Brief Research Article

The Reference Values for Muscle Mass and Strength in Healthy Indian Adults Using Whole-Body Potassium Counter and Isokinetic Dynamometer

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Summary

The study aims to define the sex-based reference data for muscle mass and strength among healthy young Indians and to compare the data from the present study with available literature. Healthy Indian adults ($n = 100$) aged between 18 and 40 years were recruited. The assessment of muscle mass and strength was performed. The body cell mass (BCM), fat-free mass, and muscle strength parameters were significantly higher among males compared to females ($P < 0.001$). A comparison of the current study data with the available literature showed that though BCM was comparable, Indians demonstrated a significantly lower isometric peak torque ($P < 0.001$ for both sexes). These findings suggest that Indians tend to have a lower muscle strength compared to the Western population, despite having a comparable BCM content.

Key words: Body cell mass, fat-free mass, isometric peak torque, physical activity level, sex-based reference

Human muscle plays a key role in the ability of a person to perform activities. Loss of muscle (sarcopenia) has been associated with increased mortality and is often reported with aging and chronic diseases. The paucity of data on sarcopenia among Indians could be attributed to a lack of reference data. In addition, recent evidence has suggested skeletal muscle changes to be one of the mechanisms contributing to the development of non-communicable diseases (NCDs).[1] Increased rates of NCDs among Indians are making it important to explore the role of muscle in NCDs. The problem gets amplified when age-related sarcopenia is associated with NCDs. The quality of life gets impacted leading to a reduction in the survival rate.

Indians have been considered to possess poor muscle mass and strength compared to the Western population. However, there is a scarcity of concrete evidence to support this finding. The present study, in this direction, will be exploring healthy young adults (both sexes) and compare the data with available literature. The sex-based differences in muscle mass and function also need attention as differences in muscle fiber composition, performance, force generation, relaxation, endurance, and muscle recovery between the two sexes have been noted.[2] Therefore, it is imperative to determine the sex-based reference data for muscle mass and strength from a healthy young population. Most of the studies among the Indian population for studying muscle mass and/or strength have used methods such as bioelectrical impedance analysis or handgrip strength assessment; however, the use of accurate methods such as whole-body potassium counting and isokinetic dynamometry is lacking. The whole-body potassium counter (WBKC) is the most accurate method of measuring body cell mass (BCM).

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BCM constitutes a large proportion of the fat-free mass (FFM), consisting of the fat-free portion of cells within the viscera, muscles, and immune system. The present study, therefore, aims to define the sex-based reference data for muscle mass and strength among healthy young Indians using accurate techniques such as the WBKC and isokinetic dynamometer and to compare the present data with available literature.

One hundred healthy young Indian adults (n = 55 females and n = 45 males) in the age group of 18–40 years were recruited from in and around St John's Medical College, Bengaluru, India. Participants were excluded based on any known history of chronic diseases, anemia, peripheral neuropathy, muscular dystrophy, any form of joint injury, or osteoarthritis. Participants were recruited after obtaining written informed consent. The study protocol was approved by the Institutional Ethics Committee (reference number: 122/2019). The physical activity level (PAL) of the enrolled participants was evaluated using a validated questionnaire. Anthropometric measurements were carried out for all participants using standard protocols. The measurement included height, weight, waist, and hip circumferences. The waist–hip ratio (W:H) was calculated from the above measures. All participants also underwent the estimation of total body potassium (TBK) using the WBKC. For this measurement, the participants were requested to lie in a supine position. The WBKC measured the TBK content from which the BCM was calculated using the following formula: BCM (kg) = (92/391) × TBK (g). The precision and accuracy of the machine used were 1.9% and 2.8%, respectively. The total body water (TBW) content required for the calculation of the FFM from BCM was obtained from an earlier study conducted by Kuriyan *et al*. on a similar population,[3] following which the FFM and fat mass for the participants were calculated. The BCM index (BCMI), an indicator of muscle mass and nutritional status, was derived by dividing the BCM (in kg) by height (in m) squared (kg/m^2). Muscle strength of the right knee extensor muscle was measured using the isokinetic dynamometer (Kin Com AP1, Chattanooga Group, Tennessee, USA). Five readings were recorded, out of which the highest reading was considered the isometric peak torque. Three angular velocities, 60°, 120°, and 180°/s, were used for assessment of the peak isokinetic strength. A comprehensive literature search was performed for the data to compare the BCM and isometric peak torque between the Indian and Western populations.

Among 100 recruited participants, 4 participants' data could not be included in the final analysis (3 were outliers and 1 technical error). All data were represented as mean and standard deviation (SD) with 95% confidence interval (CI). Independent t-test was used to compare the variables between sexes. Multiple linear regression analyses were performed to determine the association of BCM and isometric peak torque with PAL, age, and sex. One sample t-test was used to compare the current study results with available literature. The level of significance was set at 0.05. The statistical analyses were performed using SPSS version 25 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.).

Among the 96 adults studied, 44% were male and 56% were female. The mean age was comparable between males and females. PAL was significantly higher among males compared to females ($P < 0.001$) whereas the waist circumference (70.3 ± 10.2 cm for males and 76.9 ± 10.5 cm for females) and W: H (0.75 ± 0.09 for males and 0.82 ± 0.07 for females) were significantly higher among females ($P < 0.01$). No significant difference was noted in hip circumference between males and females. The mean TBK, BCM, BCMI, FFM, and muscle strength were significantly higher in males ($P < 0.001$) except fat percentage which was higher in females ($P < 0.001$). The sex-specific reference data for the above mentioned measures are presented in Table 1. In the multivariable results, PAL was found to have a significant association with BCM adjusted for age and sex (β =7.51 and 95% CI = 0.68–14.3, P = 0.03). PAL had a significant association with isometric peak torque adjusted for age (β =63 and 95% CI = 22.4–103.7, $P < 0.01$) but not sex (β =23, 95% CI = 12.3–58.3, P = 0.19). A comparison of the present study results with the Western populations is demonstrated in Figure 1. BCM content was comparable between the Western and Indian populations; however, Indians demonstrated a significantly lower isometric peak torque compared to the different populations studied ($P < 0.001$).

The present study represented the sex-based reference data for muscle mass and strength among healthy young Indians using accurate techniques and compared the reference values from the present study with available literature. Scientific literature has iterated the need to establish reference values that take into account the age and sex of the population. Studies exploring the sex differences in muscle mass and strength have found significant differences among the muscle cross-sectional areas and absolute strength between the two sexes. Previous literature has shown significantly higher FFM and isometric and isokinetic peak torques among males compared to females in Indian as well as other populations which is in line with our findings.[4,5] A novelty in our study is the use of the WBKC for the assessment of muscle mass. BCM estimation provides a suitable and more sensitive alternative to anthropometric measurements. The BCM adjusted for height (BCMI) when compared across different individuals is a powerful tool to assess nutritional, inflammatory, and muscle mass status.[6] The BCMI has been used by Kyle *et al*. as a novel index for the determination of sarcopenia among the elderly, where a cutoff of − 2SD from the sex-specific mean of BCMI derived from a young healthy adult population such as ours has been used to determine the degree of muscle loss with age.[7] A comparison of our Indian study data with that of the Western populations demonstrated a significantly lower isometric peak torque among Indians compared to others, even while maintaining an almost comparable BCM content. This observation may be explained by a significantly higher intramyocellular fat content observed among Indian adults as found by Sucharita *et al*.[8] The current study assessed certain physiological factors such as PAL, age, and sex affecting BCM and isometric peak

Table 1: Comparison of reference values with 95% confidence interval for body composition and muscle strength parameters between males and females

Parameter	Male ($n=42$)			Female ($n=54$)			*P*
	Mean±SD	95% CI		Mean±SD	95% CI		
		Lower bound	Upper bound		Lower bound	Upper bound	
Age (year)	23±6	21	25	22±4	20	23	0.181
Height (m)	1.72±0.06	1.70	1.74	1.58±0.05	1.56	1.59	<0.001
Weight (kg)	69.4±12.5	65.5	73.3	55.2±8.08	52.9	57.4	<0.001
BMI (kg/m^2)	23.3±4.06	22.1	24.6	22.2±3.33	21.3	23.1	0.125
TBK (mmoL)	3646.0±608.2	3456.5	3835.5	2398.7±538.1	2251.8	2545.5	<0.001
BCM (kg)	33.5±5.59	31.8	35.3	22.1±4.95	20.7	23.4	<0.001
BCM (%)	49.0±7.22	46.7	51.2	40.1±6.66	38.2	41.9	<0.001
BCMI (kg/m^2)	11.5±2.50	10.7	12.3	8.90±2.16	8.31	9.49	<0.001
Fat (%)	22.6±2.06	22.0	23.3	33.7±1.90	33.1	34.2	<0.001
FFM (kg)	53.5±8.95	50.8	56.3	36.6±5.42	35.1	38.1	<0.001
Isometric peak torque (Nm)	115.6±32.7	105.4	125.8	74.6±20.7	69.0	80.3	<0.001
Isokinetic at 60° (Nm)	91.6±25.9	83.5	99.7	58.7±24.5	52.0	65.4	<0.001
Isokinetic at 120° (Nm)	90.9±27.4	82.4	99.5	57.0±25.9	50.0	64.1	<0.001
Isokinetic at 180° (Nm)	84.6±26.3	76.4	92.8	53.4±25.3	46.5	60.3	<0.001

Significance at $P<0.05$; independent *t*-test. TBK: Total body potassium, BCM: Body cell mass, BCMI: BCM index, FFM: Fat-free mass, CI: Confidence interval, BMI: Body mass index, SD: Standard deviation

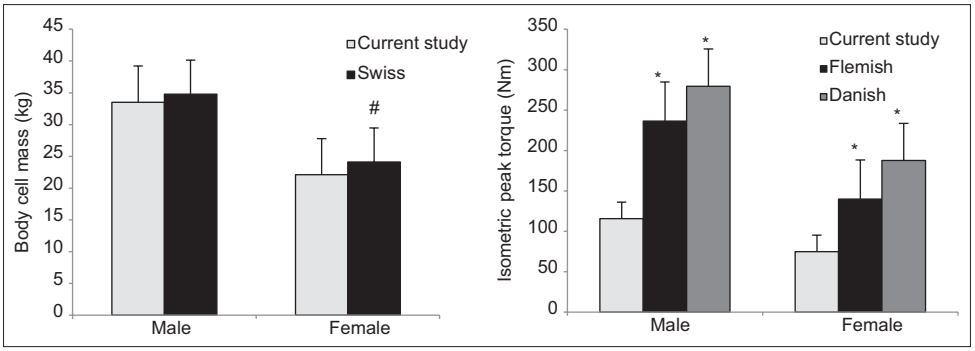

Figure 1: Comparison of muscle mass (BCM) and muscle strength (isometric peak torque) between Indian (current study) and Western populations from available literature. Matched for age and sex $^{\#}P < 0.01$, $^{*}P < 0.001$. Swiss population data: Kyle UG *et al*. Eur J Clin Nutr. 2001;55 (8):663-672; Flemish population data: Van Roie E *et al*. Exp Gerontol. 2018;110:260-266; Danish population data: Harbo T *et al*. Eur J Appl Physiol. 2012 Jan; 112 (1):267–75. BCM: Body cell mass.

torque. Both BCM and isometric peak torque were found to be significantly associated with PAL. This finding is supported by Andreoli *et al*. where they showed a significantly lower amount of BCM with lower PAL.[9] This is not surprising given that the BCM is a representative of the muscle mass and muscle mass has also been observed to be greatly affected by PAL. With regard to muscle strength, even though PAL plays an important role in its development and maintenance, this role appears to be smaller compared to the role played by sex. This is in line with previous research published by Leblanc *et al*. in 2015.[10] One of the limitations of the study of this study is the unavailability of the individual TBW content of the participants.

In conclusion, the study among young healthy Indians determines a sex-based reference for muscle mass and strength using highly accurate techniques. The findings of this study suggest that Indians possess significantly lower muscle strength compared to the Western population in spite of having a comparable BCM content, pointing toward the need to explore intramyocellular fat deposition in this population.

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Conflicts of interest

There are no conflicts of interest.

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