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Short Communication

Gender-specific reference values of dynamometric and non-dynamometric trunk performance in individuals with different body fat percentages: A preliminary study

Shiksha Tangri[1], Kanu Goyal[1], Manu Goyal[1*] and Mayur Wanjari[2*]

[1]Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi, Markandeshwar (Deemed to be University), Mullana-Ambala, India; [2]Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Maharashtra, India

*Corresponding authors: manu.goyal@mmumullana.org (MG) and wanjari605@gmail.com (MW)

Abstract

Trunk muscles maintain steady effort with adequate strength and endurance. When the muscle performance is subpar, it might cause lower back discomfort. No reference for trunk strength and endurance has been established previously. The aim of this study was to determine the normative reference values for dynamometric and non-dynamometric tests in people with various body fat percentages. Two hundred sixty-four participants aged 19–40 years old were recruited in this cross-sectional study. The Siri equation was used to calculate the individuals body fat proportions, which were divided into normal, high, and very high body fat for men and women. The Modified Sorenson's and the Back-Leg-Chest Dynamometric tests were utilized to measure muscular performance. The means of strength in females with normal, high, and very high body fat percentages were 27.39, 25.75, and 25.37 N/m^2, respectively. The males in the same category had the means of 56.48, 51.79, and 60.17 N/m^2, respectively. The highest mean of endurance in females was in those with normal body fat percentage (42.28), so did males (71.02). Our findings suggest that males had higher trunk muscle strength and endurance than females, and normal-body-fat individuals had the greatest endurance regardless of gender.

Keywords: Trunk muscles, trunk performance, dynamometric, non-dynamometric, reference value

Introduction

Muscle performance refers to a muscle capacity and ability to complete tasks [1]. Strength and endurance are the essential components that constitute physical performance [2]. The inability of the trunk muscles is the most prominent cause of lower back pain [3]. Trunk muscles are necessary for performing everyday tasks, including sitting, standing, carrying things, and moving large objects; hence, a lack of strength and endurance in trunk muscles may contribute to the symptoms of low back pain [4]. The affected trunk muscles might diminish spinal function and mobility in any condition. This is certainly relevant when the spine cannot tolerate forces generated by various motions, which results in an enhanced transfer of spinal stresses [5,6]. Spinal stiffness, a decline in muscle strength and endurance, and a loss in neuronal transmission are the main effects of muscle deconditioning [7]. Trunk muscle strength rapidly decreases as age advances [8]. Flexion was dramatically reduced after 60 years old, and extension was dropped after 70 years [9]. As age exceeds 80, flexion and extension in males and females decline by 49.1%, 63.5%, 60.7%, and 68.4%, respectively [9].

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Muscle strength is currently measured with manual muscle testing (MMT), but it is less effective in identifying subtle changes [10]. Therefore, the back-leg-chest dynamometer, which is based on length tension [11,12] and force-velocity relationships [13], is used to assess the isometric strength of the trunk muscles and the endurance was evaluated with the Modified Sorenson's Test [14]. These measurements prevent truncal musculature deconditioning and monitor the progress of muscular strength and endurance through various rehabilitation processes. However, no literature demonstrates the standard values of trunk performance used in individuals according to the body fat proportion. The aim of this study was to determine the normative reference values of trunk performance using dynamometric and non-dynamometric tests in males and females with different body fat percentages.

Methods

Study setting and participants

Healthy male and female individuals aged A cross-sectional study was conducted in academic institutions and a local community between May 2022 and April 2023. The study was based on the National Ethical Guidelines for Biomedical Research Involving Human Participants 2017 and the 2013 revision of the Helsinki Declaration's rules. This study has been prospectively filed with the Clinical Trial Registry of India (CTRI/2022/08/045127).

Healthy male and female aged 19–40 years were recruited. Those individuals who agreed to participate were asked to undergo the screening procedures. A total of 350 volunteers were gathered, and 264 met the inclusion criteria. Those with bone disorders (e.g., osteoporosis, osteomyelitis), joint disorders (e.g., osteoarthritis, rheumatoid arthritis), metabolic disorders (e.g., diabetes, thyroid disorder), history of fractures, surgeries, and compromised cognitive status were excluded. The examinations were not conducted on the same day if certain factors coincided prior to the examinations: sleep deprivation from three consecutive nights) [18], meal intake four hours beforehand [19], travel history for more than three hours [20], caffeine consumption an hour earlier, menstruation, physical complaints, mood issues, medications affecting performance, and strenuous exercise [21].

Procedures and data collection

Following the screening, the participants were divided into three categories based on their body fat percentage: normal, high, and very high body fat percentage (for men <8% is low, 8–20 % is normal, 21–25% is high and >25% is very high; for women <21% is low, 21–33% is normal, 34–39% is high and >39% is very high). Age, gender, height (measured using a stadiometer) [15], weight (measured using a weighing machine) [15], and body mass index (BMI) [16] were recorded in demographic data. The thickness of the biceps, triceps, iliac crest, and subscapular skin fold were measured using a skin fold caliper, and the body fat was calculated using the Siri equation [17]. The Modified Sorenson's and Back-Leg-Chest Dynamometric tests were used to measure muscle endurance and strength, respectively. The participants were briefed three times before the tests. The participants' weight lifts were measured in kilograms (kg) for the strength test, and the duration of holding a position for the endurance test was recorded in seconds using a mobile stopwatch.

Muscle strength and endurance measurements

The Back-Leg-Chest Dynamometric and Modified Sorenson's tests were used to measure muscle strength and endurance, respectively. In the Back-Leg-Chest Dynamometric test, the participants were instructed to stand on the footplate of the dynamometer, grab the handlebar at the level of the simian line with the extended elbows, and flex their hips over their extended knees [22]. The handle was positioned at the level of tibial tuberosity. The participants then pulled the grip by holding the instructed position. During Modified Sorenson's test [23], the participants were asked to lie prone on the treatment table by positioning the iliac crest to the edge of the table [23]. The participants' ankles, knees, and hips were strapped together while crossing both arms across their chests and putting their elbows on a chair. The participants were asked to maintain the horizontal position with their arms crossed and paralleled to the ground as long as they could after the timer started.

Statistical analysis

The normality of the data was determined using the Kolmogorov-Smirnov test. The descriptive statistics to quantify the normative reference values of dynamometric and non-dynamometric tests of different body fat percentages were presented in mean (SD) and median (IQR). The data was analyzed using SPSS (IBM, New York, USA).

Results

Participants' characteristics

Out of a total of 264 participants, the height ranged from 1.47 to 1.87 m (median 1.63, IQR 0.12) with the weight ranged from 46 to 120 kg (median 68, IQR 15). The median body fat percentage was 24.8% (range 18.1–42.7, IQR 7.4) (**Table 1**).

Table 1. Demographic characteristics of healthy individuals included in the study (n=264)

Demographic variable	Median (interquartile range)	Geometric mean (95% confidence interval)	Range
Age (years)	29.5 (11.0)	28.7 (28.7–30.2)	19–40
Height (m)	1.63 (0.12)	1.63 (1.62–1.64)	1.47–1.87
Weight (kg)	68 (15.0)	67.6 (67.1–70.1)	46.0–120.0
Body mass index (kg/m^2)	25.3 (5.4)	25.3 (25.1–26)	18.4–41.5
Body fat (%)	24.8 (7.4)	26 (25.8–27.3)	18.1–42.7

Muscle strength and endurance based on body fat percentage in females

The normal-body-fat females had the highest mean of strength (27.39 N/m^2), ranging from 10 to 110 N/m^2. The strength differed slightly between the high- and very-high-body-fat females (25.75 vs 25.37 N/m^2). The highest mean of endurance was also recorded in the normal-body-fat females (42.28), followed by the high- and very-high-body-fat females (34.96 and 31.07, respectively). The lowest endurance was identified in the high-body-fat females (21.89) (**Table 2**).

Table 2. Comparison of muscle strength and endurance based on body fat percentage in females (n=163)

Variables	Normal body fat percentage (n=118)		High body fat percentage (n=29)		Very high body fat percentage (n=16)	
	GM (95% CI)	Range	GM (95% CI)	Range	GM (95% CI)	Range
Strength (N/m^2)	27.39 (27.36–33.14)	10–110	25.75 (22.75–34.76)	12–83	25.37 (21.89–31.60)	12–45
Endurance	42.28 (42.55–50.36)	20–125	34.96 (32.11–41.06)	23–60	31.07 (27–37.74)	22–58

CI: confidence interval; GM: geometric mean

Muscle strength and endurance based on body fat percentage in males

The normal-, high-, and very-high-body-fat males had the means of muscle strength of 56.48, 51.79, and 60.17 N/m^2, respectively. The normal-body-fat males had the highest endurance (71.02), followed by the high- (61.80) and very-high-body-fat males (54.86) (**Table 3**).

Table 3. Descriptive statistics of different body fat percentages in males (n=101)

Variables	Normal body fat percentage (n=21)		High body fat percentage (n=50)		Very high body fat percentage (n=30)	
	GM (95% CI)	Range	GM (95% CI)	Range	GM (95% CI)	Range
Strength (N/m^2)	56.48 (49.36–77.21)	20–125	51.79 (49.41–63.30)	20–123	60.17 (55.48–79.78)	25–137
Endurance	71.02 (63.74–84.91)	38–123	61.80 (59.84–74.55)	20–123	54.86 (49.61–66.45)	34–150

CI: confidence interval; GM: geometric mean

Discussion

The trunk musculature assessment is essential to successfully perform everyday activities without disturbance [24]. The normative reference of trunk strength and endurance as an assessment criterion is necessary to identify the early deconditioning changes, prevent suffering pain, and plan rehabilitation protocols to prevent the disability. The lower back discomfort should be analyzed by utilizing the reference to impede complaints regarding quality of life. The available literature contains reference values for dynamometric and non-dynamometric tests and studies to identify the correlation between strength and endurance among children and school-aged adolescents [25,26], young individuals [27,28,29], and the elderly population [30,31]. The reference for gender-specific values in accordance with different body fat percentages has not been available.

Of the 264 individuals in this study, the median age was 29.5, ranging from 19 to 40 years (IQR 11). It has been reported that the prevalence of degenerative changes and muscle atrophy occurs after age 40, so further ages were excluded [1,32]. Another study explained that peak muscle strength pertains between the ages of 25 and 30 in each gender and declines gradually thereafter [31]. One of the underlying mechanisms is that older age has been associated with a decreased number of type II muscle fibers, which are mainly responsible for muscle strength [1].

We revealed that overall men had higher muscle strength and endurance compared to women. This result is different from a study consisting of 70 men and 53 women, which reported higher muscle strength in men than women but the opposite in muscle endurance [33]. This finding is also not in line with a narrative review that reported women generally had approximately 14%–17% more type I muscle fiber, which is predominantly responsible for muscle endurance [29]. The annual median of muscle mass decline in women was lower than in men (0.37% vs 0.47%). The muscle mass is correlated with the decreasing strength per day of 0.3% in women and 4.2% in men [1]. The deterioration of muscle performance is accelerated by muscle atrophy later in life [1]. Our finding might underline that body fat affects muscle strength and endurance performance. Body fat was mostly found in women, as reported in several studies conducted in India [33, 34], China [35], Indonesia [36], and Europe [37]. A hypothesis explained that the body fat in muscles might immediately restrict blood perfusion, slowing the metabolism needed for muscle contraction. The fat component might also impair the muscle force, particularly if it is located at the angle of pennation and aponeurosis of the muscle [38].

We found that the highest mean of strength (27.39 N/m^2, ranging from 10 to 110 N/m^2) and endurance (42.28, ranging from 42.55 to 50.36) was identified in the normal-body-fat females in this study. The lowest mean of these two variables was observed in the very-high-body-fat females. High body fat deteriorates endurance performance, yet great muscle mass is crucial for strength and power activities [15]. Body fat decreases muscle force by increasing muscle resistance during contraction [38]. This explanation does not support our finding in the very-high-body-fat males with the highest muscle strength (60.17 N/m^2) compared to the normal- and high-body-fat males (56.48 vs 51.79 N/m^2). On the contrary, the very-high-body-fat males had the lowest muscle endurance, followed by the high- and normal-body-fat males (61.80 and 71.02), respectively. The fat-free mass might contribute to the more prominent muscle strength of the individuals in the group of very-high-body-fat males. This group was also more qualified than normal-body-fat males in strength-related exercises compared to aerobic ones, which require more endurance [39,40].

This study has several limitations. First, the sample size was relatively small, which implies that the results might not be generally applied to all individuals according to their body fat proportion. Second, biased results were possible when only one assessor evaluated the tests. Third, the Siri equation has been reported in another study to be less accurate [17], indicating that the participants in this study might have biased categorization of body fat percentages.

Conclusions

The normative reference of dynamometric and non-dynamometric trunk performance in males and females based on different body fat percentages was conducted through this study. In general, males across all percentages of body fat had higher trunk muscle strength and endurance compared to females. The normal-body-fat participants from both genders had the highest endurance. The highest strength in females and males was in the normal- and very-high body fat categories, respectively.

Ethics approval

The Institutional Ethics Committee of the Maharishi Markandeshwar (Deemed to be University) approved the study protocol (IEC number 2225).

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Competing interests

The authors declare no conflict of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

How to cite

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