



# Hand Anthropometry; Sex Determination from Hand Dimensions in Adult Tanzanians

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## Research Article

Volume 8 Issue 1

Received Date: January 23, 2023

Published Date: March 08, 2023

DOI: 10.23880/ijfsc-16000288

## Abstract

**Background:** Personal identification through sex determination is an essential element of medico-legal examinations done by forensic scientists, clinical anatomists, clinical radiologists, anthropologists and orthopedic surgeons. The hand dimensions are sexually dimorphic and exhibit potential for sex discrimination.

**Aim:** To determine the cut-off values of hand dimensions that could discriminate between sexes in Adult Tanzanians.

**Materials and Method:** 384 students (192 males and 192 females) aged 18-59 years were studied. Hand length and breadth measurements were taken to estimate Hand Index, then statistically analyzed by the use of SPSS version 24 and Microsoft Excel.

**Results:** The average hand length and breadth were found to be about 1.6 cm and 0.7 cm greater in males than in females respectively. Cut off points to differentiate between male and female for hand length, breadth and index were 18.92 cm, 9.21 cm and 48.86 respectively.

**Conclusion:** Hand length showed the highest accuracy in the determination of sex followed by hand breadth and lastly hand index. The study clearly demonstrates that the predictive accuracy of sex estimation varies within each population, hence emphasizes the significance of generating population-specific standards to accurately estimate sex.

**Keywords:** Forensic Anthropology; Hand Anthropometry; Sex Determination; Hand Dimensions; Hand Index

**Abbreviations:** SPSS: Statistical Package for the Social Sciences; SD: Standard Deviation; SE: Standard Error; RHL: Right Hand Length; RHB: Right Hand Breadth; RHI: Right Hand Index; LHL: Left Hand Length; LHB: Left Hand Breadth; LHI: Left Hand index; M: Male; F: Female; CM: Centimeters; SD: Standard Deviation of Mean; MUHAS: Muhimbili University of Health and Allied Sciences.

## Introduction

The hand is the anatomical region located at the end of the upper limb in certain vertebrates that exhibits great

mobility and flexibility in the digits and the whole organ. It is made up of the wrist joint, the carpal bones, the metacarpals bones, and the phalanges. Each hand has five fingers namely: The thumb, index finger, middle finger, ring finger and the little finger or pinkie. The areas of the human hand include: The palm also known as the volar is the anterior part of the hand. The opisthenar area (dorsal) is the corresponding area on the posterior part of the hand.

The major function of the hand in most vertebrates is locomotion; in humans and other primates, the hand is further specialized to perform different manipulations. The

palms and undersides of the fingers are marked by creases and covered by unique ridges known as prints that improve tactile sensitivity, and grip and in humans the patterns are used for identification. The human hand is the most used and versatile part of the body; is of great scientific importance to investigators, particularly in the field of anthropometry, forensic pathology, orthopaedics surgery and ergonomics. Besides that, every ethnic group and person need to feel that their unique requirements are understood and addressed when it comes to hand anthropometry and design [1-3].

Hands are considered to be one of the most sexually dimorphic parts of the human body [3,4], therefore it is a useful tool in sex determination among different populations across the globe. Determination of sex is one of the main parameters of personal identification as it cuts half of the possible number of matching identities. Sex determination is usually a simple task in a forensic investigation when the whole body is available as external or internal genitalia can directly suggest the sex of the individual; however, the problem arises when dismembered body parts are found.

Different anthropometric techniques are employed to determine sex from such fragmented body parts. Such anthropometric techniques aim to find out cut off points in the measurement of various body parts or bones that discriminate between males and females. Due to the effect of sex hormones, males are taller, larger and more strongly built than females, so measurement more than cut off point is suggestive of a male and less than that is suggestive of a female [5].

## Materials and Methods

This was a cross-sectional study conducted at Muhimbili University of Health and Allied Sciences after the Faculty's Directorate of Research and Publications review and approval. 384 medical students (192 males and 192 females) studying at the School of Medicine aged 18-59 years, agreed on informed consent who were studied. A student with any disease, deformity, injury, fracture, amputation or history of any surgical procedure of the hand was excluded from the study. The measurement technique for measuring hand length and handbreadth was taken from the methods recommended by Weiner, et al. [6]. These measurements are taken in cm with the help of measuring tape, respectively. All measurements were taken by one observer to avoid inter-observer bias.

The procedure was as follows:

- The hand was placed on a flat surface with the palm facing upwards and the finger extended close to each other.
- Care was taken to see whether there is no abduction or

adduction of the wrist joint, as the forearm has to be directly in line with the middle finger.

- Hand length was measured as a straight distance between the distal crease of the wrist joint and the most anterior projecting point (tip of middle finger).
- Hand breadth was measured as a straight distance from the most laterally placed point on the head of the 2nd metacarpal bone to the most medially placed point located on the head of the 5th metacarpal bone.

Measuring hand length and handbreadth of both hands in each participant collected the data and compute the hand index as explained in the technique in the section above and below. The Statistical Package for the Social Sciences (SPSS) Version 24 analyzed the data. Mean, standard deviation (SD) and standard error (SE) were calculated. T-tests were performed to compare hand length, breadth and hand index in the two hands of a participant and between both sexes. P value < 0.05 was considered significant. Average mean hand length, handbreadth and hand index of both sexes were taken to a determination of sex of the sample and termed as sectioning point [1,5,7].

Sectioning point(S) = (mean male value + mean female value) / 2

A palm dimension was described as male when the value of the discriminant function was greater than the sectioning point and described as female when the sectioning point was greater than the discriminant function. Comparing the predicted sex with the actual sex assessed the accuracy of each discriminant function.

The hand index is described as the ratio between handbreadth and the hand length multiplied by 100 [8,2].

$$\text{Hand Index} = (\text{hand breadth} / \text{hand length}) 100$$

The distribution of indices among the participants was calculated on basis of the standard Krogman hand indices classification described in previous studies [2,7,8]. The five classifications of the hand indices are as follows:

- Hyperdolicholicheri (hdch) ( $\leq 40.9$ )
- Dolichochei (dch) (41.0-43.9)
- Mesocheri (mch) (44.0-46.9)
- Brachycheri (bch) (47.0-49.9)
- Hyperbrachycheri (hbch) ( $\geq 50.0$ )

## Results

384 participants were studied, including 192 males and 192 females aged 18-59. The descriptive values of hand length are represented in (Table 1). In males, the hand length ranged from 17.0 cm to 22.5 cm for the right hand (average

of 19.696 cm with a Standard deviation of 1.0872) and from 17.20 cm to 22.2 cm for the left hand (average of 19.766 cm with a Standard deviation of 1.0627). In females, the hand index ranged from 15.8 cm to 21.0 cm for the right hand (average 18.123 cm with a Standard deviation of 0.9705) and from 16.0 cm to 20.80 cm for the left hand (average 18.139 cm with a Standard deviation of 0.9759). The hand length differed significantly for corresponding male-female values ( $p < 0.05$ ) in both hands; the difference between right and left-hand length was also significant in males ( $p < 0.05$ ) however it was not significant in females.

The average hand length was found to be about 1.6 cm greater in males than in females. In both sexes, the average

left-hand length was greater than the right-hand length.

Based on the mean hand length for both sexes, 18.91 cm for the right hand and 18.93 cm for the left hand were derived as the sectioning point for the hand index to discriminate between male and female hands. By trial and error, a cut-off point of 18.92 cm was derived to determine the sexual dimorphism of the hand index. The length accurately determined sex in 75 % of males and 79 % of females for the right hand, and 77 % of males and 77 % of females for the left hand. All cases with ratios below and equal to 18.92 cm were considered female and those above 18.92 cm were considered males.

Sex	Male		Female	
	Right hand	Left hand	Right hand	Left hand
Minimum	17	17.2	15.8	16
Maximum	22.5	22.2	21	20.8
Mean	19.696	19.766	18.123	18.139
Standard error	0.0785	0.0767	0.07	0.0704
Standard deviation	1.0872	1.0627	0.9705	0.9759
Sectioning point	18.91		18.93	

**Table 1:** Measurements (Cm) of Hand Length in Males and Females.

The descriptive values of handbreadth are shown in (Table 2). The descriptive statistics for the handbreadth of both sexes are shown in Table 3. In males, the handbreadth ranged from 8.0 cm to 11.3 cm for the right hand (average 9.614 cm with a Standard deviation of 0.5997) and from 8.0 cm to 10.8 cm for the left hand (average 9.503 cm with a Standard deviation of 0.5748). In females, the handbreadth ranged from 6.8 cm to 10.5 cm for the right hand (average 8.868 cm with a Standard deviation of 0.5418) and from 7 cm to 10 cm for the left hand (average 8.833 cm with a Standard deviation of 0.5404). The handbreadth differed significantly for corresponding male-female values ( $p < 0.05$ ) in both hands; the difference between right and left handbreadth

was also significant in males ( $p < 0.05$ ) however it was not significant in females. The average handbreadth was found to be about 0.7 cm greater in males than in females. Based on the mean handbreadth for both sexes, 9.24 cm for the right hand and 9.17 cm for the left hand were derived as the sectioning point for the hand index to discriminate between male and female hands. By trial and error, a cut-off point of 9.21 cm was derived to determine the sexual dimorphism of the hand index. The breadth accurately determined sex in 69 % of males and 80 % of females for the right hand, and 65 % of males and 79 % of females for the left hand. All cases with a ratio below and equal to 9.21 cm were considered female and those above 9.21 cm were considered males.

Sex	Male		Female	
	Right hand	Left hand	Right hand	Left hand
Minimum	8	8	6.8	7
Maximum	11.3	10.8	10.5	10
Mean	9.614	9.503	8.868	8.833
Standard error	0.043	0.042	0.0391	0.039
Standard deviation	0.6	0.575	0.0542	0.054
Sectioning point	9.24		9.17	

**Table 2:** Measurements (Cm) of Handbreadth in Males and Females.

The descriptive statistics for the hand index of both sexes are shown in Table 3. In males, the average hand index ranged from 41.8 to 54.8 for the right hand (average 48.851 with a Standard deviation of 2.4457) and from 42.0 to 56.6 for the left hand (average 48.112 with a Standard deviation of 2.3209). In females, the average hand index ranged from 39.5 to 56.6 for the right hand (average 48.977 with a Standard deviation of 2.6123) and from 40.0 to 56.8 for the left hand (average 48.739 with a Standard deviation of 2.4657). The hand index differed significantly for corresponding male-female values ( $p < 0.05$ ) in both hands; the difference between the right and left-hand index was also significant in both sexes ( $p < 0.05$ ). Based on the mean hand index for both sexes, 48.914 for the right hand and 48.426 for the left hand were derived as the sectioning point for the hand index to

discriminate between male and female hands. By trial and error, a cut-off point of 48.86 was derived to determine the sexual dimorphism of the hand index. The index accurately determined sex 50 % in males and 47 % females for the right hand, and 34 % males and 52% females for the left hand. All cases with a ratio below and equal to 48.86 were considered female and those above 48.86 were considered males. Based on Krogman's classification of hand indices. Brachycheri was the most prevalent type of hand index, with more than two-fifth of the participants among both sexes followed by Hyperbrachycheri then Mesochei. Among females, there were representatives of each type of hand indices while there were no hyperdolicholicheri representatives among the males.

Sex	Male		Female	
	Right hand	Left hand	Right hand	Left hand
Minimum	41.8	42	39.5	40
Maximum	54.8	56.6	56.6	56.8
Mean	48.85	48.11	48.98	48.74
Standard error	0.177	0.168	0.189	0.178
Standard deviation	2.446	2.321	2.612	2.466
Sectioning point	48.91		48.43	

**Table 3:** Descriptive Statistics of the Hand Index in Males And Females.

## Discussion

Personal identification through sex determination is an essential element of medico-legal examinations done by forensic scientists, clinical anatomists, clinical radiologists, anthropologists and orthopedic surgeons. There are a lot of advancements of technology in developed countries that can help in sex determination quickly, timely and accurately. However, in a developing country like Tanzania, such advancement are not yet accommodated and utilized and therefore we still rely on less advanced methods like hand anthropometry. In our study the hand dimensions in males were found to be statistically larger than females. The results are similar to earlier observations that were made in different studies at different [1-5,7,9,10].

Despite the fact that males have larger hand dimensions when compared to females, our study has an estimated mean hand values that are different from other populations. In comparison to Egyptian [1], Ghanaian [7], Indian [2,4,5], Mauritius [11], North Saudi [10] and Western Australian [12] studies the hand was longer and broader; shorter and narrower in comparison to study carried out in Nigeria [3,13]. This proves the fact that each population exhibits a

specific value for hand dimensions, hence need to be studied and deduce estimations separately. The sex difference of these estimates is independent of body size, height or age [1].

The average hand length was found to be about 1.6 cm greater in males than in females, which is consistent with findings in Ghanaians [7] and Mauritius [11] populations. The average handbreadth was found to be about 0.7 cm greater in males than in females. The results similarity can be attributed by genetics, environmental and hormonal factors; whereas there is late occurrence of maturity in males as compared to females and due to higher testosterone/estrogen ratio in males with the long-term organizational benefits of prenatal testosterone, especially its effect on growth and development of the musculoskeletal system there are 2 more years of physical growth and development as compared to females [14,15]. Eventually this is an evidence of sexual dimorphism in Tanzanian population and therefore proves that hand dimensions and hand index are appropriate anthropometric parameters that can be used to discriminate sex.

In the present study, the values of mean hand index were found to be higher on the right side in both males and females which is in consonance with the studies done

Tarsem [13,14]. Although there exists variation among hand length and handbreadth within the population; the hand index suggested that Tanzanians fell predominantly into Brachycheri and Hyperbrachycheri types irrespective of the sex. These findings are contrary to Nigerian findings whose percentage expression of the breadth over the length suggested that adult Nigerians falls to Mesocheri and Dolichoheri groups [8]. Also different findings were deduced in Ghanaians study in which mesocheri predominate in most cases [7]. The comparison of hand index of different male population indicates that the male population of India belongs to Dolichoheri, Mesocheri or Brachycheri [2] while male population of Tanzania belongs to Brachycheri, Hyperbrachycheri or Mesocheri. The reason for the contradictory findings is uncertain.

Furthermore, the present study deduced that the hand length and handbreadth differed significantly for corresponding male-female values ( $p < 0.05$ ) in both hands; the difference between right and left-hand length was also significant in males ( $p < 0.05$ ) however it was not significant in females; the difference between right and left handbreadth was also significant in males ( $p < 0.05$ ) however it was not significant in females. This is contrary to the findings reported by Maalman, Dey and Kapoor that male-female differences were found to be statistically significant for both handbreadth and hand length but not significant for the difference between right and left hand [9,7]. The hand index differed significantly for corresponding male-female values ( $p < 0.05$ ) in both hands; the difference between the right and left-hand index was also significant in both sexes ( $p < 0.05$ ). The reason for the contradictory findings is uncertain.

## Conclusion

The present study succeeded to determine the cut-off values of hand dimensions that could discriminate between sexes in Adult Tanzanians. The results of the present study clearly demonstrate that the predictive accuracy of sex estimation varies with each different population. This again emphasizes the significance of generating population-specific standards to accurately estimate sex. Moreover, the results indicate that hand length showed the highest accuracy in the determination of sex followed by hand breadth and lastly hand index. The present study is limited by its relatively small sample size. It is recommended that further studies involving large samples of different ethnic groups in Tanzania are desired. Nonetheless, these preliminary results provide the baseline data for more detailed studies in the future.

## Funding

The authors received no funding for this project.

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