Original
ISSN 2521-8492

An Assessment of Anthropometric Measurements of Upper and Lower Limbs Among Female Students of Iranian Population

Tayebeh Rastegar[1*], Mohammadreza Ebrahimzade[1], Saba Behzadifard[1], Ameneh Alikarami[1], Fatemeh Taghizadeh[1], Mehdi Alididi[1], Golaleh Noorzehi[2]

[1]Department of Anatomy, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.
[2]School of Medicine, International Campus, Tehran University of Medical Sciences, Tehran, Iran.
*Correspondence to: Tayebeh Rastegar (E-mail: trastegar@tums.ac.ir)
(Submitted: 24 September 2022 – Revised version received: 11 October 2022 – Accepted: 21 October 2022 – Published online: 26 December 2022)

Abstract

Objectives: This study aimed to measure upper and lower limb dimensions among female students of Tehran University of Medical Sciences and determine the relationship between brachial and crural indices as anthropometric indices of limbs and Body Mass Index (BMI).

Methods: In this descriptive-cross sectional study, anthropometric parameters of the upper and lower limbs were evaluated among 200 Iranian female student volunteers aged 18–38 with no physical or developmental deformity. The collected data were analyzed by GraphPad Prism software.

Results: Pearson correlation and simple linear regression tests were used to find the relationship between measured anthropometric indices. Mean ± Standard deviation (SD) of age and BMI were 23.65 ± 4.97 and 24.59 ± 4.14, respectively. The brachial and crural indices were 89.47 ± 9.352 and 76.37 ± 5.320, respectively. No statistically significant association was found between brachial and crural indices and BMI. In addition, we found a significant positive correlation between wrist dimensions and BMI. The results of the present article determined the relationship between BMI and anthropometric parameters of the upper and lower limbs.

Conclusion: Our findings supported the close relationship between wrist dimension and BMI.
Keywords: Iran, population, anthropometry, body mass index, brachial index, crural index

Introduction

Anthropometry is a simple and noninvasive tool to estimate human body dimensions. Anthropometric database is widely used in ergonomics design, forensic medicine and health status.[1,2] Anthropometric features and body composition are known to be the essential requirements in sports performance.[3] In addition, the relevance of anthropometric indices (body ratios) such as body mass index (BMI) to risk factors of diseases such as cardiovascular disease highlight the importance of anthropometric parameters.[4] Anthropometric measurements of skeletal remains play a critical role in predicting evolutionary changes in modern human over the time.[5] Anthropometric differences among people as a result of genetic and environmental factors have been investigated in many populations. The concept of geographic variation is generally based on Allen's rule and Bergmann's rule which explain association of body proportions and body mass are strongly influenced by climatic and nutritional conditions.[6] In cold climates, shorter limb proportions and higher BMI values indicate an adaptation to retain body heat. On the other hand, in hot environments body shapes beside limb lengths tend to be much longer and narrower in order to lose heat effectively.[7]

Limb segment lengths and proportions, especially long bones may give anthropologists useful information including stature, gender, age and race. Variation in tibia length is assumed to be more significant than other segments.[8] Tibio-femoral (crural) index is known as tibial length divided by femur length. Radio-humeral (brachial) index is defined as the ratio of radius length to humerus length.[9] Three categories have been suggested to classify brachial index: Brachycerish (Short forearms), Mesocerish (Medium forearms), Dolicocerish (Long forearms).[10] Lower intralimb indices appear in Japanese and higher one in American negro population.[9] Indeed, it is all-important to establish a comprehensive database of anthropometric data to compare with other populations.

In Iranian population, the majority of the research have been conducted to determine stature estimation using length of limb segments.[11,12] Furthermore, anthropometric variation between a large group of Iranian ethnicities and other Asian population have been studied.[13] However, there are not enough reports about crural and brachial indices in Iranian population. Therefore, we aimed to evaluate limb lengths, brachial and crural indices based on standard anthropometric landmarks in a population of female students. We analyzed the correlation between mentioned indices and BMI.

Materials and Methods

In this descriptive cross-sectional study, a total of 200 healthy female students of Tehran university of medical sciences both undergraduate and postgraduate were selected randomly. Data collection process carried out in June 2022 by one measurer and one recorder. Age, weight and height were recorded. Other anthropometric parameters of right upper and lower limbs (Table 1) were measured by a standard tape measure in an anatomical position. The measurement techniques were performed according to The International Society for the Advancement of Kinanthropometry (ISAK) standards through palpating skeletal landmarks[14] (Table 2). The indices were calculated as follows:[9]

BMI = weight in kg/[height in cm × height in cm]

Table 1. **Anthropometric dimensions used in the study**

Upper limb length	Distance between acromiale- dactylion landmarks
Humerus length	Distance between acromiale- radiale landmarks
Radial length	Distance between radiale- stylion landmarks
Hand length	Distance between mid-stylion and dactylion landmarks
Wrist breadth	Distance between the radial and ulnar styloid processes
Hand breadth	Distance from distal end of 5th to 2nd metacarpal bones
Wrist girth	Distance around radius and ulna just distal to the styloid processes
Lower limb length	Distance between trochanterion- lateral malleolus
Femur length	Distance between trochanterion- tibiale laterale landmarks
Tibia length	Distance between tibiale mediale- Sphyrion tibiale landmarks
Foot length	Distance between akropodion- Pternion landmarks
Inter-ASIS* breadth	Distance between ASIS landmarks
Bi-trochanteric breadth	Distance between trochanteria landmarks
Ankle breadth	Distance between lateral and medial malleoli
Foot breadth	Distance between the distal end of 1st to 5th metatarsal bones
Ankle girth	Distance around tibia and fibula just superior to the Sphyrion tibiale

Table 1. **Anthropometric landmarks used in the study**

Landmark	Location
Acromiale	The point on the superior aspect of the most lateral part of the acromion border
Radiale	The point at the proximal and lateral border of the head of the radius.
Stylion	The most distal point on the lateral margin of the inferior head of the radius.
Mid-stylion	The midpoint, on the anterior surface of the wrist, of the horizontal line at the level of the Stylion
Dactylion	The tip of the middle (third) finger
Trochanterion	The most inferior or undermost tip of the anterior superior iliac spine
Iliospinale	The most superior point on the greater trochanter of the femur, not the most lateral point.
Tibiale laterale	The most superior point on the lateral border of the head of the tibia.
Tibiale mediale	The most superior point on the medial border of the head of the tibia.
Sphyrion tibiale	The inferior aspect of the distal tip of the medial malleolus.
Akropodion	Anterior point on the longest toe
Pternion	Most posterior point on the heel of the foot

Brachial index = (radius length in cm × 100)/humerus length in cm

Crural index = (tibial length in cm × 100)/femur length in cm

Measured brachial indices less than 75, 75–79.9, and ≤80 was considered as brachycerich, mesocerich and dolicocerich, respectively. The statistical analysis was done using GraphPad Prism software (version 9.2). Descriptive statistics analysis included frequency, percentage and mean ± standard deviation (SD). Pearson correlation and simple linear regression tests were applied to assess the relationship between BMI, crural and brachial indices. The significance level was set at <*P* value 0.05.

Results

The age ranged from 18 to 38 (23.65 ± 4.97). Mean weight was 60.86 ± 10.29 and mean stature was 164.30 ± 5.60. Descriptive statistics of measured dimensions are summarized in Table 3. The obtained crural and brachial indices were 89.47 ± 9.352 and 76.37 ± 5.320, respectively. Most of the subjects (39.50%) were in mesocerich category. In Figure 1, the frequency of each category is reported. The distribution of brachial index categories in comparison to BMI values are shown in Figure 2. The mean of BMI was 24.59 (SD ± 4.14). There was not any statistically significant relationship between BMI and crural and brachial indices ($P = 0.19$ and $P = 0.29$, respectively). However, Pearson Correlation and between wrist girth and BMI ($P < 0.0001$, $r = 0.477$) and wrist width and BMI ($P < 0.0001$, $r = 0.3903$) was strongly significant. In addition, simple linear regression test was strongly significant between wrist girth and BMI ($P < 0.0001$, Equation: $Y = 0.1610^{*}X + 11.46$) and wrist width and BMI ($P < 0.0001$, Equation: $Y = 0.1100^{*}X + 6.054$) (Figure 3).

Table 3. **Descriptive statistics of the limb dimensions in iranian female university students**

Dimensions (Cm)	*N* = 200	
	Range	Mean ± SD
Upper limb length	49.00–80.00	69.09 ± 4.31
Humerus length	26.00–38.00	32.70 ± 2.16
Radial length	20.00–29.00	24.90 ± 1.58
Hand length	15.00–21.00	17.54 ± 0.96
Wrist breadth	6.00–12.50	8.759 ± 1.16
Hand breadth	7.00–10.00	8.295 ± 0.55
Wrist girth	13.00–19.00	15.42 ± 1.06
Lower limb length	66.00–90.00	78.18 ± 4.47
Femur length	32.00–53.00	40.50 ± 3.87
Tibia length	29.00–43.00	35.97 ± 2.50
Foot length	19.00–27.00	23.22 ± 1.25
Inter-ASIS breadth	22.00–42.00	30.72 ± 3.56
Bi-trochanteric breadth	31.00–74.00	47.95 ± 5.31
Ankle breadth	9.00–20.00	12.19 ± 1.12
Foot breadth	8.00–13.00	10.56 ± 0.76
Ankle girth	10.00–28.00	22.6 ± 2.301

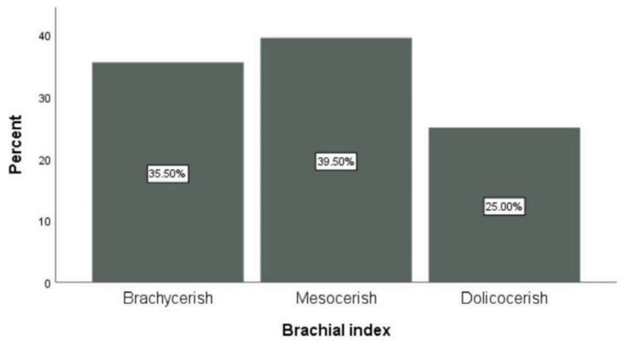

Fig. 1 **Brachial index in Iranian female university students.**

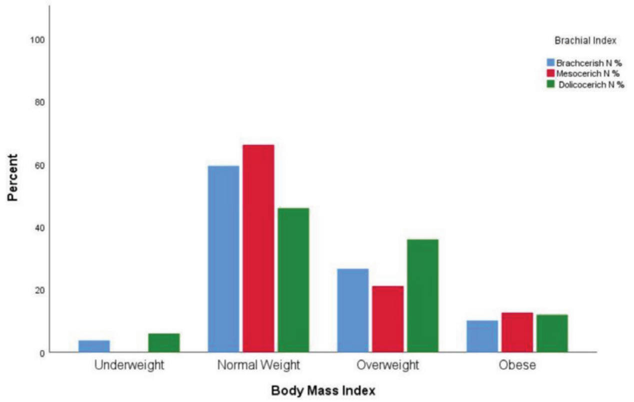

Fig. 2 **Distribution of brachial index based on BMI categories.**

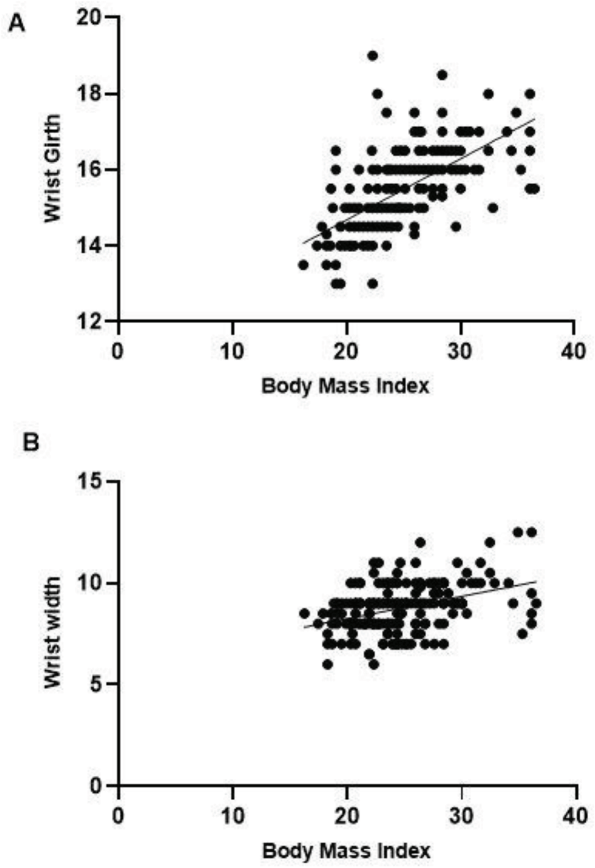

Fig. 3 **Simple linear regression analysis of A) wrist girth and BMI and B) wrist width and BMI.**

Discussion

In the present article, we measured anthropometric variable of limbs in a sub-group of Iranian population. Correlation between our subjects' limb indices and BMI was non-significant. There was a direct and positive relationship between wrist dimensions and BMI. The association of Carpal Tunnel Syndrome (CTS), the most common neuropathy due to median nerve entrapment, with BMI has been reported in previous studies.[15] Both BMI and intralimb indices are influenced by various factors such as lifestyle, nourishment habits, genetics and climatic conditions. High value of BMI is an indicator related to health problems including cardiovascular disease and diabetes type 2.[16] We should mention this point that the mean of BMI of our subjects demonstrated a trend toward overweight range. Indeed, more investigations and consideration may help to monitor public health status and prevent the consequences of obesity in our society.

Msculoskeletal disorders (MSDs), a common work-related illness, can affect joints, bones and soft tissue of upper and lower limbs.[17] Some studies have been carried out among Iranian population to explore the impact of workstation design on Msculoskeletal disorders prevalence.[18, 19] Regardless of the incorrect posture, musculoskeletal problems as a result of inappropriate design of workplaces reflect the key role of taking anthropometric consideration in ergonomics design.

A wide body of research has supported Bergmann's rule and Allen's rule defined as adaptation to climate via body proportions.[6,20] Our results indicate that forearm is predominantly in mesocerish (median forearm) category. Current available literature in Iran investigated limb segments lengths nearly close to our findings.[21,22] A comprehensive data bank is provided through combination of the main previously reports by Saremi et al.[23] Our 75th percentile of hand length and hand breadth (18.00 cm and 9 mm, respectively) were similar to that of their results (189 mm and 80 mm). In addition, we measured the foot length and foot breadth 23.22 cm and 10.56 cm, respectively. Saremi et al has reported these as 236 mm and 91 mm. We could not compare our measured indices to the literature because there are not enough evidences based on brachial and crural indices in our country. This article conducted to fill this point as much as possible. Moreover, it seems essential to update anthropometric data bank as a matter of time progression.

The main limitation of this research was to evaluate intralimb indices only in female subjects. It thus seems necessary to assess mentioned indices in larger groups of people. In addition, traditional method technique can be more reliable if the subjects present themselves in minimal clothing.

Conclusion

As a conclusion, the measurements found in present article may help in comparing the anthropometric limb values with those of other populations, designing body prosthesis and furniture products.

Conflict of Interest

The authors declare that there is no conflict of interests.

References

1. Padilla CJ, Ferreyro FA, Arnold WD. Anthropometry as a readily accessible health assessment of older adults. Experimental Gerontology. 2021;153:111464.
2. Gupta D. Anthropometry and the design and production of apparel: an overview. Anthropometry, Apparel Sizing and Design. 2014:34–66.
3. Silva AM. Structural and functional body components in athletic health and performance phenotypes. European Journal of Clinical Nutrition. 2019;73(2):215–24.
4. Martins MV, Ribeiro AQ, Martinho KO, Franco FS, de Souza JD, de Morais KBD, et al. Anthropometric indicators of obesity as predictors of cardiovascular risk in the elderly. Nutricion Hospitalaria. 2015;31(6):2583–9.
5. Wróbel G, Spałek J, Zieliński P. Anthropometric aspects of the human skeleton. Journal of Education, Health and Sport. 2017;7(12):602–11.
6. Leonard WR, Katzmarzyk PT. 10 Body Size and Shape: Climatic and Nutritional Influences on Human Body Morphology. Human Evolutionary Biology. 2010:157.
7. Cowgill LW, Eleazer CD, Auerbach BM, Temple DH, Okazaki K. Developmental variation in ecogeographic body proportions. American Journal of Physical Anthropology. 2012;148(4):557–70.
8. Tatarek NE, Sciulli PW. Anthropological analysis of the lower extremity. Forensic Medicine of the Lower Extremity: Springer; 2005. p. 69–98.
9. Garcia RV. The Brachial and Crural Indices of Modern North American Populations. 2015.
10. Singh S, Singh H, Kaur P. Anthropometric Determination of Radio-Humeral Index in Jammu Region.
11. Akhlaghi M, Hajibeygi M, Zamani N, Moradi B. Estimation of stature from upper limb anthropometry in Iranian population. Journal of Forensic and Legal Medicine. 2012;19(5):280–4.
12. Moshkdanian G, Mahaki Zadeh S, Moghani Ghoroghi F, Mokhtari T, Hassanzadeh G. Estimation of stature from the anthropometric measurement of lower limb in Iranian adults. Anatomical Sciences Journal. 2014;11(3):149–54.
13. Sadeghi F, Mazloumi A, Kazemi Z. An anthropometric data bank for the Iranian working population with ethnic diversity. Applied Ergonomics. 2015;48:95–103.
14. Norton KI. Standards for anthropometry assessment. Kinanthropometry and exercise physiology: Routledge; 2018. p. 68–137.
15. Madani AM, Gari BS, Al Zahrani EM, Al-Jamea LH, Woodman A. A literature review of carpal tunnel syndrome and its association with body mass index, wrist ratio, wrist to palm ratio, and shape index. Journal of Hand Therapy. 2022.
16. Cazares-Manríquez MA, Wilson CC, Vardasca R, García-Alcaraz JL, Olguín-Tiznado JE, López-Barreras JA, et al. A review of carpal tunnel syndrome and its association with age, body mass index, cardiovascular risk factors, hand dominance, and sex. Applied Sciences. 2020;10(10):3488.
17. Nestorova VD, Mircheva IS. Work-related musculoskeletal disorders (WMSDs): risk factors, diagnosis and prevention. Scripta Scientifica Salutis Publicae. 2018;4:15–21.
18. Mohammadipour F, Pourranjbar M, Naderi S, Rafie F. Work-related musculoskeletal disorders in Iranian office workers: prevalence and risk factors. Journal of Medicine and Life. 2018;11(4):328.
19. Tirgar A, Aghalari Z, Salari F. Musculoskeletal disorders & ergonomic considerations in computer use among medical sciences students. Iranian Journal of Ergonomics. 2014;1(3):55–64.
20. Longman DP, Murray AM, Roberts R, Oakley S, Wells JC, Stock JT. Ultra-endurance athletic performance suggests that energetics drive human morphological thermal adaptation. Evolutionary Human Sciences. 2019;1.
21. Gh M, Shiasi M, Hassanzadeh G, Alaghebandha N, Dehbashipour A, Zeidi H, et al. Anthropometric characteristics of upper limb in Iranian and Pakistani subjects. Journal of Gorgan University of Medical Sciences. 2014;16(3):80–5.
22. Mirmohammadi SJ, Mehrparvar AH, Jafari S, Mostaghaci M. An assessment of the anthropometric data of Iranian university students. International Journal of Occupational Hygiene. 2011;3(2):85–9.
23. Saremi M, Kazemhaghighi M. Anthropometric Estimations for Iranian General Population. Iranian Journal of Public Health. 2019;48(8):1503.