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DOES HAND GRIP STRENGTH CHANGE WITH GENDER? THE TRADITIONAL METHOD VS. THE ALLOMETRIC NORMALISATION METHOD

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Abstract:
The results of muscle strength and force tests were complicated by various factors, such as age, gender and level of physical activity. The most well-known factor is body size. The allometric normalising method has been recommended to obtain more precise results from strength and force tests. Therefore, the aim of this study was to determine if gender plays a role in hand grip strength (HGS), and we used two methods: the traditional method (TM; non-normalised strength) and the allometric normalisation method (ANM; strength independent of body size). A total of 124 men (age: 21.0 ± 2.0 yr; BMI: 23.42 ± 2.47 kg/m^2) and 77 women (age: 21.0 ± 2.0 yr; BMI: 21.07 ± 2.02 kg/m^2) participated in this study. The HGS was measured in kilograms using the dominant hand via an adjustable hand grip dynamometer. When the traditional method was used, HGS was expressed in Newtons (kg × 9.81). Otherwise, a formula (S_n= S / m^{0,67}) was used for the allometric normalisation scaling (Sn = normalized strength, S = recorded strength, m = body mass and 0.67 = allometric coefficient). Both the TM (women: HGS of 323.7 N vs. men: HGS of 461.1 N; p<0,001) and the ANM (women: HGS of 21.31 ± 2.54 N vs. men: HGS 26.39 ± 3.78 N; p<0,001) confirmed that there are differences in HGS as a function of gender. Replication studies are required to determine which method is more appropriate for determining the gender differences in HGS.

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1. Introduction

Currently, physical fitness is considered one of the most important health markers and is a determinant for future disability, morbidity and mortality (Ortega, et al., 2008). Muscular strength is the one of the primary components of physical fitness (American College of Sports Medicine, 1990). Ortega et al. (2012) reported that muscular strength is associated with premature mortality due to cardiovascular disease; it is also accepted that low muscular strength is an emerging risk factor for major causes of death in young adults (Ortega, et al., 2012; Ruiz, et al., 2008). It is well known that a lack of physical fitness is associated with many diseases, including cardiovascular disease, in middle-aged and older people (Rodriguez, et al., 1994; Blair, et al., 1995; Ruiz, et al., 2008; Leong, et al., 2015). However, less is known about physical fitness and the related health outcomes in young adults (Ortega, et al., 2008).

Thus, resistance training and physical fitness level tests have been recommended by health and fitness authorities to prevent premature death and to enhance a person's lifespan (Ruiz, et al., 2008; ACSM position Stand, 1990). There is no single test for measuring muscle strength; however, the hand grip test has been one of the most used to assess muscular fitness in epidemiological studies (Ortega, et al., 2008; Norman, et al., 2011; Newman, et al., 1984).

A person's gender, age, body mass and height influence the hand grip strength in addition to one's occupation and leisure activities (Puh, 2010; Norman, et al., 2011). Recently, some researchers reported that men have a stronger hand grip strength than women (Newman, et al., 1984; Pieterse, Manandhar, & Ismail, 2002; Kamarul, et al., 2006; Dopsaj, et al., 2009; Puh, 2010). However, we recognized that the traditional method was used in these studies to evaluate the hand grip strength to determine if it there was a difference as a function of gender.

However, Jaric, Mirkov and Markovic (2005) suggested that various factors may confound physical performance tests, such as gender, age, level of physical activity and skill, and the most recognized factor is body size (Atkins, 2004). According to one position, when strength is normalized for body mass, the difference as a function of gender becomes smaller and disappears (American College of Sports Medicine, 1990) because the geometric similarity suggests that all human bodies have the same shape but differ in size (Jaric, Mirkov, & Markovic, 2005). To account for body size, a ratio or isometric scaling method is typically used. This technique normalizes the strength per body unit or fat-free mass (Atkins, 2004). However, the isometric scaling method fails to account for differences in the lean, fat and total mass (Nevill, Ramsbottom, & Williams, 1992). Therefore, the allometric normalisation method can provide a more accurate result. In the presence of conflicting results, this study aims to examine if there are differences as a function of gender for hand grip strength (HGS) by using two different methods, the traditional method (TM) and the allometric normalisation method (ANM).

2. Material and Methods

2.1 Subjects

A total of 124 men (age: 21,0 ± 2,0 yr; BMI: 23,42 ± 2,47 kg/m^2) and 77 women (age: 21,0 ± 2,0 yr; BMI: 21,07 ± 2,02 kg/m^2) participated in this study from the physical education and sport department. The height and mass of the students were recorded based on their statements. The subjects were fully informed regarding the research protocols. This study required no local ethics committee approval because it provided no risks or burdens to the subjects.

2.2 International Physical Activity Questionnaire (IPAQ)

The physical activity levels of the subjects were evaluated using the short form version of the International Physical Activity Questionnaire, which was translated into the Turkish language by Sağlam et al. The physical activity levels of the subjects were assessed using the method of Sağlam et al. Additionally, the questionnaires were answered with the guidance of a lecturer.

2.3 Hand Grip Strength (HGS)

The HGS was evaluated for the dominant hand after 5 minutes of light jogging using an adjustable digital hand grip dynamometer (Takei Scientific Instruments Co., Ltd., Japan). All subjects were tested three times with 20 second intervals, and the HGS was measured in kilograms. The best of the three measurements was recorded. HGS tests were applied while in the standing position with the shoulder adducted and neutrally rotated and with the elbow fully extended (Saha, 2014).

2.4 Determination of HGS using the Traditional Method

The peak isometric force generated was quantified by multiplying the maximal measurement detected by the dynamometer by 9.81 m·s^{-2} (gravitational constant) to convert kilograms into Newtons (Kurt, 2014).

2.5 Determination of HGS using the Allometric Normalisation Method (ANM)

The following formula (Jaric, Ugarkovic, & Kukoli, 2002; Jaric, et al., 2005) was used to obtain the strength independent of the body size, which is known as allometric normalisation:

$$S_n = S / m^{0,67},$$

where S_n = normalised strength, S = recorded strength, m = body mass, and 0,67 = the allometric coefficient.

2.6 Statistical Analyses

The Kolmogorov-Smirnov test was used to assess the normality of the numeric variables. For the numeric variables that were normally distributed, the two groups were compared using an independent sample t-test, and descriptive statistics are presented as the mean ± the standard deviation. For the numeric variables that were not normally distributed, the two groups were compared using the Mann–Whitney U test, and the descriptive statistics are presented as medians (25-75 percentiles). The p values below 0.05 were considered statistically significant.

3. Results

The descriptive statistics of the subjects are shown in Table 1. We found meaningful statistical differences in the height (<0.001), body mass (<0.001), BMI (<0.001) and IPAQ score (0.001) that favour the man except in regards to age. Additionally, there are meaningful statistical differences for hand grip strength (expressed in kilograms and Newtons) and for the allometric normalisation (Table 2).

Table 1: Descriptive statistics for women and men

	Women (n=77)	men (n=124)	P
Age (yr)	21±2	21±2	0,235
Height (cm)	1,67±0,06	1,80±0,07	<0.001
Body mass (kg)	59,05±7,47	76,03±10,13	<0.001

BMI (kg/m²)	21,07±2,02	23,42±2,47	<0.001
IPAQ	2384 (1434-4765,9)	3985,5 (2515,1-5493)	0.001

IPAQ: International Physical Activity Questionnaire

Table 2: Hand grip strength in kilograms and Newtons and allometric strength

	Women (n=77)	Men (n=124)	P
Hand grip strength in kg	33 (29,9-36,4)	47 (43,5-54,6)	<0.001
Hand grip strength in Newton	323,7 (293,3-356,6)	461,1 (426,2-535,6)	<0.001
Allometric Strength	21,31±2,54	26,39±3,78	<0.001

4. Discussion

It is generally accepted that hand grip strength measurements can be used as a health marker (nutritional status, cardiovascular health and functional limitations, such as impaired walking and balance, etc.) and for overall fitness assessment (Norman, et al., 2010; Ortega, et al., 2008; Newman, et al., 1984). Additionally, measuring the hand strength using a hand dynamometer is fast, easy to perform, reliable and produces results that are simple to record (Puh, 2010)

Budziareck, Duarte and Barbosa-Silva (2008) argued that age and gender are the strongest influencing factors for hand grip strength in healthy people. In many studies, it has been suggested that there are differences in the HGS between sedentary women and men that favour men (Kamarul, Admad, & Loh, 2006; Chilima, & Ismail, 2000; Isen, McGue, & Iacono, 2014; Puh, 2010; Haward, & Griffin, 2002). This situation is similar for women and men athletes (Laskowski, 2010; Dopsaj, et al., 2009; Noorul, Pieter, & Erie, 2008; Dopsaj, et al., 2007).

According to Dopsaj et al. (2007), differences in HGS as a function of gender may be explained by factors, such as the cross-sectional area, muscle fibre characteristics, amount of skeletal muscle mass, distribution of muscle mass in the upper limbs and common anatomical differences.

Isen, McGue and Iacono (2014) reported that the mean HGS of young men is at least twice that of young women. This result may be explained by a) masculinizing agents (e.g., testosterone) that contribute to higher mean HGS values, b) greater participation of boys in sports and other extra-curricular activities involving upper-body strength and c) upper body mass, which is approximately 75% greater in men than in women.

According to Puh (2010), HGS can be affected by leisure activities, occupation and physical activity levels. In this study, the physical activity level, as measured by the IPAQ score, of men was higher compared with women. In the present study, the IPAQ was a factor that determined that there are HGS differences related to gender.

Jaric, Ugarkovic and Kukoli (2002) argued that body size independent indices for muscle strength can serve as a valid assessment of muscle function. Additionally, Jaric, Mirkov and Markovic (2005) suggested that the performance in a number of functional tests, which were based on muscle actions that were intended to support the body weight during strength demanding conditions (push ups, squats, posture, etc.), may be negatively related to body size (Jaric, Ugarkovic, and Kukoli, 2002; Jaric, 2003).

Our results presented above of the hand gip strength were not normalized; thus, if the strength were evaluated using allometric scaling, different results could be obtained. Additionally, this recommendation was suggested by Noorul, Pieter and Erie (2008).

However, not enough studies exist in the literature that use the allometric normalisation method to explain whether the differences in HGS are due to gender differences, except for one study by Dopsaj et al. (2007). They reported there are HGS differences as a function of gender when HGS was evaluated via the allometric normalisation method as in this study.

In conclusion, this study confirmed that there are differences in the HGS as a function of gender when evaluated by both the TM and ANM.

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