International Journal of Research in Medical Sciences
Dey S et al. Int J Res Med Sci. 2015 Jun;3(6):1466-1472
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: 10.18203/2320-6012.ijrms20150169

Research Article

Sex determination from hand dimensions for forensic identification

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Received: 21 April 2015
Accepted: 08 May 2015

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ABSTRACT

Background: Sex determination is an important and foremost criteria in establishing the identity of an individual. The issue of Sex discrimination can be very complicated in cases of intersex, bodies in 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 has been very useful tool in sexual identification.
Objectives: This paper attempts to discriminate between male and female on the basis of hand dimensions, to investigate among the variables which can better predict sex, to derive sectioning point for discriminating sex and to reflect frequent hand index category among the sexes.
Methods: The research study was based on 182 subjects (91 males & 91 females) within age 18-60 years, devoid of any deformity, fracture or surgical proceedings of either hand were randomly selected from Udaipur district of Rajasthan. Hand Length and Hand Breadth was obtained from each subject and results were analyzed using IBM SPSS computer software.
Results: Hand length and hand breadth show statistically significant male – female differences at $p<0.001$. Hand Breadth was found as best predictor of sex in comparison with hand length. Frequency of hand index categories reveals that females have highest dolichocheir morphology of hand. Sectioning point analysis confirms that cut-off point of 43 and below is suggestive of male hand whereas above 43 were considered as female hand.
Conclusions: This study has implications in mass disasters and in criminal cases where an isolated hand is recovered and needs forensic identification.

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

INTRODUCTION

The process of individualizing person is commonly known as personal identification. Amongst the various parameters of identification, Sex determination is an important and one of the foremost criteria in establishing the identity of anindividual.[1] Sex Determination is often considered as one of the simplest task in forensic investigation as the genitalia can directly suggest the sex of the individual. However, the issue of Sex discrimination can be very complicated in cases of intersex, bodies in advanced state of putrefaction, mutilated, fragmentary and skeletonized remains in which it is common to recover dismembered & peripheral parts of the body. Forensic anthropologists routinely work with skeletonised and badly decomposed bodies, and collect osteometric data which is generally very straight-forward and stature estimation from various parameters[2-5] such as Hand outlines[6] and determination of sex[7,8] are often the easiest component for generation of the biological profile. But, the collection of osteometric data can be more challenging when dealing with fleshed remains as there is the need for soft tissue dissertation. One way to bypass this requirement would be the use of anthropometric measurements for the determination of sex. Anthropometry is the best known and the earliest method of identification also known as Bertillon system of criminal identification.[9] As human population exhibit some sort of sexual dimorphism which provides discriminating features regarding sex such as skeleton of male are on average larger than female thus the size of the skeleton can be used

to estimate sex of the individual.[10] Traditionally, the pelvic bone has been used extensively for sex determination together with skull. Then arose the trend to determine sex from long bone measurements.[7,11] Then, it is recognized that anthropometric measurements of the hand has been very useful tool in sexual dimorphism detection.[12-16] This is also shown with the discriminant function equation that hand bone length measurements have been sexually dimorphic[17,18] Literature review suggests that sex can be determined with metacarpals length,[19,20] with first proximal phalanx[21], with measurements and foot index.[22,24] Extensive work has been done with finger length ratios.[25-28]

The present study has the following aims & objectives:

a. To investigate sexual dimorphism using Hand Length, Hand Breadth& Hand Index.
b. To study among the variables which can better predict sex.
c. To find the sectioning point for discriminating sex on the basis of hand dimension.
d. To indicate most frequent hand index category among the sexes.

METHODS

The research study was based on 182 subjects (91 males and 91 females) devoid of any deformity, injury, fracture or surgical proceedings of either hand were randomly selected from Udaipur district of Rajasthan. The age of the subjects ranges from 18-60 years, because at this age range, maximum growth of hand was achieved. A database of Hand Length and Hand Breadth was obtained as shown in (Figure 1) from each subject as anthropometric measurements with the help of standard anthropometric instrument i.e. sliding caliper. Informed consent was obtained from each subject prior to the study.

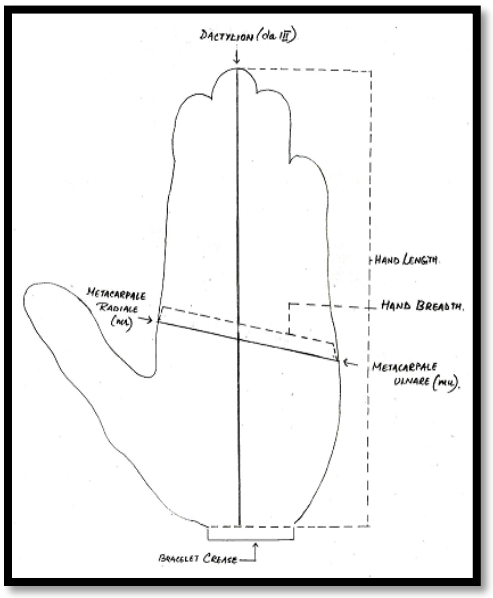


Figure 1: Human Hand showing Hand Measurements (Hand Length & Hand Breadth) and Landmarks.

Anthropometric Measurements

- The hand length was measured as a straight distance between inter-stylion and dactylion (III).
- The hand breadth was measured as a straight distance between metacarpal radialis and metacarpal ulnare. The techniques for measurements were followed as described by Singh & Bhasin.[2]
- Hand index was calculated by dividing hand breadth with the hand length and multiplied by 100.

Hand index (HI) =

$$\frac{\boldsymbol{Hand\ breadth\ (mr-mu)}}{\boldsymbol{Hand\ length\ \ (sty-da)}} \times \mathbf{100}$$

Hand Index was analyzed on the basis of Standard range described by Martin & Saller [30] in which five range of Hand indices were introduced as shown in (Table 1).

Table 1: Martin & Saller Standard range of Hand Indices.

Range - Variation (According to Martin & Saller)	
Hyperdolichocheir	X – 40.9
Dolichocheir	41.0 – 43.9
Mesocheir	44.0 – 46.9
Brachycheir	47.0 – 49.9
Hyperbrachycheir	50.0 – X

Statistical analysis

The databases for Hand Length & Hand Breadth were analyzed using IBM SPSS (Statistical Package for Social Sciences, Version 20.0) computer software. Descriptive statistics i.e. mean, standard deviation, range for the Hand Length, Hand Breadth and Hand Index were calculated. Male – female differences for the variables was observed using student's t-test at $p<0.05$ as level of significance. Sex determination point or Sectioning point was derived for Hand Index which is often described as cut off point.

Sectioning Point (S.P) =

$$\frac{(\boldsymbol{Mean\ Male\ Value + Mean\ Female\ Value})}{\mathbf{2}}$$

Percentage accuracy of sex determination was also performed on the basis of sectioning point for all the hand dimensions & ratio in the entire population.

RESULTS

Hand Length

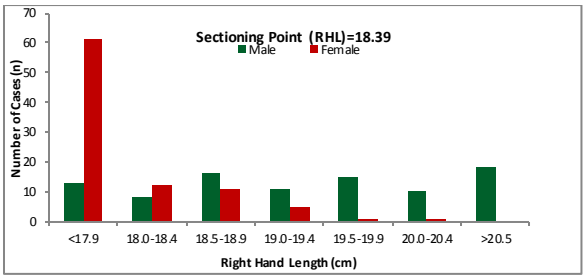
Descriptive statistics for Hand Length for both males & females are depicted in (Table 2). In males the average Right Hand Length was 19.30±1.15 varied from 16.9cm to 22.5cm and the average Left Hand Length was 19.21±1.13 varied from 16.5cm to 22.3cm. In females,

the average Right Hand Length was 17.48±1.07 varied from 14.3cm to 20.3cm and the average Left Hand Length was 17.34±1.04 varied from 13.9cm to 20.1cm. Male-female differences was found statistically significant at p<0.001 for both right and left hand however non significant for difference between right and left hand in both sexes. It is observed that Hand Length was significantly larger in males about 1.8cm as compare to females thus sexual dimorphism exists on the basis of hand length. Sex wise frequency distribution of the entire population for both right and left Hand Length are depicted in (Figure 2) to demonstrate sexual dimorphism.

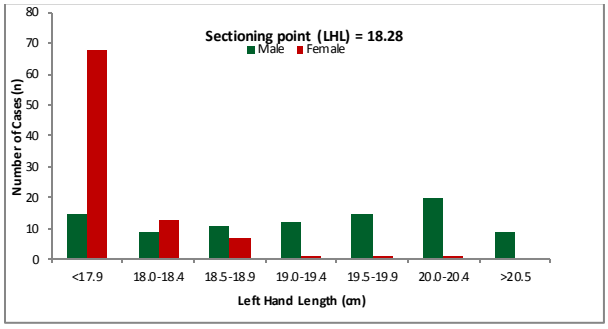
Table 2: Descriptive statistics: Hand Length (cm) in Males & females.

Variables (cm)	Minimum	Maximum	Mean	S.D.
Males(n=91)				
RHL	16.9	22.5	19.30*	1.15
LHL	16.5	22.3	19.21*	1.13
Females(n=91)				
RHL	14.3	20.3	17.48*	1.07
LHL	13.9	20.1	17.34*	1.04

RHL - Right Hand Length, LHL - Left Hand Length, factor, S.D. – Standard Deviation, * - P < 0.001.



(a) Right Hand Length



(b) Left Hand Length

Figure 2: Hand Length (cm): Distribution of males & Females in entire population.

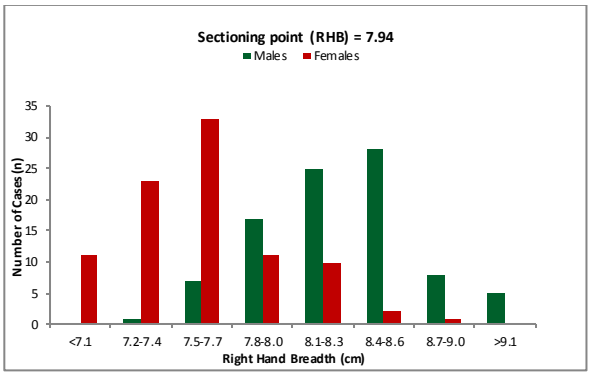
Hand Breadth

Descriptive statistics for Hand Breadth for both males & females are depicted in (Table 3). In males the average Right Hand Breadth was 8.29±0.39 varied from 7.3cm to 9.2cm and the average Left Hand Breadth was 8.17±0.37varied from 7.1cm to 9.0cm. In females, the average Right Hand Breadth was 7.58±0.39 varied from 6.9cm to 8.7cm and the average Left Hand Breadth was 7.47±0.38 varied from 6.8cm to 8.5cm. Male-female differences was found statistically significant at p<0.001 for both right and left hand however non significant for difference between right and left hand in both sexes. It is observed that Hand Breadth as Hand Length was significantly larger in males about 0.7cm as compare to females thus sexual dimorphism exist on the basis of hand Breadth. Sex wise frequency distribution of the entire population for both right and left Hand Breadth are depicted in (Figure 3) to demonstrate sexual dimorphism.

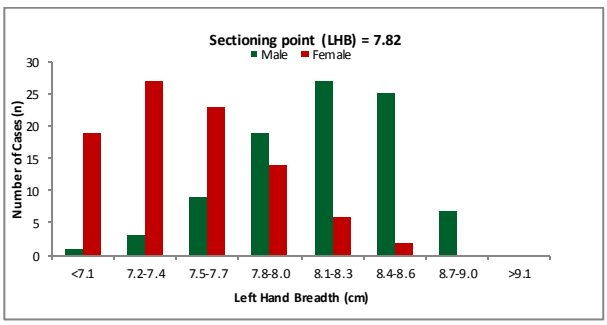
Table 3: Descriptive statistics: Hand Breadth (cm) in Males & females.

Variables (cm)	Minimum	Maximum	Mean	S.D.
Males(n=91)				
RHB	7.3	9.2	8.29*	0.39
LHB	7.1	9.0	8.17*	0.37
Females(n=91)				
RHB	6.9	8.7	7.58*	0.39
LHB	6.8	8.5	7.47*	0.38

RHB - Right Hand Breadth, LHB - Left Hand Breadth, S.D. – Standard Deviation, * - P < 0.001.



(a) Right Hand Breadth



(b) Left Hand Breadth

Figure 3: Hand Breadth (cm): Distribution of males & Females in entire population.

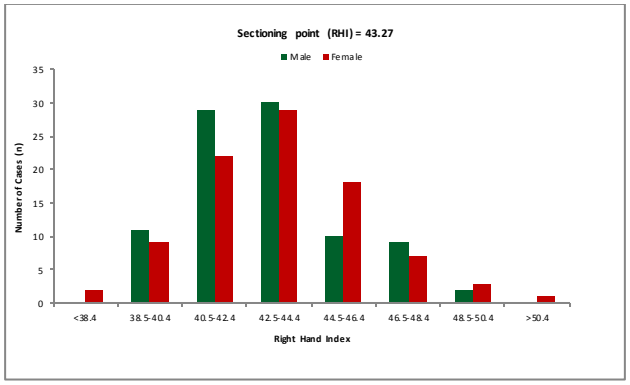
Hand Index

Descriptive statistics for Hand Index for both males & females are depicted in (Table 4). In males the average Right Hand Index was 43.08±2.45 varied from 39.0cm to 49.5cm and the average Left Hand Index was 42.63±2.37varied from 38.5cm to 48.2cm. In females, the average Right Hand Index was 43.45±2.37 varied from 38.4cm to 51.7cm and the average Left Hand Index was 43.21±2.63 varied from 38.4cm to 51.8cm. Male-female differences was found statistically significant at $p<0.001$ for both right and left hand however non significant for difference between right and left hand index in both sexes. Sex wise frequency distribution of the entire population for both right and left Hand Index are depicted in (Figure 4) to demonstrate sexual dimorphism.

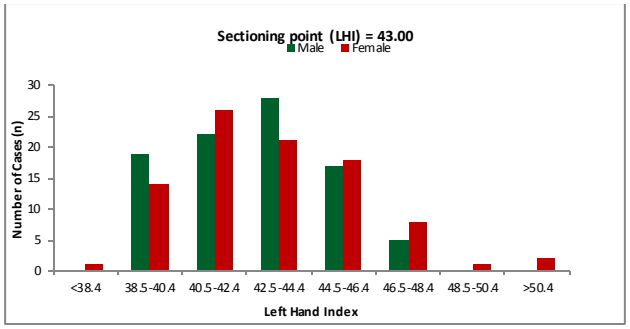
Table 4: Descriptive statistics: Hand Index in Males & females.

Variables	Minimum	Maximum	Mean	S.D.
Males (n=91)				
RHI	39.0	49.5	43.08*	2.45
LHI	38.5	48.2	42.63*	2.37
Females (n=91)				
RHI	38.4	51.7	43.45*	2.63
LHI	38.4	51.8	43.21*	2.63

RHI – Right Hand Index, LHI – Left Hand Index, S.D. – Standard Deviation, * - P < 0.001.



(a) Right Hand Length



(b) Left Hand Length

Figure 4: Hand Index: Distribution of males & Females in entire population.

Classification of Hand Index

Frequency Distribution of Hand Index categories according to the Martin & Saller [30] standard range of Hand Index is depicted in (Figure 5). It is observed that in 56% cases, females show Dolichocheirwhere as completely absent Brachycheir whereas Males show 41.8% & 29.7% Dolichocheir and Mesocheir respectively. This clearly depicts about females dolichocheir morphology of hand.

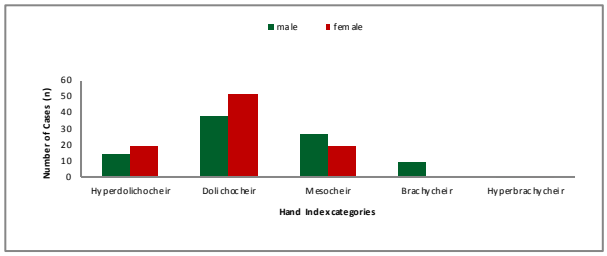


Figure 5: Frequency Distribution of Hand Index Categories among both Sexes.

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 5). Sectioning point or cut-off was calculated based on average hand index for both sexes. In hand length, 18.39 for right hand and 18.28 for left hand were derived as the sectioning point to determine Sexual dimorphism. It accurately determines sex in 77% males and 80% females for the right hand and 79% males and 81% females for the left hand. In Hand Breadth, 7.94 for right hand and 7.82 for left hand were derived as the sectioning point to determine Sexual dimorphism. It accurately determines sex in 80% males and 83% females for the right hand and 81% males and 82% females for the 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, 43.2 for right hand and 43.0 for left hand were derived as the sectioning point to determine Sexual dimorphism. It accurately determines sex in 59% males and 52% females for the right hand and 58% males and 46% females for the left hand. Thus index below and equal to 43 is suggestive of male hand whereas those above 43 were considered as female.

Table 5: Percentage accuracy of sex determination based on S.P analysis in the entire population (n = 182).

Variables	Right Hand			Left Hand		
	S.P	Male	Female	S.P	Male	Female
HL	18.39	76.9	80.2	18.28	79.1	81.3
HB	7.94	80.2	83.5	7.82	81.3	82.4
HI	43.27	59.3	51.6	43.00	58.2	46.2

HL – Hand Length, HB – Hand Breadth, HI – Hand Index, S.P – Sectioning point.

Table 6: Comparative of the hand dimension mean for sex determination for various populations.

Population	Sex	Side	HL	HB	HI	References
North Indian Population	Male	Right	19.9	8.0	40.4	(Kanchan & Rastogi, 2009)
		Left	19.9	7.9	40.0	
	Female	Right	17.9	7.2	40.1	
		Left	17.9	7.1	39.5	
South Indian population	Male	Right	19.9	8.1	40.7	(Kanchan & Rastogi, 2009)
		Left	19.9	8.0	40.5	
	Female	Right	17.9	7.2	40.5	
		Left	17.9	7.1	39.7	
Mauritius population	Male	Right	18.9	8.5	44.02 – 45.05	(Agnihotri, Purwar, & Jeebun, 2005)
		Left	18.9	8.4		
	Female	Right	17.2	7.5	42.65 – 43.79	
		Left	17.2	7.4		
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	19.3	8.3	43.1	-
		Left	19.2	8.2	42.6	
	Female	Right	17.5	7.6	43.5	
		Left	17.3	7.5	43.2	

HL - Hand length, **HB** - Hand Breadth, **HI** – Hand Index.

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 a times it cannot fulfils 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 found that hand length was significantly larger about 1.8cm as compare to females thus sexual dimorphism exists on the basis of hand length. Hand Breadth like Hand Length was significantly larger in males about 0.7cm as compare to females thus sexual dimorphism exist on the basis of hand breadth. Earlier studies on sex determination with hand dimension also suggest the similar results that males have statistically larger dimension of hands than females.[16, 25] Male-female differences was found statistically significant at $p<0.001$ for both hand length and hand breadth but non-significant for difference between right and left hand in both sexes. However these measurements i.e. HL & HB are dependent to body size of the individual thus hand index was derived in the present research to combat as it is independent and not related to stature as well as age and more reliable to determine sex of human remains. In males the average hand index was 42.85 whereas in females, the average hand index was 43.33. Male-female differences was found statistically significant at $p<0.001$ for both right and left hand however non significant for difference between right and left hand index in both sexes.

Frequency Distribution of Hand Index categories revealed that in 56% cases, females show Dolichocheir with absence of Brachycheir whereas Males show 41.8% & 29.7% Dolichocheir and Mesocheir respectively. This clearly depicts about females highest dolichocheir morphology of hand. However more studies on different population groups are needed to validate the results as hand dimensions tend to differ in various ethnic groups which is reported in earlier studies.[14]

Sectioning point was derived as a cut-off point on the basis of hand index for sexual dimorphism. The results demonstrate that cut-off point of 43 and below is suggestive of male hand whereas above 43 were considered as female hand. This is also demonstrated by showing gender wise frequency distribution (Figure 4). 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.[25] Foot index in females was foundto be more than 36 and in males less than 36. A study on determination of sex from foot index revealed that it will be female if foot index is found to be equal or more than 36 and male if it is les than 36.[31]

Sectioning point analysis also depicts the percentage accuracy of various hand dimensions for determining sex.Hand length accurately determines sex in 77% males and 80% females for the right hand and 79% males and 81% females for the left hand. In Hand Breadth, accurately determines sex in 80% males and 83% females for the right hand and 81% males and 82% females for the 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. Similar results were also found among north and south Indians.[16]

CONCLUSION

From the present research it can be concluded that hand dimensions can be successfully applied to determine sex. Among the hand dimensions hand was identified as more reliable predictor of sex. Hand index categories suggest that females mostly belong to dolichocheir group. This study shows cut-off point of 43 and below is suggestive of male hand whereas above 43 were considered as female hand. This study has implication in mass disasters and in criminal cases where an isolated hand was recovered and needs forensic identification. Similar studies on the said topic should be initiated for a proper database and also for future references.

ACKNOWLEDGEMENTS

The authors are sincerely grateful to all participants for their participation and support in the study.

Funding: No Funding Sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Paola M, Stefano D, Inmaculad L, Aleman K and Miguel C. Sex assement from the carpal bone. Forensic science international journal 2011; 206-216.
2. Boldsen J. A Statistical Evaluation of the Basis for Predicting Stature from Lenghts of Long bones in European Populations. American Journal of Physical Anthropology. 1984; 65: 305-311.
3. Trotter M, and Gleser G C. Estimation of Stature from long bones of American Whites and Negroes. American journal of Physical Anthropology 1952; 9: 427-440.
4. Telkka A. On the Prediction of human stature from the long bones. Acta Anat. 1950; 103-117.
5. Sangeeta Dey and Kapoor A K. Hand length and Hand Breadth: A Study of Correlation Statistics among Human Population. International Journal of Science and Research 2015; 4(4): 148 – 150.
6. Sangeeta Dey and Kapoor A K. Hand Outlines: A New Dimension in Forensic Examination. International Journal of Advanced Research 2015; 3(1): 193-199.
7. Case D T and Ross R H. Sex determination from hand and foot bone lengths. J Forensic Sci 2007; 52: 264-270.
8. Smith S L. Attribution of hand bones to sex and population groups. J Forensic Sci 1996; 41: 469-477.
9. Bertillon, A. Identification Anthropometrique. Melun 1885; 65-73.
10. Nancy E, Paul M and Schivilli L. Forensic medicine of the lower extremity.Anthropological analysis of the lower extremity. Forensic Science and medicine 2005; 69-98.
11. Iscan M Y. Forensic anthropology of sex and body size. forensic science international 2005; 147: 107-112.
12. William T et al. Finger length ratios and sexual orientation. Nature 2000; 404: 455-456.
13. Tanuj K, Kewal K, Abhilasha S and Ritesh, G. A study of correlation of hand & foot dimensions for personal identification in mass disasters. Forensic Science International 2010; 112e1-112e6.
14. Okunribido O O. A survey of hand anthropometry of female rural farm workers in Ibadan, Western Nigeria. Ergonomics 2000; 43: 282-292.
15. Agnihotri A K, Purwar B and Jeebun N. Determination of sex hand Dimensions. Internal j. of Forensic Science 2006; 2(1).
16. Kanchan T and Rastogi P. Sex determination from hand dimensions of North and South Indians. J Forensic Sci 2009; 54(3): 546–50.
17. Giles E and Elliot O. Sex determination by discriminant function analysis of crania. Am. J. Phys. Anthrop. 1963; 21: 53-68.
18. Eshak G, Ahmed H and Abdelgwad, V. Gender determination from hand bone length and volume using multidirector computed tomography. j of forensic legal medicine 2011; 18(6): 246-252.
19. Falsetti A B. Sex assessment from metacarpals of the human hand. J Forensic Sci 1995; 40: 774-776.
20. Lazenby R A. Identification of sex from metacarpals: effect of side asymmetry. J Forensic Sci 1994; 39: 1188-94.
21. Scvheuer J L and Elkington N M. Sex determination from metacarpals and the first proximal phalanx. J Forensic Sci 1993; 38: 769-778.
22. Agnihotri A K, Shukla S, and Purwa B. Determination of Sex from foot measurements. International journal of Forensic Science 2007; 2(3).
23. Moudgil R, Kaur R, Menezes R G, Kanchan T and Garg R K. Foot index: is it a tool for sex determination? J Forensic Leg Med 2008; 15: 223-226.

24. Tyagi A K, Rani M and Kohli A. Sexing by foot index. J Forensic Med 2004; 21: 10-1.
25. Aboul-Hagag K E , Mohamed S A, Hilal M A and Mohamed E A. Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians. Egyptian Journal of Forensic Sciences 2011; 1: 80-86.
26. Kanchan T and Kumar G P. Index and ring finger ratio - a morphologic sex determinant in South - Indian Children. Forensic Sci. Med. Pathol 2010; 6: 255-260.
27. Kanchan T, Kumar G P, Menezes R G, Rastogi P, Rao PPJ, and Menon A. Sexual dimorphism of index to ring finger ratio in south Indian adolescents. J Forensic Leg Med 2010; 17: 243–246.
28. Lippa R A. Are 2D: 4D finger-length ratios related to sexual orientation? Yes for men, no for women. J PersSocPsychol 2003;85:179-188.
29. Singh I P and Bhasin M K. A Manual of Biological Anthropology. Delhi: Kamla Raj enterprises, 2004.
30. Martin R and Saller K. Lehrbuch der Anthropologie, DritteAuflage. Vol. II. Stuttgart: Gustav Fischer Verlag, 1957.
31. Singla R, Bedi M, and Biswas M. Sex estimation from foot anthropometry in haryanvijats and north indian mixed population. J Punjab Acad Forensic Med Toxicol 2012;12(1):13-16.

DOI: 10.18203/2320-6012.ijrms20150169
Cite this article as: Dey S, Kapoor AK. Sex determination from hand dimensions for forensic identification. Int J Res Med Sci 2015;3:1466-72.