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Original Article

Anatomy Section

A Cross-Sectional Study to Determine Sex from Hand Dimensions in Gujarati Population

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ABSTRACT

Introduction: The hand dimensions can be used as a basis for determination of sex in cases where only fragmentary or mutilated remains of an unknown person are recovered.

Aim: To determine sex from hand dimensions in living subjects of Gujarati population.

Materials and Methods: The present study was conducted at Department of Anatomy, GMERS Medical College Gandhinagar, Gujarat, India, on 250 students (125 males and 125 females) aged between 18-22 years, belonging to Gujarat Region. Hand length and hand breadth were measured using digital vernier caliper and hand dimensions were measured separately for right and left hand. Statistical analysis was done using Epi Info version 7 software. Statistical analysis of data was done in relation with gender.

Results: Statistically significant difference was found between males and females for right hand index, left hand length and left hand index ($p<0.05$). The dimensions of hand length were more on left side than on right side in both sexes while the dimensions of hand breadth and hand index were more on right side than on left side in both sexes. The dimensions were larger in males than in females. Among hand dimensions, hand breadth was found to be the best indicator.

Conclusion: Hand breadth and hand length can be used with fair accuracy in identifying sex in medicolegal investigations. These measurements can be used particularly for Gujarati population.

Keywords: Hand measurements, Hand index, Sex determination

INTRODUCTION

Determination of sex from incomplete skeletal and decomposing human remains is particularly important in person identification. Traits tend to undergo change in varying degrees from birth to death, in health and disease. Persons living under different environmental conditions, having different nutritional requirements and dietary habits and different levels of physical activity present interesting differences in body form and proportions frequently [1].

Varu PR et al., has also conducted similar study on cadavers, but cadavers cannot represent a population as dimensions vary in cadavers and living persons [2]. To the best of our knowledge data on sex determination from hand dimensions are not available for adult Gujarati community. Hence, the aim of the study was to provide authentic database for forensic investigators to determine sex from Hand Dimensions in Gujarati population.

MATERIALS AND METHODS

This was an observational cross-sectional type of study, conducted in the Department of Anatomy, GMERS Medical College, Gandhinagar, during December 2017 to May 2018. Prior approval from the central research committee of our institute was taken with registration no. GMERS/MCG/CRC/28/2017. Study was conducted on 250 students (125 males and 125 females), born and brought up in Gujarat region. The subjects from other regions were excluded. The sample size was calculated by using formula $4PQ/L^2$ by following assumptions: 95% confidence interval and prevalence of gender (male or female) in nature is considered as 50%, allowable error 7% and non response rate 10%, {P(Prevalence/proportion)=50, Q (100-P)=50,L (allowable error)=7}. By using these considerations, minimum sample size was 204 and therefore, the study was conducted on 250 students.

Only right handed person were included in this study to avoid the possibility of influence of handedness on data standards [3]. Students with any deformities, injuries, fractures, amputations, history of surgical interventions for the hands or fingers of both hands were excluded.

The age group included for study was 18-22 years because ossification of hand bones completes by this age [4]. All the study subjects were given adequate information about the study and informed consent was taken. All the measurements were taken in a reasonably well lighted room. Measurements were taken by a single researcher to avoid inter-observer error in methodology. Measurements were taken separately for right and left hands, data were taken twice and the average value was recorded.

Anthropometric Measurements

The hand was placed on a flat surface with palm facing upwards and the fingers extended and close to each other. Care was taken to see that there was no abduction or adduction at the wrist joint, i.e., the forearm was directly in line with the middle finger. The measurements were taken by digital vernier caliper in centimetres with standard error of 0.05 mm.

Hand length: From distal wrist crease to distal end of the most anterior projecting point, i.e., tip of the middle finger [Table/Fig-1].

[Table/Fig-1]: Measurement of hand length.

Hand breadth: From most lateral point on the head of 2nd metacarpal to the most medial point on the head of 5th metacarpal [Table/Fig-2].

Hand index: Hand breadth/Hand length x 100

[Table/Fig-2]: Measurement of hand breadth.

Sectioning point can be used for determination of sex and it is obtained by mean values of a particular parameter. Values higher than the sectioning point usually indicate a male individual and lower values indicate a female individual [5]. Sectioning point for hand dimensions was derived by following formula [6].

$$\text{Sectioning Point (SP)} = \frac{\text{mean male value + mean female value}}{2}$$

STATISTICAL ANALYSIS

Data were entered and analysed through Epi Info version 7. Minimum, maximum, standard deviation were calculated. Unpaired sample t-test was used to compare continuous measurements. The p-value <0.05 was considered as statistically significant.

RESULTS

The observations in both sexes were analysed separately for both Right and Left hands in all 250 subjects. The statistical data which were extracted from the calculation and analysis are tabulated in [Table/Fig-3-8]. Measurements were higher in males than in females.

	Right hand length (cm)		Right hand breadth (cm)		Right hand index	
	Male	Female	Male	Female	Male	Female
Range	16.9-21	15.3-20.2	7.2-9.1	6.1-8.3	38.69-48.91	37.13-47.06
Mean	18.91	17.36	8.27	7.40	43.81	42.62
SD	0.97	0.85	0.41	0.37	2.24	1.87
p-value	0.12		0.21		0.04	

[Table/Fig-3]: Measurements of right hand dimensions.

	Left hand length (cm)		Left hand breadth (cm)		Left hand index	
	Male	Female	Male	Female	Male	Female
Range	16.7-21.2	15.6-19.9	7.3-9.3	6.4-8.4	38.5-49.14	37.72-48.48
Mean	19.02	17.40	8.26	7.36	43.53	42.35
SD	1.01	0.82	0.41	0.38	2.12	1.76
p-value	0.02		0.42		0.02	

[Table/Fig-4]: Measurements of left hand dimensions.

As shown in [Table/Fig-3], average Right hand length was 18.91±0.97 cm (range: 16.9-21 cm) in males and. 17.36±0.85 cm (Range: 15.3-20.2 cm) in females. Average Right hand breadth in males was 8.27±0.41 cm (Range: 7.2-9.1 cm) and in females it was 7.40±0.37 cm (Range 6.1-8.3 cm). Average Right hand Index was found to be 43.81±2.24 (Range: 38.69-48.91) in males and 42.62±1.87 (Range: 37.13-47.06) in females.

As shown in [Table/Fig-4], average Left hand length was 19.02±1.01 cm (Range:16.7-21.2 cm) in males and 17.40±0.82 cm (Range: 15.6-19.9 cm) in females. Average Left hand breadth in males was 8.26±0.41 cm (Range:7.3-9.3 cm) and in females it was 7.36±0.38 cm (Range: 6.4-8.4 cm). Average Left hand Index was found to be 43.53±2.12 cm (Range: 38.5-49.14 cm) in males and 42.35±1.76 (Range: 37.72-48.48) in females.

The p-value was statistically significant between male and female for Right hand index (0.04) and no statistically significant difference was found among male and female for right hand length (0.12) and right hand breadth (0.21). In left hand, statistically significant difference between male and female was found for Left hand length (0.02) and left hand index (0.02), and no statistically significant difference was found among male and female for left hand breadth (0.42).

Age wise distribution of Hand Length, Hand Breadth and Hand Index in males is tabulated in [Table/Fig-5] and in females in [Table/Fig-6].

Age groups (yrs)	Average HL (cm)	Average HB (cm)	Hand index
18			
Right	19.1	8.41	44.03
Left	19.22	8.40	43.70
19			
Right	18.51	8.22	43.41
Left	18.62	8.17	43.88
20			
Right	18.86	8.22	43.58
Left	19.08	8.25	43.03
21			
Right	19.02	8.25	43.38
Left	19.03	8.25	43.35
22			
Right	19.04	8.27	43.43
Left	19.13	8.23	43.02

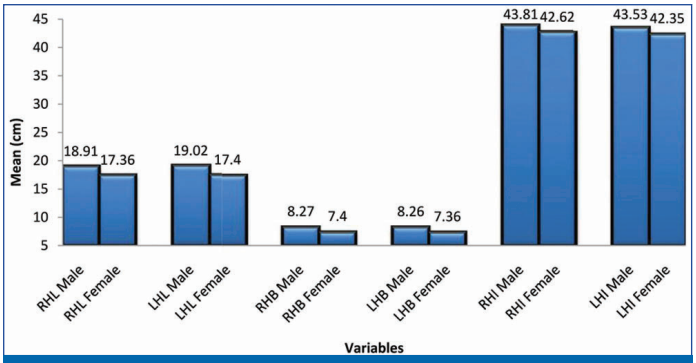
[Table/Fig-5]: Age wise distribution of hand dimensions in males.

Age groups (yrs)	Average HL (cm)	Average HB (cm)	Hand index
18			
Right	17.41	7.40	42.50
Left	17.47	7.28	41.67
19			
Right	17.40	7.42	42.64
Left	17.43	7.44	42.69
20			
Right	17.37	7.34	42.26
Left	17.32	7.29	42.09
21			
Right	17.25	7.41	42.95
Left	17.42	7.44	42.71
22			
Right	17.36	7.44	42.85
Left	17.28	7.39	42.77

[Table/Fig-6]: Age wise distribution of hand dimensions in females.

As shown in graph [Table/Fig-7], the dimensions of hand length were more on left side than on right side in both sexes while the dimensions of hand breadth and hand index were more on right side than on left side in both sexes.

Sectioning point for right hand length was 18.13 cm, from which 76.8% subjects were identified as males and 84% subjects were identified as females. For left hand length sectioning point was found to be 18.21 cm, by which 76.8% and 88% of subjects were identified as males and females respectively. Sectioning points for hand breadth was 7.83 cm on right side and 7.81 cm on left side. Accordingly, by right hand breadth 80.8% subjects were identified as male and 87.2% subjects were identified as female; and by left hand breadth, 79.5% subjects were identified as male and 88% subjects were identified as female. For right hand index, sectioning point was found to be 43.21 cm and by this 60.8% and 63.11% subjects were identified as males and females respectively. Sectioning point for left hand index was 42.94 cm and 63.2% of subjects were identified



[Table/Fig-7]: Graphical representation of descriptive statistical data for hand dimensions.
RHL: Right hand length; LHL: Left hand length; RHB: Right hand breadth; LHB: Left hand breadth; RHI: Right hand index; LHI: Left hand index

Variables	Right hand			Left hand		
	SP (cm)	Male (%)	Female (%)	SP (cm)	Male (%)	Female (%)
HL	18.13	76.8	84	18.21	76.8	88
HB	7.83	80.8	87.2	7.81	79.5	88
HI	43.21	60.8	63.11	42.94	63.2	68.0

[Table/Fig-8]: Showing sectioning point for hand dimensions (cm) and percentage of subjects identified as male and female (N=250, male=125, female=125).
HL: Hand Length; HB: Hand Breadth; HI: Hand Index; SP: Sectioning Point

as males and 68% of subjects were identified as females. In the present study, hand breadth was found to be the best parameter among hand dimensions for sex determination by sectioning point.

DISCUSSION

Regarding any medicolegal investigation, identification of unknown human remains is essential. DNA technology has simplified the issue of sex determination to a great extent, but it has its own limitations, regarding skilled man power, time consumption and financial issues particularly in developing countries [7]. So, anthropometry is still most commonly employed technique when DNA analysis cannot be performed. Among hand dimensions, hand length and hand breadth are not always reliable for sex discriminator because of variability in the built of a person. As the relative growth of bony components are supposed to be propotional to each other, sex determination by indices become more reliable [7]. When we consider sex differences in the ratios of these parameters, it is independent of body size and they are not significantly related to height and age in both sexes [8]. So, the objective of our study was to calculate hand dimensions, to determine sex in Gujarati population.

Hand dimensions were found to be larger in males than in females in our study. These findings were similar to that of previous studies conducted by other authors which is shown in [Table/Fig-9] [3,6,7,9-15]. Between male and female, we found statistically significant difference for right hand index, left hand length and left hand index. Regarding hand length and hand breadth our findings were in accordance with most of the other authors [3,6,7,10-14]. Ibeabuchi NM et al., in their study on Nigerian population found slightly higher value for mean hand length on right side in males than our study [15].

In the present study, we found mean hand index to be 43.81±2.24 on right side and 43.53±2.12 on left side in males. In females, it was 42.62±1.87 on right side and 42.35±1.76 on left side. Similar results were observed by other authors for both sexes [6,10,12-14]. Slightly higher values than our study were found by Dhavan V et al., in their study on Haryanvi population [14]. Hand index was found to be lower than our study in males and in females on both sides in the studies conducted by Khaled EAH et al., in upper Egyptians populations and by Kanchan T et al., in north and south Indian population [7,11]. Ibrahim MA et al., in their study on Saudi Arabian population found lower values for hand index than our study in females on right and left side [3] [Table/Fig-10] shows the comparison of sectioning points among male and female in various studies [3,6,7].

In the present study, we found hand length and hand breadth as better indicators for sex determination than hand index. Similar results were observed by Dey S et al., [6]. In their study, they reported that hand breadth is the best indicator. In contrast to this, Ibrahim MA et al., and Khaled EAH et al., documented that hand index is the best indicator for identification of sex [3,7].

Sr no.	Authors	Population and country	Age group (years)	Sex and No of subjects	Mean hand length (cm)		Mean hand breadth (cm)		Mean hand index	
					Right	Left	Right	Left	Right	Left
1	Ibrahim MA et al., [3]	Saudi arabia	18-30	M-300	19.56±0.87	19.64±0.04	8.23±0.47	8.34±0.47	42.87±1.32	42.86±1.28
				F-300	18.24±0.86	18.26±0.87	7.27±0.47	7.29±0.44	39.94±1.74	39.90±1.79
2	Dey S et al., [6]	Rajasthan	18-60	M-91	19.3±1.15	19.2±1.13	8.3±0.39	8.2±0.37	43.1±2.45	42.6±2.37
				F-91	17.5±1.07	17.3±1.04	7.6±0.39	7.5±0.38	43.5±2.63	43.2±2.63
3	Khaled EAH et al., [7]	Upper Egypt	18+	M-250	19.47±0.92	19.49±0.92	8.13±0.39	8.14±0.39	41.78±1.50	41.79±1.44
				F-250	18.13±0.90	18.16±0.91	7.16±0.39	7.17±0.40	39.53±1.50	39.5±1.59
4	Agnihotri A et al., [9]	Mauritius	18-30	M-125	18.89±0.88	18.9±0.87	8.45±0.40	8.42±0.40	>44	
				F-125	17.22±0.92	17.22±0.93	7.48±0.38	7.42±0.37	<44	
5	Danborno B et al., [10]	Nigeria	18+	M-250	19.85±0.86	19.93±0.93	8.9±0.95	8.68±0.92	44.92±5.15	43.65±5.15
				F-250	18.51±0.66	18.52±0.77	7.82±0.49	7.72±0.46	42.27±2.67	41.74±2.34
6	Kanchan T et al., [11]	North India	-	M-230	19.9	19.9	8.0	7.9	40.4	40.0
					17.9	17.9	7.2	7.1	40.1	39.5
		South India	-	F-270	19.9	19.9	8.1	8.0	40.7	40.5
					17.9	17.9	7.2	7.1	40.5	39.7
7	Devi KVS et al., [12]	South India	17-20	M-99	19.01	19.07	8.46	8.28	44.59	43.52
				F-151	17.72	17.59	7.65	7.39	43.34	42.1
8	Ibeachu PC et al., [13]	Nigeria	18-30	M-150	19.02±0.08	19.09±0.07	8.58±0.03	8.43±0.03	44.68±0.19	
				F-150	17.62±0.07	17.69±0.07	7.69±0.03	7.58±0.03	43.29±0.19	
9	Dhavan Vet al., [14]	Haryana, India	21-25	M-200	19.36±0.82	19.42±0.78	8.77±0.48	8.81±0.47	45.34±2.63	45.41±2.31
				F-200	17.73±0.68	17.72±0.72	7.8±0.4	7.92±0.8	43.99±2.12	44.72±4.29
10	Ibeabuchi NM et al., [15]	Nigeria	18-36	M-100	20.13±1.11	19.86±1.12	8.53±0.49	8.42±0.48	-	-
				F-130	18.21±1.06	17.97±1.04	7.55±0.41	7.41±0.40	-	-
11	Present study	Gujarat, India	18-22	M-125	18.91±0.97	19.02±1.01	8.27±0.41	8.26±0.41	43.81±2.24	43.53±2.12
				F-125	17.36±0.85	17.4±0.82	7.39±0.37	7.36±0.38	42.62±1.87	42.35±1.76

[Table/Fig-9]: Comparison of various studies on hand dimensions.

	Variables	Right hand			Left hand		
		SP (cm)	Male (%)	Female (%)	SP (cm)	Male (%)	Female (%)
Khaled EAH et al., [7]	HL	-	-	-	-	-	-
	HB	-	-	-	-	-	-
	HI	40.659	80	80	40.650	81.2	78.0
Dey S et al., [6]	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	43.0	58.2	46.2
Ibrahim MA et al., [3]	HL	-	-	-	-	-	-
	HB	-	-	-	-	-	-
	HI	41.41	90.7	93.2	41.38	91.2	92.0
Present study	HL	18.13	76.8	84	18.21	76.8	88
	HB	7.83	80.8	87.2	7.81	79.5	88
	HI	43.21	60.8	63.11	42.94	63.2	68.0

[Table/Fig-10]: Comparison of sectioning points (cm) and percentage of subjects identified as male and female among various studies.
[HL: Hand Length; HB: Hand Breadth; HI: Hand Index]

As discussed earlier, Khaled EAH et al., and Lippa RA et al., suggested that individual parameters like hand length and hand breadth are not always reliable sex discriminator [7,8]. But in our study as well as that of Dey S et al., and Kanchan T et al., hand breadth was found to be the best sex discriminator [6,11]. These differences between different populations may be attributed to genetic and environmental factors like climate, nutrition as well as level of physical activities.

LIMITATION

Limitations of the study are that, the present study was conducted on live adult population in particular age group of Gujarati population and in right handed persons only. So, the findings of the present study are not applicable to children, adolescents or elderly individuals. Rigor mortis or putrefactive changes occurring after death may alter the hand dimensions, so the observations of the present study can be applied if human remains are relatively fresh. These findings cannot be applied to decomposed or bloated bodies which affect hand dimensions.

Further research involving larger sample sizes, having different age groups in various regions and ethnic groups are suggested to provide larger database for hand dimensions.

CONCLUSION

In case of medicolegal investigations, sex can be estimated by anthropometric measurements when extremities or other body parts are not available for examination or when more reliable methods of sex determination are not available. In the present study, it is concluded that hand breadth and hand length can be applied to determine sex with fair accuracy in Guajarati population. Among hand dimensions, hand breadth is the best indicator and gives high accuracy in determining sex. As the measurements have better applicability when applied for the same population, further studies on determination of sex among different age groups and population should be encouraged.

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