorptiometry

Total body composition was evaluated using dual energy X-ray absorptiometry (DEXA) technologies obtained on a whole body scan. All DEXA scans were ordered by a licensed physician in the state of Florida and were performed in the Body Composition Laboratory by a technician licensed in the state of Florida.

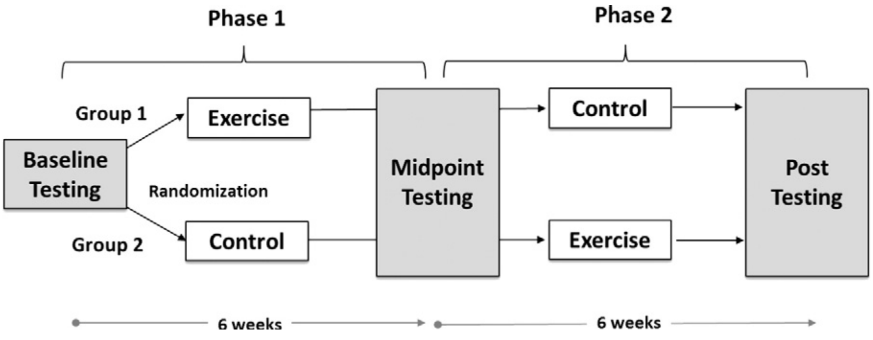

Fig. 1. Study design.