Archives of Gerontology and Geriatrics 59 (2014) 300–304

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

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

Physical working capacity at fatigue threshold (PWC_{FT}) is associated with sarcopenia-related body composition and measures of functionality in older adults☆

Nadia S. Emerson [a], David H. Fukuda [a,*], Jeffrey R. Stout [a], Edward H. Robinson IV[a], William P. McCormack [a], Tyler C. Scanlon [a], Ashlee M. Warren [b], Adam J. Wells [a], Adam M. Gonzalez [a], Gerald T. Mangine [a], Maren S. Fragala [a], Jay R. Hoffman [a]

[a] Institute of Exercise Physiology and Wellness, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816, United States
[b] University of Central Florida Health Center, P.O. Box 163333, University of Central Florida, Orlando, FL 32816, United States

ARTICLE INFO

Article history:
Received 17 January 2014
Received in revised form 11 April 2014
Accepted 24 April 2014
Available online 4 May 2014

Keywords:
Aging
Neuromuscular function
Disability
Skeletal muscle index

ABSTRACT

The relationship between PWC_{FT} and common measures used to assess sarcopenia in older adults were examined. Fifty-eight older adults [age: 71.1 ± 6.2 years; body mass index (BMI): 28.0 ± 5.4 kg/m^2] completed the testing procedures. Sarcopenia-related body composition was measured by dual-energy X-ray absorptiometry and participants performed a discontinuous cycle ergometry test to determine PWC_{FT}. Functionality assessments included maximal isometric grip strength (GRIP) and sit-to-stand (STS) repetitions in 30 s. Muscle quality (MQ) was defined as GRIP relative to appendicular lean soft tissue (ALM), while skeletal muscle index (SMI) was defined as ALM/height^2. Pearson correlations were used to examine the relationships among dependent variables. PWC_{FT} showed significant relationships with ALM ($r = 0.57$), SMI ($r = 0.47$), body fat percentage (BF%) ($r = -0.50$), GRIP ($r = 0.49$), and STS ($r = 0.44$). For follow-up analyses, study participants were categorized into low sarcopenia risk ($n = 31$) or high sarcopenia risk ($n = 27$) groups by SMI. Sarcopenia risk was associated with PWC_{FT} [odds ratio (OR): 1.051, 95% confidence interval (CI): 1.016–1.087] and STS (OR: 1.305, CI: 1.060–1.607), but not GRIP (OR: 1.098, CI: 0.989–1.218). Using receiver–operator characteristic curve analysis, both PWC_{FT} [area under the curve (AUC): 0.737, CI: 0.608–0.866, optimal cutoff: 37.5 W] and STS (AUC: 0.749, CI: 0.623–0.874, optimal cutoff: 12.5 repetitions) showed discriminative ability with regard to sarcopenia risk. The current data suggest that the neuromuscular fatigue threshold, as measured by PWC_{FT}, is related to measures of body composition and function in older adults.

1. Introduction

Aging is a dynamic and progressive process characterized by a reduction in skeletal muscle mass, strength, and quality. Physical function in older adults is often evaluated with measures of muscular strength and body composition, such as MQ and SMI (Baumgartner et al., 1998; Janssen, Baumgartner, Ross, Rosenberg, & Roubenoff, 2004; Janssen, Heymsfield, & Ross, 2002; Lamoureux, Sparrow, Murphy, & Newton, 2002; Misic, Rosengren, Woods, & Evans, 2007). Low MQ and SMI have been associated with limitations when performing activities of daily living (ADLs) and an overall increased risk of physical disability (Goodpaster et al., 2006; Newman et al., 2003).

Most ADLs require repeated, sustained submaximal efforts, in which the capacity to perform physical work and delay fatigue may be particularly important to age-associated loss of functional performance (Katsiaras et al., 2005). deVries et al. (1987) suggested that impaired muscle function may be related to fatigue-induced deterioration of motor coordination. Thus, assessment of resistance to fatigue may be important to consider when evaluating the health status of older adults. However, measurement of fatigue is difficult in the older population, often requiring near maximal effort (i.e., VO_2max). With this in mind, deVries et al. (1987) developed the PWC_{FT}, a submaximal exercise test to evaluate the capacity for physical work and the ability to delay fatigue.

☆ New England IRB Protocol #: 11-343.

* Corresponding author at: 12494 University Blvd, ED 320R, Orlando, FL 32816, United States. Tel.: +1 407 823 0211; fax: +1 407 823 2368.
E-mail address: david.fukuda@ucf.edu (D.H. Fukuda).

http://dx.doi.org/10.1016/j.archger.2014.04.012
0167-4943/

The PWC_{FT} is non-invasive, submaximal, reliable, and sensitive to change in physical status (deVries et al., 1989). Several studies have reported significant increases in PWC_{FT} following training (deVries et al., 1989) and/or nutritional supplementation (Stout et al., 2007, 2008) in older adults; however, the extent to which the PWC_{FT} relates to measures of physical function in older adults remains to be investigated. Therefore, the purpose of this study was to identify the relationship between the PWC_{FT} and other measures associated with sarcopenia-related body composition and physical function in older adults. Additionally, the effectiveness of the ability of select functional measures to discriminate between high and low sarcopenia risk was evaluated.

2. Methods

2.1. Subjects

Baseline values from 60 healthy, independently living men and women over the age of 60 years old, who participated in a separate interventional study (McCormack et al., 2013), were used for this investigation. Two subjects were excluded due to incomplete data; therefore, 58 subjects (25 men and 33 women) with a mean age of 71.1 ± 6.2 years (range 60–84) were included in the analysis (Table 1). All subjects completed a medical history questionnaire. No subjects reported major surgery within the last 6 months, history of asthma, heart or pulmonary disease, uncontrolled hypertension, and were not taking any medications that would interfere with exercise testing. All procedures were approved by the New England Institutional Review Board (IRB number 11-343). Prior to the beginning of the study, all subjects were advised of any possible risks before providing written informed consent.

2.2. Procedures

Upon arriving at the laboratory, subjects' height and body mass were measured using a standard stadiometer and electronic scale (Health-o-Meter; Patient Weighing Scale, Model 500 KL, Pelstar, Alsip, IL, USA). Appendicular lean mass (ALM) and BF% were assessed using dual energy X-ray absorptiometry (DEXA) (Prodigy™; Lunar Corporation, Madison, WI, USA). Regions of interest for the arms (delineated from the thorax through the head of the humerus) and legs (delineated from the thorax through the neck of the femur), as estimated by the DEXA software, were summed to determine ALM. Skeletal muscle mass index (SMI) was calculated as ALM/height^2 as previously defined by Baumgartner et al. (1998). MQ was calculated with GRIP and DEXA-derived ALM [GRIP(kg)/ALM(kg)].

Table 1
Physical characteristics and functional measures for study participants.

	All (n = 58)	Risk of sarcopenia: High (n = 27) M = 11; W = 16	Risk of sarcopenia: Low (n = 31) M = 14; W = 17
Physical characteristics			
Age (yrs)	71.1 ± 6.2	71.7 ± 6.1	70.6 ± 6.3
Height (m)	1.65 ± 0.13	1.66 ± 0.10	1.65 ± 0.16
Body mass (kg)*	76.7 ± 18.3	71.3 ± 16.9	81.4 ± 18.5
BF%	36.2 ± 8.7	37.1 ± 7.7	35.5 ± 9.5
BMI (kg/m^2)*	28.0 ± 5.5	25.7 ± 4.6	30.1 ± 5.4
SMI (kg/m^2)*	7.23 ± 1.50	6.33 ± 1.14	8.01 ± 1.34
Functional measures			
PWC_{FT} (W)*	52.0 ± 24.4	41.9 ± 19.2	60.8 ± 25.2
STS (# in 30 s)*	13.3 ± 4.5	11.4 ± 3.8	14.9 ± 4.5
GRIP (kg)	31.2 ± 12.5	28.8 ± 10.1	33.2 ± 14.1
MQ	1.54 ± 0.39	1.63 ± 0.41	1.47 ± 0.36

M: men, W: women.
* Significantly different between high and low sarcopenia risk groups.

Subjects performed a discontinuous, cycle ergometry test on an electronically braked cycle ergometer to determine the PWC_{FT}, a handgrip dynamometry test (GRIP) to assess muscle strength, and a 30-s STS test to measure lower body functionality.

2.3. Electromyography (EMG) measurements

A bipolar (4.6 cm center-to-center) surface electrode (Quinton Quick-Prep silver-silver chloride) arrangement was placed over the right vastus lateralis muscle, at approximately 60% of the distance from the lateral portion of the patella on a line with the greater trochanter. The reference electrode was placed over the lateral epicondyle of the distal femur. Inter-electrode impedance was kept below 5000 Ω with abrasion of the skin beneath the electrodes. The raw EMG signals were pre-amplified using a differential amplifier (MP150 BIOPAC Systems, Inc., Santa Barbara, CA), sampled at 1000 Hz, bandpass filtered at 10–500 Hz (zero-phase shift fourth-order Butterworth), and stored on a personal computer (Dell Latitude E6530; Dell Inc., Round Rock, TX) for off-line analysis. The EMG signals were expressed as root mean square (rms) amplitude values (μVrms) by software (AcqKnowledge v4.2, BIOPAC Systems, Inc., Santa Barbara, CA).

2.4. Determination of PWC_{FT}

Determination of PWC_{FT} values was previously described by deVries et al. (1987) for the vastus lateralis. The initial work rate was set at 30 W for each test. The subjects pedaled at 50 revolutions per minute (rpm) for each 2-min stage of the test on an electronically braked cycle ergometer (Lode, Excalibur Sport, Groningen, Netherlands). A discontinuous protocol was adopted and each participant's heart rate was allowed to return to within 10 beats per minute of resting values prior to completing subsequent 2-min stages. Toe clips were utilized for each subject. Following each stage, the raw EMG rms amplitude values were saved on a laptop computer and further analyzed with custom-written software (LabView, National Instruments Corporation, Austin, TX). If the stage did not produce a statistically significant, positive slope ($p < 0.05$) for the EMG rms amplitude versus time relationship, the resistance was increased 10–20 W until a statistically significant, positive slope was achieved or the subject reached 75% of their age-predicted maximal heart rate, or surpassed a rating of perceived exertion (RPE) of 13 ("Somewhat Hard") on the Borg scale. Once a statistically significant, positive slope was reached, one final stage was performed at 5–10 W less than the resistance of the stage that produced the statistically significant, positive slope. The PWC_{FT} was estimated to be the mean resistance of the highest non-statistically significant positive slope and the lowest statistically significant positive slope. In the event the subject did not have a statistically significant, positive slope during any stage of their PWC_{FT}, a regression analysis was performed utilizing slope and the corresponding workload (watts) as described by deVries, Moritani, Nagata, and Magnussen (1982). The y-intercept (watts) produced in this analysis was then used as the PWC_{FT}. The reliability of the PWCft values for ten men and women similar to the cohort used in this study were analyzed using both calculation methods, resulting in intraclass correlation of 0.95 and standard error (SE) of measurement of 13.7 W.

2.5. Functional measures

During the GRIP, subjects were standing with the dynamometer (JAMAR, Sammons Preston Rolyan, Bolingbrook, IL) in their