

Sex Determination from Hand Dimensions in a South Indian Population

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Abstract

The aim of this research was to generate a standard formula for estimating sex in the South Indian population from hand anthropometric measurements. Sex is one most important and foremost criteria in establishing the identity of an individual. The present study comprised a sample of 300 healthy individuals (150 males and 150 females). The databases for Hand Length, Hand Breadth and Hand index were analysed using IBM SPSS (Statistical Package for Social Sciences, Version 20.0) computer software. The issue of sex discrimination can be very complicated in cases of intersex, bodies in an advanced state of putrefaction, mutilated & fragmentary remains in which it is common to recover dismembered & peripheral parts of the body. It was realized that anthropometric measurements of the hand have been a very useful tool in sexual identification. Hand length and hand breadth show statistically significant male – female differences at $p < 0.0001$. Hand Breadth was found as best predictor of sex in comparison with hand length. Sectioning point confirms that cut-off point below and equal to 44 is suggestive of male hand whereas those above 44 were considered as female hand.

Keywords: Sexual determination, Forensic identification, Sectioning point, Hand length, Hand breadth, Hand index, Mass disaster.

Introduction

Identification can be complete or partial. Complete identification means absolute fixation of the individuality of a person. Complete identification is possible, only when all facts about the individual are available. Whereas in partial identification, only certain facts like race, age, sex, stature etc. are determined while other characteristics are not known.¹ Sex and Stature are two key components of

partial identification. They provide one important aspect of an individual's physiognomy. Dimensions of various parts of the body show sexual dimorphism also.² However, different population group exhibits variation in their body proportions as they are affected by race, diet, genetics of a person, geographical location and climatic conditions.³ As a result of it, results of a study conducted on one population group cannot be applied to other population group. Even

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the results of a study conducted on one generation of a population cannot be applied to the next generation as they are affected by secular changes in physical growth.⁴

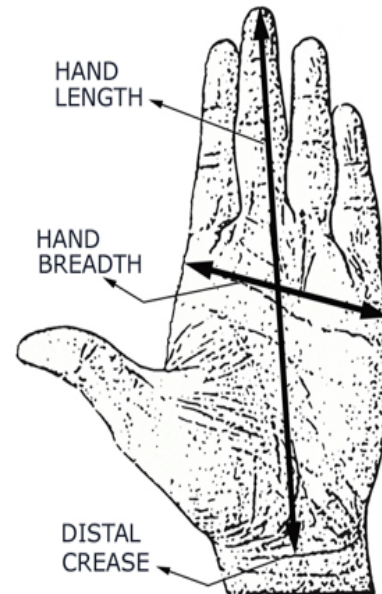
As very few studies of this kind have been conducted in the population of and around perambalur region of Tamilnadu, there was always a need for the study to derive formulae for determining sex from the anthropometric measurements of hand, with this view, the present study was carried out to evaluate sexual dimorphism in hand index calculated from hand dimensions in healthy individuals at Dhanalakshmi Srinivasan Medical College & Hospital, Perambalur, Tamilnadu.

Aims and Objectives

- To investigate sexual dimorphism using Hand Length, Hand Breadth and Hand Index.
- To assess the usefulness of the Hand index (Hand breadth X 100/Hand length) to determine sex.
- To assess bilateral variations for the above-mentioned parameters.
- To compare the results of this study with other workers.

Material and Method

Ethical approval was taken from the Institutional Ethics Committee, Dhanalakshmi Srinivasan Medical College & Hospital, Perambalur, Tamilnadu. (vide letter no. IECHS /IRCHS /DSMCH /Cert /009, dated: 17.10.2019). the research study was based on 300 healthy individuals (150 males and 150 females) devoid of any deformity, injury, fracture or surgical proceedings of either hand were randomly selected from the Perambalur district of Tamilnadu. The age of the subjects ranges from 18 to 70 years because, at this age range, maximum growth of the hand was achieved. A database of Hand Length and Hand Breadth was obtained from each subject as anthropometric measurements with the help of a standard anthropometric instrument i.e. sliding caliper. Informed consent was obtained from each subject prior to the study.



Hand Length & Hand Breadth: Hand of the subject was kept straight and flat on the table. All fingers were kept extended and adducted. Thumb was kept extended and abducted. Hand length was measured from a palmer aspect of the hand as a straight distance between the midpoint of the distal transverse crease of the wrist joint and the tip of the middle finger.

Hand Breadth was measured from a palmer aspect of the hand as a straight distance between the most laterally placed point on the head (Lower epiphyses) of the 2nd metacarpal to the most medially placed point on the head (Lower epiphyses) of the 5th metacarpal.

Hand Index: Hand Index was calculated from Hand Length & Hand Breadth as below.

$$\text{Hand index} = \frac{\text{Hand Breadth}}{\text{Hand Length}} \times 100$$

The data was analyzed statistically software like **Statistical Package for the Social Sciences (SPSS)-Version 20 and Microsoft Excel.**

The mean, standard deviation and standard error were derived for each of the above measurements in both the sexes. The paired T-test was applied to determine the statistical significance of differences in

measurements like Hand length, Hand Breadth and Hand Index. Male-female differences for the variables were observed using the student's t-test at $p < 0.05$ as a level of significance. The sex determination point or sectioning point was derived for the hand index which is often described as the cut-off point. Percentage accuracy of sex determination was also performed on the basis of sectioning points for all the hand dimensions and ratios in the entire population.

$$\text{Sectioning point (S.P)} = \frac{(\text{Mean Male Value} + \text{Mean Female Value})}{2}$$

Results

Hand Length

Descriptive statistics for Hand Length for both males & females are depicted in Table 1. In males, the average Right-Hand length was 18.11 ± 1.01 varying from 15.3 cm to 21 cm and the average left-Hand length was 17.98 ± 1.04 varying from 14.4 cm to 20.6 cm. In Females, the average Right-Hand length was 16.81 ± 0.93 varying from 14.9 cm to 19.8 cm and the average left-Hand length was 16.74 ± 0.98 varying from 14.7 cm to 19.6 cm. Male-female differences were found statistically significant at $p < 0.001$ for both right and left hand however non-significant for the difference between right and left hand in both sexes. It is observed that Hand Length was significantly larger in males about 1.2 cm as compared to females thus sexual dimorphism exists on the basis of hand length.

Table 1: Descriptive statistics: Hand Length (cm) in Males & females.

Parameter	Min.	Max.	Mean \pm SD
Male (n =150)			
RHL	15.3	21	18.11 ± 1.01
LHL	14.4	20.6	17.98 ± 1.04
Female (n =150)			
RHL	14.9	19.8	16.81 ± 0.93
LHL	14.7	19.6	16.74 ± 0.98

RHL - Right-Hand Length, LHL - Left Hand Length, S.D. - Standard Deviation

Hand Breadth

Descriptive statistics for Hand breadth for both males & females are depicted in Table 2. In males, the average Right-Hand breadth was 8.18 ± 0.51 varying from 7 cm to 9.8 cm and the average left-Hand breadth was 8.09 ± 0.56 varying from 6.5 cm to 9.5 cm. In Females, the average Right-Hand breadth was 7.35 ± 0.47 varying from 6.4 cm to 9 cm and the average left-Hand breadth was 7.26 ± 0.57 varying from 6.2 cm to 9.1 cm. Male-female differences were found statistically significant at $p < 0.001$ for both right and left hand however non-significant for the difference between right and left hand in both sexes. It is observed that Hand breadth was significantly larger in males about 0.8 cm as compared to females thus sexual dimorphism exists on the basis of hand breadth.

Table 2: Descriptive statistics: Hand Breadth (cm) in Males & females.

Parameter	Min.	Max.	Mean \pm SD
Male (n =150)			
RHB	7	9.8	8.18 ± 0.51
LHB	6.5	9.5	8.09 ± 0.56
Female (n =150)			
RHB	6.4	9	7.35 ± 0.47
LHB	6.2	9.1	7.26 ± 0.57

RHB - Right-Hand Breadth, LHB - Left Hand Breadth, S.D. - Standard Deviation

Hand Index

Descriptive statistics for Hand Index for both males & females are depicted in Table 3. In males, the average Right-Hand Index was 45.21 ± 2.16 varying from 38.1 cm to 49.73 cm and the average left-Hand Index was 45.03 ± 2.66 varying from 35.33 cm to 52.73 cm. In Females, the average Right-Hand Index was 43.73 ± 1.89 varying from 38.64 cm to 47.59 cm and the average left-Hand Index was 43.38 ± 2.73 varying from 38.07 cm to 50.34 cm. Male-female differences were found statistically significant at $p < 0.001$ for both right and left hand however non-significant for the difference between right and left hand in both sexes.

Table 3: Descriptive statistics: Hand Index (cm) in Males & females.

Parameter	Min.	Max.	Mean ± SD
Male (n =150)			
RHI	38.10	49.73	45.21 ± 2.16
LHI	35.33	52.73	45.03 ± 2.66
Female (n =150)			
RHI	38.64	47.59	43.73 ± 1.89
LHI	38.07	50.34	43.38 ± 2.73

RHI - Right-Hand Index, LHI - Left Hand Index, S.D. - Standard Deviation

Percentage accuracy of sex determination based on sectioning point analysis

Percentage accuracy of sex determination based on S.P analysis in the entire population is shown in (Table 4). Sectioning point or cut-off was calculated based on average hand index for both sexes. In hand

length, 17.46 for right hand and 17.36 for left hand were derived as the sectioning point to determine sexual dimorphism. It accurately determines sex in 83% males and 75% females for the right hand and 77% males and 73% females for left hand. In hand breadth, 7.76 for right hand and 7.67 for left hand were derived as the sectioning point to determine sexual dimorphism. It accurately determines sex in 89% males and 84% females for the right hand and 84% males and 77.3% females for left hand. Thus, Hand dimension can identify sex with higher accuracy and hand breadth seems to be best discriminator of sex in comparison with hand length. In hand index, 44.47 for right hand and 44.20 for left hand were derived as the sectioning point to determine sexual dimorphism. It accurately determines sex in 59.3% males and 60% females for the right hand and 66% males and 66.6% females for left hand. Thus, index below and equal to 44 is suggestive of male hand whereas those above 44 were considered as female hand.

Table 4: Percentage accuracy of sex determination based on S.P analysis in the entire population (n = 300)

Variables	Right Hand			Left Hand		
	S. P.	Male	Female	S. P.	Male	Female
HL	17.46	83.3	74.6	17.36	77.33	72.66
HB	7.76	89	84	7.67	84	77.33
HI	44.47	59.3	60	44.20	66	66.6

Table 5: Comparative of the hand dimension mean for Sex determination for various population.

Population	Sex	Side	HL	HB	HI	References
North Indian Population	Male	Right	19.9	8.0	40.4	(Kanchan & Rastogi, 2009) ⁵
		Left	19.9	7.9	40.0	
	Female	Right	17.9	7.2	40.1	
		Left	17.9	7.1	39.5	
Mauritius Population	Male	Right	18.9	8.5	44.02	(Agnihotri, Purwar, & Jeebun, 2005) ⁶
		Left	18.9	8.4	45.05	
	Female	Right	17.2	7.5	42.65	
		Left	17.2	7.4	43.79	
Rajasthan Population	Male	Right	19.3	8.3	43.1	(Sangeeta Dey,*, A. K. Kapoor, 2015) ⁷
		Left	19.2	8.2	42.6	
	Female	Right	17.5	7.6	43.5	
		Left	17.3	7.5	43.2	

Upper Egyptians	Male	Right	19.5	8.1	41.8	(Aboul-Hagag, Mohamed, Hilal, & Mohamed, 2011)
		Left	19.5	8.1	41.8	
	Female	Right	18.1	7.1	39.5	
		Left	18.1	7.1	39.5	
Present Study	Male	Right	18.1	8.1	45.2	-----
		Left	17.9	8.1	45.0	
	Female	Right	16.8	7.3	43.7	
		Left	16.7	7.2	43.3	

Discussion

Sex determination of unknown fragmentary evidence was a challenge for forensic experts however they compete with the challenge by inventing newer methodology for determining sex. With the advancement of modern technology such as determination of sex with DNA analysis has simplified forensic investigation to a greater extent. But many at times it cannot fulfil the expectations to identify mutilated or fragmentary remains, again it cannot be employed in all the cases due to time consumption and limited expenditure. Thus, anthropometry is still most commonly employed for identification of humans. In our study hand length and hand breadth was determined as sex indicators and an attempt was made to discriminate sexes on the basis of hand dimension indicators.

In males, it was observed that Hand Length was significantly larger in males about 1.2 cm as compared to females thus sexual dimorphism exists on the basis of hand length. Whereas it is observed that Hand breadth was significantly larger in males about 0.8 cm as compared to females thus sexual dimorphism exists on the basis of hand breadth. Male-female differences were found statistically significant at $p < 0.001$ for both right and left hand however non-significant for the difference between right and left hand in both sexes. Even though these measurements i.e. Hand length and Hand breadth are dependent to body size of the individual thus hand index was derived in the present research as it is independent and not related to the stature as well as age and more reliable to determine sex of human remains.

In males the average hand index was 45.12, whereas in females, the average hand index was 43.55.

Male-female differences were found statistically significant at $p < 0.001$ for both right and left hand however non-significant for the difference between right and left hand in both sexes.

Sectioning point was derived as a cut off point on the basis of hand index for determine sexual dimorphism. The results demonstrate that cut-off point of below and equal to 44 is suggestive of male hand whereas those above 44 were considered as female hand. Aboul-Hagag, et al. in their study of determination of sex from hand indices in upper Egyptians derived cut-off point of 40.55 to discriminate between sex.

Sectioning point analysis also able to percentage of accuracy of various hand dimensions for determine sex. Hand length accurately determines sex in 83% males and 75 % females for the right hand and 77% males and 73 % females for left hand. In hand breadth, accurately determines sex in 89 % males and 84% females for the right hand and 84 % males and 77.3 % females for left hand. Thus, Hand dimension can identify sex with higher accuracy and hand breadth seems to be best discriminator of sex in comparison with hand length.

Conclusion

This study has its implication in mass disasters and in criminal cases where an isolated hand was recovered from the scene, which needs a forensic identification. Similar studies on the said topic need to be carried out for a proper database and for future references.

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