

# Sexual Dimorphism in Morphometry of Length of Dry Adult Human Left Calcaneus

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## Abstract

**Context:** The determination of sex from an adult human skeleton is a fundamental task for forensic and physical anthropologists. The calcaneus, the largest tarsal bone, is a compact bone that can withstand high tensile forces. Length of calcaneus provide an additional reliable method for sex estimation via discriminant function analysis. Morphometric data of calcaneus is essential for plastic and reconstructive surgeons for proper management of various diseases of the foot. The present study intends to assess the dimorphic reliability of different length measurements of calcaneus. Objective of the study is to assess different morphometry of length of dry adult human left calcaneus and to evaluate the morphological differences between male and female.

**Materials and Methods:** The present study was a cross sectional analytical type of study conducted in the department of Anatomy, Dhaka Medical College, Dhaka from January 2018 to December 2018. The study material consists of two hundred left calcaneus of unknown sex. The study samples were distributed in male and female sex groups by 'discriminant function analysis technique'. Maximum length, total length and length of the body of calcaneus were measured.

**Results:** The mean  $\pm$  SD of maximum length, total length and length of the body were significantly higher ( $p < 0.001$ ) in male than female.

**Conclusion:** The findings of the present study revealed that different length measurements of calcaneus was higher in male compared to female. These differences can be useful in sex differentiation.

**Keywords:** Sexual dimorphism, length, calcaneus

## Introduction

Skeletonized human remains are commonly recovered within medico-legal contexts and mass disasters. The forensic anthropologist carefully examines the remains and assists with the human identification through the creation of a biological profile (i.e. estimation of sex, age at death, stature, and biological affinity).<sup>1-3</sup> When identifying

skeletonized remains, the estimation of sex is of primary significance, as the estimation of age at death and stature are sex-dependent.<sup>4</sup> Most of the bones that are conventionally (e.g. pelvis, skull, long bones) used for sex determination are often recovered either in a fragmented or incomplete state, thus, it has become necessary to use denser bones that are often recovered intact e.g. patella, calcaneus and talus for sex determination studies.<sup>5</sup>

Bones of the foot have recently gained interest as subjects of study for sex estimation using osteometric analysis. The foot and ankle are weight-bearing parts of the body and therefore tend to exhibit large size differences between male and female. Fessler and coworkers<sup>6</sup> found that in individuals of similar body height males tend to have longer foot than females.<sup>7</sup>

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Sex determination is done either by assessing morphological features or by doing osteometric measurements.<sup>8</sup> The sexual dimorphism of the calcaneus has been studied in India<sup>9,10</sup> and other population groups.<sup>5,11-19</sup> The calcaneus is the largest foot bone and has proved useful for human identification as it is often well preserved during excavations. This increased preservation is related to the increased strength and density of the bone's trabeculae and because it is often encased in socks and/or shoes.<sup>13</sup>

Calcaneus is often recovered in forensic and archaeological contexts.<sup>20</sup> By virtue of its anatomical position, it can resist putrefaction better than other bones.<sup>21</sup> Measurements of length of the calcaneus provide an additional reliable method for sex estimation via discriminant function analysis.<sup>12</sup> Sexual dimorphism regarding the length measurements of calcaneus has been studied in Japanese population by Sakaue.<sup>19</sup> The knowledge of the detailed morphology of calcaneus is necessary as this region is frequently affected by many disorders such as achillodynia, achillar enthesopathy, retrocalcaneal bursitis, Haglund's deformity and others, which have been diagnosed and surgically treated from the end of the 19th century. Morphometry of calcaneal length measurements are essential for screw placement during surgical management of calcaneal fractures.<sup>22</sup> The present study was planned to measure the length of adult human left calcaneus and to provide a baseline data for further researches in our country.

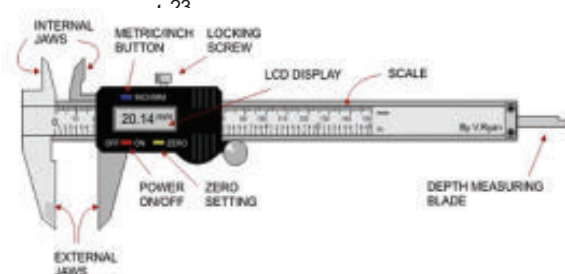
**Materials and Methods**

The present study was carried out in the Department of Anatomy, Dhaka Medical College (DMC), Dhaka from January 2018 to December 2018. A total of two hundred (200) dry adult human left calcaneus of unknown sex were collected from the Department of Anatomy and from the MBBS students of DMC, Dhaka National Medical College, Dr. Sirajul Islam Medical College and Dhaka Community Medical College. By discrimination function analysis technique<sup>23</sup> and also with the help of various morphological criteria used by different authors,<sup>23,20</sup> the sex was determined and the grouping was done (Table-I).

**Table I**  
*Grouping of the sample*

Sex	Number of study sample
Male	103
Female	97

Then maximum length, total length and length of the body of calcaneus were measured with the help of digital slide caliper (Fig 1). Measurements were recorded in metric unit millimeter (mm). Measurements were taken three times and then the average values were taken for each



**Fig- 1: digital slide caliper**

**A. Maximum length**

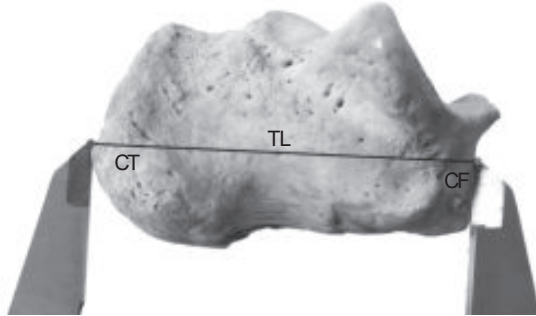
To measure the maximum length, the anterior most point of the calcaneus was identified and marked by a white dot. A black dot was given on the posterior most point of the calcaneal tuberosity. The fixed jaw of the digital slide caliper was placed on the anterior most point of the calcaneus and the sliding jaw was fixed on the posterior most point of the calcaneal tuberosity. With the help of the digital slide caliper, the maximum length was measured between the white dot and the black dot. The reading was recorded in millimeters. The distance between the two dots was represented by maximum length (MAXL).<sup>20</sup>



**Fig.-1: showing the measurement of the maximum length (MAXL) by digital slide caliper. white dot indicates the anterior most point of the calcaneus and the black dot indicates the posterior most point of the calcaneal tuberosity. CT represents the calcaneal tuberosity**

**B. Total length**

To measure total length, the center of the cuboidal articular facet was identified and marked by a white dot. A black dot was given on the posterior most point of the calcaneal tuberosity. The fixed jaw of the digital slide caliper was placed on the center of the cuboidal articular facet and the sliding jaw was fixed on the posterior most point of the calcaneal tuberosity. With the help of the digital slide caliper, the total length was measured between the white dot and the black dot. The reading was recorded in millimeters. The distance between the two dots was represented by total length (TL).<sup>19</sup>

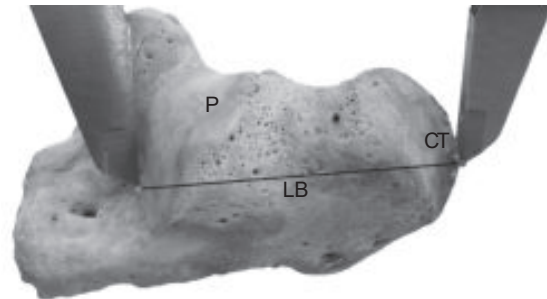


**Fig.-2:** showing the measurement of total length (TL) by digital slide caliper. The white dot indicates the center of the cuboidal articular facet and the black dot indicates the posterior most point of the calcaneal tuberosity. CT represents the calcaneal tuberosity and CF represents the cuboidal articular facet

**C. Length of the body**

To measure length of the body, the anterior most point of the posterior articular facet was identified and marked by a white dot. A black dot was given on the posterior most point of the calcaneal tuberosity. The fixed jaw of the digital slide caliper was placed on the anterior most point of the posterior

articular facet and the sliding jaw was fixed on the posterior most point of the calcaneal tuberosity. With the help of the digital slide caliper length of the body was measured between the white dot and the black dot. The reading was recorded in millimeters. The distance between the two dots was represented by length of the body (LB).<sup>19</sup>



**Fig.-3:** showing the measurement of the length of the body (LB) by digital slide caliper. The white dot indicates the anterior most point of the posterior articular facet and the black dot indicates the posterior most point of the calcaneal tuberosity. CT represents the calcaneal tuberosity and P represents the posterior articular facet

**Results**

The mean ± SD of maximum length was 77.47±2.67 mm and 68.78±2.4 mm in male and female respectively. The mean ± SD of total length was 73.42±2.45 mm and 66.58±2.74 mm in male and female respectively. The mean ± SD of length of the body was 55.14±1.26 mm and 50.17±1.25 mm in male and female respectively. The finding of the present study revealed that the mean maximum length, the mean total length and the mean length of the body were significantly higher (p< 0.001) in the male than in the female (Table-II).

**Table II**

*Maximum length, total length and length of the body of left calcaneus in male and female (N = 200)*

Variables	Male(n=103)	Female(n=97)	p value
	Mean ± SD (Range)	Mean ± SD (Range)	
Maximum length in mm	77.47±2.67 (71.15-85.43)	68.78±2.4 (63.62-75.46)	0.000***
Total length in mm	73.42±2.45 (64.24-78.31)	66.58±2.74 (60.42-75.77)	0.000***
Length of the body in mm	55.14±1.26 (51.52-58.31)	50.17±1.25 (46.78-54.94)	0.000***

Figure in parentheses indicate range. Comparison between sex was done by unpaired Student's 't' test  
 \*\*\* = Significant at P < 0.001 (2 tailed) N = Total number of sample samples n = Study samples in each group SD = Standard Deviation

## Discussion

In the present study, the mean maximum length was higher in the male than in the female and the difference was found statistically significant ( $P < 0.001$ ). Significant difference between mean maximum length in male and female was observed by many researchers.<sup>12,19,21,23</sup> Their study results revealed higher value in male than in female resembling the present study.

The findings of the present study differ in both male and female from those of Steele<sup>14</sup> and DiMichele et al<sup>12</sup> who investigated different ethnic groups of America, and from Sakaue<sup>19</sup> who studied Japanese people. On the other hand, Jung et al<sup>24</sup> worked on Korean population and found no significant difference between mean maximum length in male and female. This divergence might be due to racial variation and use of calcaneus collected from cadaver instead of dry ossified calcaneus.

In the present study, the mean total length was found higher in the male than in the female and the difference was statistically significant ( $P < 0.001$ ). Sakaue<sup>19</sup> observed a significant difference between the mean total length in male and female in Japanese people. He reported a higher value in male than in female, which concurred with the present study. This similarity might be due to geographic, socioeconomic and demographic resemblance.

Zhang et al<sup>25</sup> carried out a study on Chinese population. Their study result showed that the mean total length value in male was almost similar to that of the present study, but the mean value in female was somewhat contrary to the findings of the present study. Zakaria et al<sup>26</sup>, who studied Egyptian people, found no significant difference between the mean total length in male and female which disagreed with the present study. It might be due to variation in race and ethnicity.

In the present study, the mean length of the body was higher in the male than in the female and when compared between male and female it was found to be statistically significant ( $P < 0.001$ ). Sakaue<sup>19</sup>, Zhang et al<sup>25</sup> and Silva<sup>27</sup> noticed that the mean length of the body was significantly higher in the male than in the female.

The mean length of the body of the present study in both sexes was significantly higher than that of Japanese people<sup>19</sup> and Chinese people<sup>25</sup>. But it was significantly lower than that of Portuguese people<sup>27</sup> and Croatian people<sup>28</sup>. Krmek et al<sup>28</sup> stated that the mean length of the body was higher in the male than in the female but when compared was found to be statistically non-significant. This divergence might be due to variation in race and ethnicity. Japanese and Chinese people belonged to Mongoloid race; Portuguese and Croatian people are Causasoid in type.

## Conclusion

In the present study, the mean maximum length, mean total length and mean length of the body of calcaneus were higher in the male than in the female and the difference was statistically significant. These data may be helpful to orthopedic and reconstructive surgeons for proper management of various diseases of the foot and may be useful for the sex determination of skeletal remains.

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