Brazilian Journal of Forensic Sciences, Medical Law and Bioethics 9(3):308-320 (2020)

Brazilian Journal of Forensic Sciences, Medical Law and Bioethics

Journal homepage: www.ipebj.com.br/forensicjournal

Measurement of Long Bones of Southern Minas Gerais, Brazil: Anthropometric Study

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Received 24 March 2020

Abstract. This study aims to estimate the main measures in long bones of Southern Brazilians adults, and to compare them with those of other ethnicities already cataloged in literature. The measurements were made with an anthropometric ruler and a digital caliper, according to a specific protocol. For this, being the humerus, radius, ulna, femur and tibia (50 specimes of each bone) in which some parameters were measured that allow comparing with existing data in literature. The data shown the mean (cm) and the standard deviation of long bone measured. Femurs are: ML = 46.41 ± 2.35, EW = 7.84 ± 0.57 and HD = 4.43 ± 0.47; Humerus: ML = 33.52 ± 1.45, EW = 6.04 ± 0.39, HD = 4.48 ± 0.24; radios: ML = 26.24 ± 1.51 and APD = 1.58 ± 0.14; ulna: ML = 27.9 ± 1.41 and APD = 1.67 ± 0.10; and tibias: ML = 38.76 ± 2.21, DEW = 5.03 ± 0.38 and DAP = 4.99 ± 0.38. According to results obtained in this study, it is possible to conclude that the values used by forensic anthropology for identification of Southern Brazilian long bones, such as humerus, radius, ulna and tibia, with exception of femurs, do not in fact represent any values already established for some ethnic groups, since the Brazilians presented their own pattern, which was different from the European standard already classified.

Keywords: Forensic sciences; bones; Southern Minas Gerais; Anthropometry.

http://dx.doi.org/10.17063/bjfs9(3)y2020308

1. Introduction

Forensic anthropology represents a dynamic and rapidly evolving complex discipline within physical anthropology. Academic roots extend back to early European anatomists but development coalesced in the Americas through high-profile court testimony, assemblage of documented collections and focused research[1].

The use of anthropometry in forensic science and medicine dates back to 1882, with the need to identify individuals in various circumstances, such as natural, intentional and accidental deaths - war, air crashes, road and rail accidents, earthquakes, floods and fires[2].

The Identification is of paramount importance in forensic cases where decomposed human bodies and human remains are brought to the Medical-Legal Institutes for examination. Bones provide a source of information about the individual's origins, offspring, sex, height, and age at death, helping to establish their identity[3].

Bone anthropometry develops specific patterns in a population for identification of a biological profile in deceased or living individual. These patterns are created from qualitative observations, which compare the morphological differences in skeleton, and quantitative observations, which statistically measure and quantify these differences[4]. Thus, the anthropometric analysis of bones allows us to verify indispensable inferences about identity of victim, in a fast, reliable and accurate way, beyond using low cost equipment[5,6]. However, the methodologies must be validated for different populations due to ethnic differences, which are directly related to individual phenotype[6,7].

The stature of present populations has undergone changes, possibly due to genetic combinations, general conditions of feeding, medical advances and influence of different environmental factors[8]. The most significant results showed that height difference between the highest and lowest populations was 19-20 cm, remaining the same for women and increasing for men a century later, despite substantial changes in ranking of countries[9].

In Brazil, such parameters are used for measurement of bones, but there are no well-defined ethnic groups, causing a misunderstanding in use of these measurements, since they do not respond to Brazilian ethnic miscegenation. Thus, the correct identification of bones by Forensic Anthropology is compromised, as there are no standards that correspond to our population. Based on these facts, the importance in elaboration of Brazilian bone parameters is perceptible, starting from development of scientific research adapted to reality of legal medical Institutes and death verification services of our country.

According to Institute of Applied Economic Research (IAER), there was an increase in rate and number of homicides, from 2006 to 2016, in Brazil[10]. This increase occurred mainly in poorest and least developed states, where resources for the identification of cadavers are often very scarce; so, the criminal experts, both civilian police and scientific technical police, do not have advanced features, such as DNA analysis equipment, and need to use other more simpler methods to do reconnaissance. Also for these reasons, the need for elaboration of more precise Brazilian bone parameters increases, in order to correctly identify individuals.

For reasons presented, this study aims to evaluate the main measures of Brazilian adult long bones and to compare them with those of other ethnicities, already cataloged in the literature, comparing also with the osteometric tables, most used by forensic anthropology[11,12].

2. Material and methods

In this work, were used 250 human natural long bones of young adults between 40 and 50 years, which compose the appendicular skeleton; of these humerus (n=50), radius (n=50), ulnas (n=50), femurs (n=50) and tibias (n=50) of these, 25 bones were on the left side and 25 bones on the right side, being excluded from measurements cut bones or with some anatomical variation.

Correct measurements were performed by a single evaluator at Anatomy Laboratories of Higher Education Institutions in Alfenas city (Southern Minas Gerais). The samples of these Anatomy Laboratories were collected from in the cemeteries of the city of Alfenas respecting the law 1.796 of December 9, 2016.

For the measurement of long bones used in this study, the same pattern of measures was used as referenced[13,14,15]. The measurements of maximum bone length were made with an anthropometric ruler (Carci®, São Paulo, Brasil), with values in centimeters (cm), while the distance obtained between some bone structures was performed with a digital caliper (Marberg®, China), with values in millimeters (mm) and, subsequently, converted to centimeters (cm); and followed the protocol described below:

2.1 Humerus (Figure 1A)

Maximum length (ML): maximum distance obtained as of proximal end, from the head humerus to the distal end condyle of humerus.

Figure 1. Human bones, humerus, ulna and radius, respectively, with areas that were measured, being: **A (Humerus):** ML- maximum length; EW- Epicondillary width; HD- Diameter of the humerus head; **B (Ulna):** ML- Maximum length; APD- Anteroposterior diameter; **C (Radius):** ML- Maximum length; APD- Anteroposterior diameter. Source: Department of Anatomy/ ICB-Unifal-MG.

Epicondyle Width (EW): Maximum distance of humeral distal epiphysis, obtained between the medial epicondyle and lateral epicondyle.

Diameter of the humerus head (HD): Maximum distance from the most superior point on articular margin to the lowest point on margin of this surface, in humerus head.

2.2 Ulna (Figure 1B)

Maximum length (ML): maximum distance obtained from proximal end (olecranon) to the distal end (ulna head).

Anteroposterior diameter (APD): obtained in middle third of ulna, where there is maximum projection between the interosseous border and posterior border of ulna.

2.3 Radius (Figure 1C)

Maximum length (ML): maximum distance obtained between the most proximal point of radius head to most distal end of radial styloid process.

Anteroposterior diameter (APD): was obtained in middle third of radius, where there is the maximum projection of anterior border in relation to posterior border of radius.

2.4 Femur (Figure 2)

Maximum length (ML): maximum distance from proximal end (greater trochanter) to the distal end of femoral condyles.

Epicondylar width (EW): maximum distance between the medial epicondyle and the lateral epicondyle, in distal epiphysis of femur.

Diameter of femur head (HD): maximum distance from the most superior point at the margin of articular surface, to the lowest point on margin of this surface, in head femur.

Figure 2. Human femur bone with measured areas. A: ML- maximum length; EW- Epicondillary width; B: Proximal epiphysis of femur bone (head and neck of femur), area that was measured HD- Diameter of the femur head.
Source: Department of Anatomy / ICB-Unifal-MG.

2.5 Tibia (Figure 3)

Maximum length (ML): maximum distance between proximal end (intercondylar eminence) to most distal end of tibia medial malleolus.

Distal width epiphysis (DEW): maximum distance from medial malleolus to most prominent point of fibular notch.

Anteroposterior diameter (APD): distance obtained from tibial tuberosity until to posterior intercondylar area.

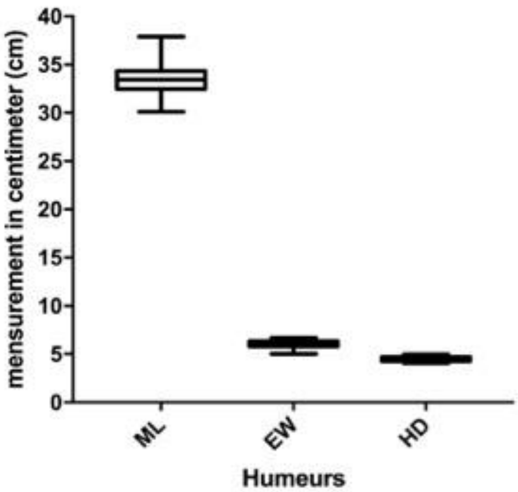
Figure 3. Human tibia, with measured areas. A: ML- maximum length; DEW- distal epiphysis width; B: Proximal epiphysis of tibia (condylar area) with APD- Anteroposterior diameter. Source: Department of Anatomy/ ICB-Unifal-MG.

The GraphPad Prisma 7 program was used to analyze the data obtained, to verify the presence of significant interactions between the measured structures. The statistical analysis was performed by means analysis of maximum and minimum values and the means of each measurement obtained[16].

3. Results

The values of measurements, for each bone, are presented in form of graphs and tables for better visualization from obtained data. It is possible to observe that all values of standard deviations and standard error from mean are low, which confers reliability to data.

The figure 4 shows values obtained from humerus bones measures, referring to maximum length (ML), which ranged from 30.1 to 37.9 cm (mean 33.52 cm); the epicondyle width (EW) 5.01 to 6.69 cm (mean 6.04 cm); and the diameter of humerus head (HD) 4.07 to 4.93 cm (mean 4.48 cm).

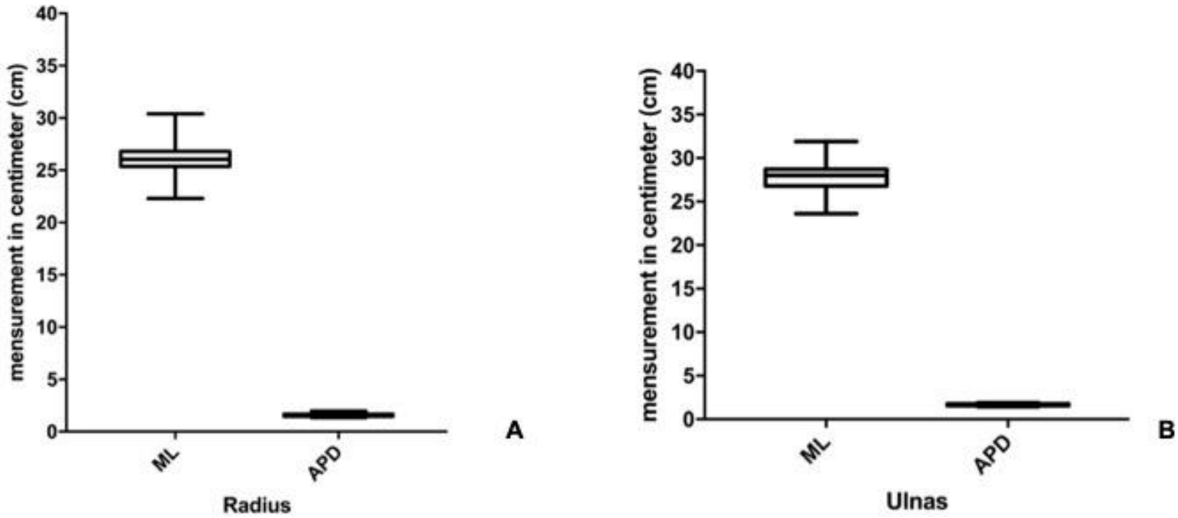


	Humerus		
	ML	EW	HD
Mean and Std. Deviation	33.52±1.45	6.04±0.39	4.48±0.24
Std. Error of Mean	0.20	0.05	0.03

Figure 4. Graph and table representing the mean values, standard deviation and standard error of mean found in humerus. Being: ML-maximum bone length; EW-epicondylar and HD-diameter of humerus head.

The Figure 5 shows values obtained in radius and ulna bones, referring to maximum length (ML), which ranged from 22.3 to 30.4 cm (mean 26.24 cm) on radius and from 23.6 a 31.9 cm (mean 27.9 cm) on ulna; and for anteroposterior diameter (APD), which ranged from 1.34 to 1.96 cm (mean of 1.58 cm) in radius and 1.46 to 1.89 cm (mean of 1.67 cm) in ulna .

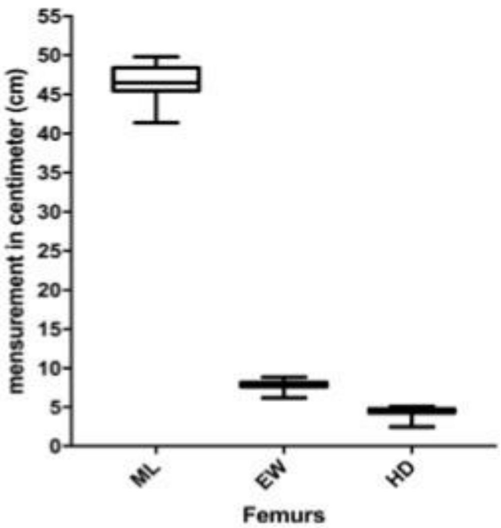
Figure 6 shows respectively the statistical values found in femurs referring to maximum length (ML), which varied from 37.9 to 49.8 cm (mean 46.41 cm); (EW) 6.22 to 8.82 cm (mean 7.84 cm) and diameter of femur head (HD) 2.48 to 5.12 cm (mean 4.43 cm).



Radius		
	ML	APD
Mean and Std. Deviation	26.24±1.51	1.58±0.14
Std. Error of Mean	0.21	0.02

Ulnas		
	ML	APD
Mean and Std. Deviation	27.9±1.41	1.67±0.10
Std. Error of Mean	0.26	0.019

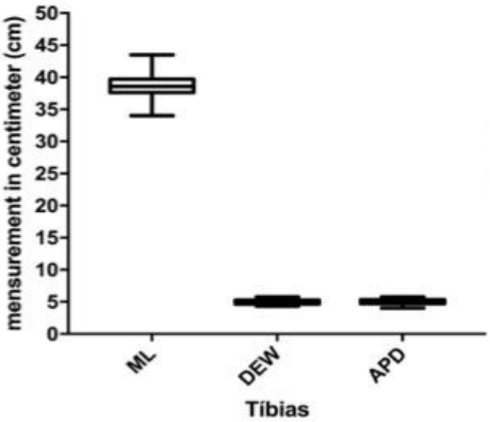
Figure 5. A-Graph and table representing the values of mean, standard deviation and standard error from mean found in radius bone; and B-Graph and table representing the values of mean, standard deviation and standard error from average found in ulna bone. Being: ML-maximum bone length; APD- anteroposterior diameter.



Femurs			
	ML	EW	HD
Mean and Std. Deviation	46.41±2.35	7.84±0.57	4.43±0.47
Std. Error of Mean	0.33	0.08	0.06

Figure 6. Graph and table representing the values of mean, standard deviation and standard error from average found in femur bone. Being: ML-maximum bone length; EW-epicondylar and HD-diameter femur head.

Figure 7 shows the values obtained in tibia, referring to maximum length (ML), which ranged from 34 to 43.5 cm (mean 38.72 cm); the width of distal epiphysis (DEW), which ranged from 4.30 to 5.74 cm (mean of 4.97 cm); and the anteroposterior diameter (APD), ranging from 4.00 to 5.76 cm (mean of 4.96 cm).



Tibias			
	ML	DEW	APD
Mean and Std. Deviation	38.72±1.94	4.97±0.37	4.96±0.39
Std. Error of Mean	0.32	0.06	0.06

Figure 7. Graph and table showing the values of mean, standard deviation and standard error of average found in tibia. Being: ML-maximum bone length; DEW-width of distal epiphysis and APD-anteroposterior diameter of tibia.

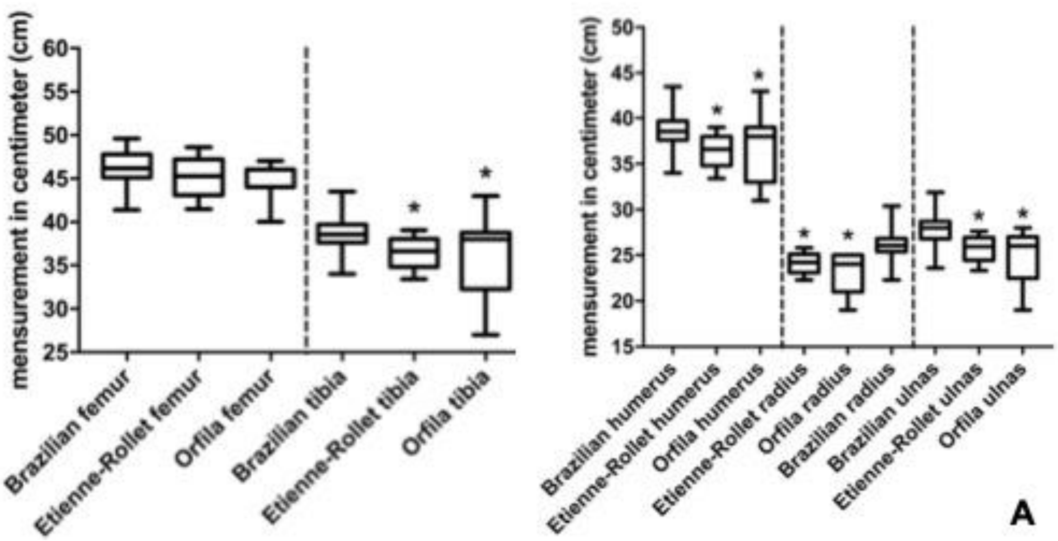
The results of this work also show values referring to comparison of data obtained from maximum length averages of all bones with the data presented by[11,12]. Regarding these data, significant differences in the humerus, radius, ulna and tibia bones were observed, and did not show significant differences related to femur bone. This is shown in Figure 8.

4. Discussion

A study analyzed the maximum length of humerus and femurs in 200 Portuguese cadavers. The mean maximum humerus and femur lengths of cadavers were 31.22 cm and 42.93 cm, respectively[14]. In this case, it is possible to observe difference of results obtained in this study, in which the humerus had mean values from maximum length of 33.52 cm and the femurs of 46.41 cm.

Another study analyzed only humerus of Greek nationality individuals. There were 168 bones measured, with mean values from maximum length of 30.73 cm, head diameter of 4.37 cm and epicondylar width of 5.8 cm[17]. The same values of maximum length (33.52 cm) and epicondyle width (6.04 cm) obtained in bones found in Brazilian territory were very different from values found by the cited authors.

In a study carried out only femurs of Indian origin. There were 280 bones, with a maximum length average of 42.68 cm, head diameter of 4.28 cm and epicondylar width of 7.27 cm[18]. It is possible to observe, in relation to results of this study, a greater discrepancy in values of maximum length (46.41 cm), while the values of femoral head diameter (4.43 cm) and epicondly width (7.84 cm) are closer.



	Etienne-Rollet	Orfila	Brazilian
	Maximum length averages (cm)		
Femur	43,37cm	43,15cm	46,41cm
Tibia	34,97 cm	36,20 cm	38,72cm
Humerus	31,25 cm	30,80 cm	33,52cm
Radius	22,83 cm	22,80 cm	26,24cm
Ulnas	24,46 cm	25,20 cm	27,90cm

B

Figure 8. A-graphs of comparisons from values presented by Etienne-Rollet (1888), Orfila (1828) and the values obtained in this work.
* significant differences from values of this work with the other groups, compared for each bone analyzed. B-table with the means of each group compared.

Another study, presented data referring to maximum lenght measurement of humerus and tibias in Bulgarians. The values were 32.5 cm and 35.46 cm, respectively[19]. It is possible to observe a significant difference in values of tibias (38.72 cm), but in relation to maximum length of humerus, the values were very close (33.52 cm) to those found in this study.

Duyar and Pelin[20] showed, in 121 tibias of Turkish origin, that average of maximum length values was 38.98 cm, a value very close to what was found in this work. However, this does not make it possible to affirm a likelihood between Brazilians and Turks, since a larger sampling and with more parameters of comparison would be necessary.

Krüger, L'abbé and Stull[21] analyzed the maximum length of 360 African bones, being humerus (31.25 cm), radius (23.88 cm), ulnas (25.66 cm) and femurs (44.25 cm); also evaluated the epicondylar width and the diameter from heads of humerus (5.9 cm and 4.25 cm, respectively), as well as the femurs (7.66 cm and 4.38 cm, respectively), besides the anteroposterior diameter of radius (1.18 cm). When comparing the values found by authors with the results obtained in this study, very relevant differences are observed for maximum length values of all bones studied.

Garmendia, Sánchez-Mejorada and Gómez-Valdés[22], measured the maximum length of humerus (29.94 cm), femurs (41.49 cm) and tibias (34.68 cm) of 86 Mexican adult cadavers. The values found from analysis of Brazilian bones in this study were very distinct, being for humerus 33.52 cm, for femurs 46.41 cm and for tibias 38.76 cm.

Already Muñoz et al.[23], when analyzing the maximum bone length of 104 adult cadavers from Spanish origin, found mean values for humerus of 30.88 cm, for femurs 45.02 cm, for tibias 36.95 cm, for radius 23.65 cm and for ulnas 22.57 cm. From this analysis it is possible to observe that data obtained in this work referring to humerus (33.52 cm), tibias (38.76 cm), radius (26.24 cm) and ulnas (27.90 cm) are very different from those results found by Muñoz et al. However, when femur values are compared (46.41 cm), this difference is less significant.

The European tables of Rollet[11] and Orfila[12] are most used by forensic anthropology in identification of human bones. What can be observed is that when comparing the mean maximum bone length presented by Rollet[11] and Orfila[12] with the values obtained in this work, there is a significant difference for humerus, radius, ulna and tibia bones. This did not occur with femur values and may suggest that use of femurs values is more reliable. The difference in values observed from comparison of results obtained with cited authors can be explained by the extensive ethnic miscegenation in Brazil.

5. Conclusion

According to results obtained in this study, it is possible to conclude that the values used by forensic anthropology for identification of Brazilian long bones, do not in fact represent any values already established for some ethnic groups, since the Brazilians presented their own pattern, which was different from the European standard already classified. Therefore, the importance of new studies to determine regional groups in the country is emphasized, with new configurations of their indexes.

Declaration of competing interest

The authors declare that they have no competing interest.

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