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Hand-grip Strength is Correlated with Aerobic Capacity in Healthy Sedentary Young Females

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Abstract

Aerobic capacity, which is the maximum limit of the rate of oxygen consumption, is an important parameter in determining health-related physical fitness. This study was conducted to investigate the relationship between grip strength and aerobic capacity in healthy sedentary young females. Forty healthy, young, and sedentary females participated in the study (20.5±1.5 years). Body composition was assessed with the bioelectrical impedance method. The hand-grip strength of the individuals was measured with a hand-grip dynamometer. An indirect graded arm crank ergometer test was used to determine the peak oxygen uptake (VO_2peak). It was found that the grip strength was correlated with height (r=0.51, p=0.001), fat-free mass (r=0.45, p=0.004), and VO_2peak (r=0.36, p=0.023); however, there was no correlation between grip strength and body weight, body mass index, and body fat percentage (p>0.05). VO_2peak was negatively correlated with body fat percentage (r= -0.38, p=0.016) and body mass index (r= -0.30, p=0.045). The results showed that higher muscle strength and fat-free mass are related to higher aerobic capacity. It is considered that increasing muscle strength and fat-free mass as well as decreasing body fat may be an appropriate strategy to increase cardiorespiratory fitness.

Keywords: *oxygen consumption, hand strength, body composition*

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Introduction

Aerobic capacity is most commonly used to assess health-related physical fitness (Williams et al., 2007). Aerobic capacity (VO_2max) is the maximum limit of oxygen consumption, which is measured by a cardiopulmonary exercise tolerance test. It is also one of the main variables in exercise physiology and widely accepted as the best measure of an individual's cardiorespiratory fitness (Basset & Howley, 2000). In contrast, muscle strength is another parameter to assess health-related physical fitness (Williams et al., 2007). There are several methods to measure muscle strength; however, a hand-held dynamometer is very useful for this task. It was suggested that grip strength measurements could be used as a tool to rapidly acquire information about overall muscle strength in healthy individuals (Wind, et al., 2010). Furthermore, previous studies have reported that hand-grip strength is correlated with body composition, anthropometric characteristics (Ingrová, et al., 2017; Pizzigalli, et al., 2016), bone mineral density (Sutter et al., 2019), functional capacity (Braun et

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al., 2018), walking speed (Braun, et al., 2018), health and fitness scores (Kuh, et al., 2005), and physical activity level (Cooper, et al., 2017).

Aerobic capacity is related to many factors, such as age, gender, and physical activity level (Nazerian et al., 2016; Wilson & Tanaka, 2000). Furthermore, it is well-known that overall muscle strength is directly related to aerobic capacity (Burich, et al., 2015). It could be expected that hand-grip strength may be related to aerobic capacity, considering the relationship between hand-grip strength and overall muscle strength. Indeed, the relationship between hand-grip strength and aerobic capacity has been investigated by a few studies (Kim et al., 2018; Moberg, et al., 2017; Thomaes, et al., 2012; Wallymahmed, et al., 2007); however, these studies were conducted in a geriatric population or in those with different pathological conditions (type I diabetes, cancer, or cardiovascular disease, etc.). The relationship between hand-grip strength and aerobic capacity may be different in young individuals, considering the loss of muscle mass or changes in neuromuscular interaction in the geriatric population or in those with different pathological conditions. Therefore, the purpose of this study was to investigate the relationship between hand-grip strength and aerobic capacity in healthy young sedentary females. We hypothesized that hand-grip strength would be related to aerobic capacity in healthy young sedentary females.

Methods

Subjects

The study included 40 healthy sedentary young females between the ages of 19 and 25 (20.5±1.5 years). Participants who had not been exercising regularly for at least 6 months prior to the study were accepted as sedentary individuals. Individuals were excluded if they had any upper extremity problems that may impair cycling ability and also had a history of any active infection, peripheral vascular disease, metabolic disease, and other autoimmune, chronic systemic inflammatory disease, malignancy, presence of serious pulmonary, cardiac, or endocrine diseases, which may affect the outcomes of the exercise test. The ethics approval was obtained from the Non-Invasive Clinical Research Ethics Board of the Mersin University (Protocol Number: 2019/434) and written informed consent was obtained from each participant.

Anthropometric measurements

Height was measured with a stadiometer with subjects standing in bare feet. Body composition parameters (body weight, body mass index (BMI), fat-free mass (FFM), and body fat (%)) were assessed with the bioelectrical impedance method, which was reported to be valid and reliable, using a Tanita BC-418MA Segmental Body Composition Analyzer (Tanita Corporation, Tokyo, Japan).

Hand-grip strength

Hand-grip strength was measured with a hand-grip dynamometer (Baseline, Fabrication Enterprises Enc, Inc, NY, USA). Hand-grip strength measurements were performed on the dominant hand, which was determined by asking the subjects to write something. Prior to the test, the device was set for average hand size. Similar to previous studies (Pizzigalli, et al., 2016; Wind, et al., 2010), hand-grip strength measurements were performed in a sitting position, upright against the back of a chair with the feet flat on the floor and the shoulder adducted and neutrally rotated, elbow flexed to 90° (Figure 1). The subjects were instructed to squeeze the device "as hard as possible", and verbal encouragement was given during each trial. The device measures the value of hand-grip strength in kilogram (kg). The hand-grip strength was calculated by taking the average of three successive measurements.

FIGURE 1. Measurement of hand-grip strength

Arm Crank Test

The participants performed a maximal exercise test on an arm crank ergometer (Monark 831 E; Monark Exercise AB, Varberg, Sweden). The metabolic analyser was calibrated before each test with known gas concentrations (Quark CPET, COSMED, Rome, Italy). Heart rate (HR) was recorded throughout the graded maximal exercise test using a transmitter belt (Wireless HR Monitor, COSMED).

The subjects were asked to fill out a Physical Activity Readiness Questionnaire (PAR-Q), which screens health

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problems that may occur during exercise tests (Thomas, et al., 1992). All participants were instructed to refrain from vigorous exercise, caffeine, tobacco, and alcohol on the day before and on the test day and be ready at the laboratory after three (3) hours of fasting. After a 15-minute rest period, the participants performed unloaded cranking for 2 min. This period was followed by the first stage that began with 20 W and then increased by 6 W every minute until they were unable to maintain the specified wok rate (Mitropoulos, et al., 2017). Throughout the exercise test, they were verbally encouraged to continue the test until exhaustion. The rating of perceived exertion (RPE) was recorded by Borg's scale (6–20 points) at the end of each stage (Borg, 1982). All measured variables and HR data were averaged every 15 s. If VO_2max was not achieved during the test, the peak oxygen consumption (VO_2peak) was used instead.

Statistics

The sample size was calculated using the SPSS Sample Power 3.0 software (IBM Corporation, Armonk, NY, USA). The calculations were based on an expected correlation coefficient value of 0.50, followed by an alpha level of 0.5, and the desired power level of 80%. The estimated sample size was calculated to be at least 29 participants (Browner et al., 2007).

Statistical analyses were performed using software (SPSS version 22, IBM Corporation, Armonk, NY, USA). Analytical (Shapiro-Wilk's/Kolmogorov-Smirnov test) and visual methods (probability plots and histograms) were performed to determine whether or not the assessed parameters were normally distributed. Descriptive analyses are presented using mean and standard deviation (SD). The correlation between the assessed parameters was determined using the Pearson test. An overall 5% Type 1 error level was accepted for inter-statistical significance.

Results

The characteristics of the subjects and the results of the measurements are presented in Table 1. The right hand was the dominant side in all subjects.

Table 1. Mean (± SD), Minimum and Maximum Values of Demographic Data and Assessed Parameters

Parameters	Mean ± SD	Minimum-Maximum
Age (years)	20.5±1.5	19.0–25.0
Height (m)	1.61±0.05	1.51–1.72
Body weight (kg)	56.5±7.9	45.0–73.3
Body mass index (kg/cm²)	21.6±3.0	16.8–29.1
Body fat (%)	26.3±5.8	16.6–36.7
Fat free mass (kg)	41.5±3.8	35.4–49.1
VO_{2peak} (ml/kg/min)	22.4±2.7	17.9–28.0
Handgrip strength (kg)	25.9±4.0	18.0–33.0
Peak heart rate (beat/min)	171.9±6.7	162.0–191.0
Respiratory quotient	1.1±0.1	0.9–1.2
Rating of perceived exertion	18.3±1.0	17.0–20.0

Note. VO_{2peak}: peak oxygen consumption.

Dominant grip strength was positively correlated with height (r=0.51, p=0.001), FFM (r=0.45, p=0.004), and VO_2peak (r=0.36, p=0.023); however, there was no correlation between grip strength age, body weight, BMI, and body fat percentage (p>0.05) (Table 2). VO_2peak was negatively correlated with body fat (%) (r=-0.38, p=0.016) and body mass index (r=-0.30, p=0.045); however, VO_2peak was positively correlated with RPE (r=0.40, p=0.011) (Table 2) (Figure 2).

Table 2. Correlation Analysis Results among Handgrip Strength, Demographic Data, and Maximal Exercise Test Parameters

Parameters	Height	Body Weight	BMI	Body fat	FFM	VO_{2peak}	Handgrip Strength	HR_{peak}	RQ	RPE
Age (years)	0.14	-0.19	-0.29	-0.06	-0.20	0.04	0.09	0.08	-0.08	-0.11
Height (m)		0.31	-0.21	-0.01	0.52†	0.11	0.51†	-0.01	0.01	-0.01
Body weight (kg)			0.84†	0.78†	0.83†	-0.23	0.26	0.00	-0.01	0.04
Body mass index (kg/m²)				0.85†	0.51†	-0.30*	-0.06	0.05	0.04	0.01
Body fat (%)					0.30	-0.41*	-0.02	0.20	0.05	0.01
Fat-free mass (kg)						0.09	0.46†	0.09	-0.12	0.06
VO_{2peak} (ml/kg/min)							0.34*	0.05	-0.25	0.40*
Hand-grip strength (kg)								0.17	0.06	0.19
Heart rate (beat/min)									0.02	-0.09
Rating of perceived exertion										-0.26

Note. *p<0.05, †p<0.001. BMI: body mass index; FFM: fat-free mass; VO_{2peak}: peak oxygen consumption; HR_{peak}: peak heart rate; RQ: respiratory quotient; RPE: rating of perceived exertion.

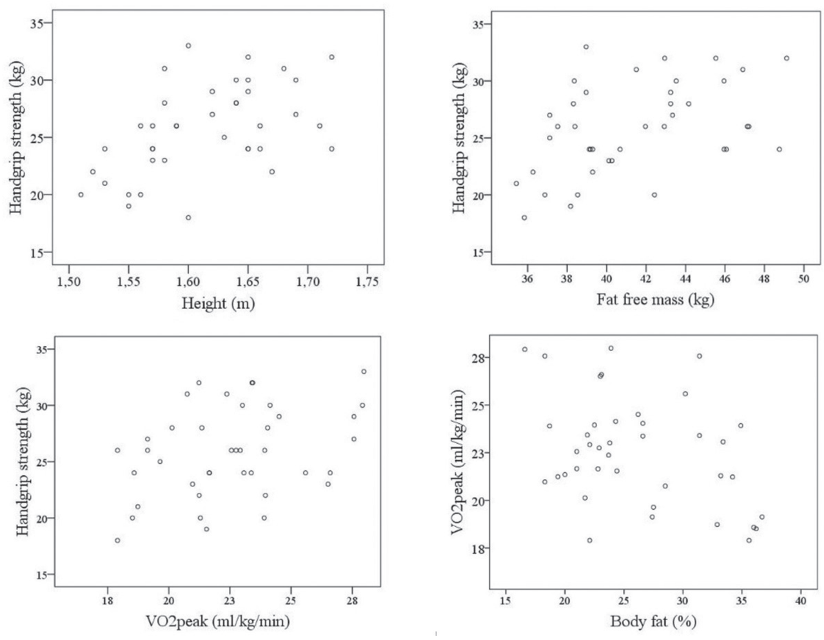

FIGURE 2. Scatterplots of correlation analysis of assessed parameters. VO2peak- peak oxygen consumption.

Discussion

The purpose of the present study was to investigate the relationship between hand-grip strength and aerobic capacity. To the best of our knowledge, this is the first study investigating the relationship between hand-grip strength and aerobic capacity in young, healthy individuals. In line with our hypothesis, it was found that hand-grip strength was correlated with VO_2peak in healthy sedentary young women. Similar to our results, Wallymahmed et al. (2007) revealed that aerobic capacity was adequately (i.e., fairly well) correlated with hand-grip strength ($r=0.27$, $p<0.01$) in patients with Type I diabetes. Furthermore, Thomas, Reading, and Shephard (2012) found a fair-to-moderate correlation between hand-grip strength VO_2peak in CAD patients.

Furthermore, it was reported that resistance exercise intervention could increase aerobic capacity and muscle strength (Giuliano, et al., 2017; Scribbans, et al., 2016; McRae et al., 2012). The results of the present study support the assertion that grip strength is related to aerobic capacity; however, the relationships were relatively low ($r=0.34$). The results are reasonable, considering the complex process of aerobic capacity. R-squared, which explains the strength of the relationship between the assessed parameters, shows that variance in hand-grip strength explained the variance in VO_2^{peak} in just up to 12% of the assessed individuals (Cohen, et al., 2003). In this study, healthy, young, and sedentary females with normal body weight were recruited to obtain a homogeneous study group, but many factors affect aerobic capacity; these factors were not controlled in the present study (e.g., cardiac output or arterial-venous oxygen difference, pulmonary system, etc.) (Bassett & Howley, 2000).

Some studies investigate the relationships between hand-grip strength and the other physiological and physical fitness parameters. For example, Sutter et al. (2019) reported that hand-grip strength was fairly correlated with bone mineral density ($r=0.28–0.35$, $p<0.05$). Matsudo and Rezende (2015) demonstrated that hand-grip strength was correlated with the vertical jump test ($R^2=0.20$; $p=0.001$) and speed (in metres per second: $R^2=0.47$; $p=0.001$) in children and adolescents. Peterson et al. (2019) reported that there was a moderate-to-strong correlation between hand-grip strength and respiratory muscle strength ($r=0.54–0.74$, $p<0.05$). Girard and Millet (2009) also demonstrated that hand-grip strength was significantly correlated with tennis performance in competitive teenage players. There have been many attempts to investigate the relationships between hand-grip strength and physical fitness parameters because hand-grip strength measurement is low-cost, easy, and quick, and determining the hand-grip strength may be used to predict other physical fitness parameters. Prior to this study, we hypothesized that hand-grip strength would be strongly correlated with aerobic capacity, and hand-grip strength measurement might assist in predicting aerobic capacity. However, the results obtained do not support this hypothesis.

Another critical finding of the present study is that an increase in body fat percentage and BMI was negatively correlated with a decrease in VO_{2peak}; however, the fat-free mass percentage was positively correlated with hand-grip strength. The results suggest that an increase in body fat percentage may cause a decrease in aerobic capacity. Similar to our results, Durkalec-Michalski et al. (2019) revealed that body mass and fat-free mass significantly contributed to the prediction of VO_2max in highly trained male rowers. Furthermore, Badaam, Deore, and Shazia (2015) found that overweight young females had lower aerobic capacity compared to normal-weight young females. In contrast, Muollo et al. (2019) reported that a decrease in body fat via an exercise and diet programme could cause an increase in aerobic power in obese individuals. Similar to previous studies, our results also support that decreasing body fat percentage or weight loss may be an appropriate strategy to increase aerobic power.

The study has some limitations. First, it was conducted with healthy, young, and sedentary females; however, the relationships between hand-grip strength and aerobic capacity may be different in different populations, such as males, geriatric patients, or athletes. Second, hand-grip strength was used

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in this study to investigate the relationships between muscle strength and aerobic capacity. Assessing the strength of different muscles in addition to hand-grip strength could have yielded more information about the relationship between muscle strength and aerobic capacity.

In conclusion, the results of the present study show that hand-grip strength was positively correlated with aerobic capacity; however, body mass index and body fat percentage were negatively correlated with aerobic capacity in healthy young sedentary females. Our results support the assertion that increasing the grip strength or decreasing body mass and body fat percentage may be an appropriate strategy to increase aerobic power.

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