# Determination of Sex Using Hand Dimensions

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**A B S T R A C T**

***Background****:* Whenever unknown or mutilated dead bodiesor dismembered body parts are found, crime investigative agencies focuses on establishment of identity of deceased in their primary investigation. Determination of sex from dismembered body parts can play vital role for identification of deceased. Present study can be helpful in such cases to determine sex from Hand dimensions, if isolated hand is found. Present study was done with the aim to derive cut off points for Hand length, breadth and Hand index to differentiate male and female.

***Methods:*** Value more than cut off point denotes male and less than that denotes female. Total 100 male and 100 female cases were randomly selected from cadavers brought for post-mortem examination at mortuary of P.D.U. Govt. Medical College and Hospital, Rajkot. Hand length and breadth was measured by sliding caliperup to nearest 0.1 cm after breaking Rigor mortis, if developed. Collected data were statistically analysed using software like Epi info 7 and Microsoft excel 2007.

***Results:*** No significant bilateral difference was found in Hand length ($P>0.05$) but Hand breadth was showing significant bilateral difference ($P<0.05$). However, bilateral difference in Hand breadth was relatively small (0.17 cm for males and 0.15 cm for females, on an average). So, combined right and left hand measurements were used to derive cut off points. Cut off point to differentiate male and female for Hand length, breadth and index were 17.2, **7.7** and 44.6 respectively.

***Conclusion:*** Hand length, breadth and Hand index are showing sexual dimorphism and therefore they can be used for determination of sex when isolated hand is found. Hand breadth was showing highest accuracy in determination of sex, followed by Hand length and Hand index.



►*Implication for health policy/practice/research/medical education:* Determination of Sex Using Hand Dimensions

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## 1. Introduction:

Forensic anthropometry is a scientific specialization emerged from the discipline of forensic anthropology dealing with identification of human remains with the help of metric techniques (1). In modern era, dismembered body parts are frequently found due to increased events of natural and man-made disasters and also due to increased events of the murders where the mutilation of dead body is done by a murderer to destroy all traces of identity as well as to facilitate the disposal of the dead. In such cases, forensic anthropologist can provide a tentative identification of unknown remains by formulating a 'biological profile', which involves the determination of stature, sex, age and ethnicity (2). Such tentative identification is important as it helps to narrow down the pool of victims in mass death scenarios by excluding individuals who do not have the same biological attributes.

Among 'big fours' of the biological profile, determination of sex is considered as one of the main parameter of personal identification as it cuts the possible number of matching identities by half. Sex determination is usually a simple task in forensic investigation when whole body is available as external or internal genitalia can directly suggest the sex of the individual; however problem arises when dismembered body parts are found. Forensic anthropometrists use various anthropometric techniquesto determine sex from such dismembered body parts. Such anthropometric techniques aims to find out cut off point in measurement of various body parts or bonesthat discriminate between male and female. Due to effect of sex hormones, males are taller, larger and more strongly built than females, so measurement more than cut off point is suggestive of male and less than that is suggestive of female. The degrees of such sexual dimorphism are influenced by a variety of environmental and genetic factors, and also by interaction between them (3). As genetic and environmental factors are different between different populations, no two populations can have same anthropometric measurements. So population specific cut off point should be found out. Keeping this in view, present study was carried out to derive cut off points for Hand dimensions specifically for population of and around Rajkot region of Gujarat (India).

## 2. Materials and Methods:

This study was carried out on 100 male and 100 female cases randomly selected from cadavers brought for post-mortem examination at mortuary of P.D.U. Govt. Medical College and Hospital, Rajkot (India). Age group selected for the study was more than 20 years as after 20 years hand dimensions do not change much. Cadavers with any injury, disease or anomaly that affect Hand dimensions were excluded from the study. Decomposed, charred or mutilated dead bodies were also excluded from the study.

Hand of the deceased was kept straight and flat on autopsy table. Hand length and breadth were measured by sliding caliper in centimeters up to accuracy of 1 decimal. Hand dimension were measured from palmer aspect of hand after breaking rigor mortis in hand, if developed. As shown in figure 1, all fingers were kept extended and adducted. Thumb was kept extended and abducted. Hand length was measured as a straight distance between the midpoint of distal

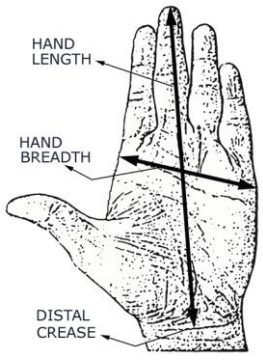


**Fig. 1.** Measurements of Hand length and Hand breadth.

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transverse crease of wrist joint and the tip of the middle finger. Hand breadth was measured as a straight distance between most laterally placed point on the head of the 2nd metacarpal and most mediallyplaced point on head of the 5th metacarpal.

It is well known fact that even among people of same population group, measurements of various parts of body and therefore Hand dimensions varies from individual to individual. To decrease effect of such variations, ratio of hand dimensions was derived in the present study for sex determination. Ratio of hand dimensions, i.e. Hand Index was calculated from Hand Length and Hand Breadth up to accuracy of 2 decimals as below.

Hand index = (Hand BreadthX 100) / Hand Length

**Statistical Analysis:** All the measurements were statistically analysed using software like Epi info 7 and Microsoft Excel 2007.Mean valuesof Hand dimensions and index were derived up to accuracy of 2 decimals. Independent samples T-test was applied to determine statistical significance of bilateral differences well as to determine statistical significance of gender difference in Hand dimensions and Hand Index. P-value of less than 0.05 was considered significant. Cut off points were derived to determine sex from Hand length, Hand breadth and Hand index as below (7).

Cut off point (7) = (Mean value for male + Mean value for female) / 2

Value more than cut off point suggests male and value less than that suggests female.

Accuracy of cut off points was calculated as below.

Accuracy (%) = (Correctly assigned male cases + correctly assigned female casesX 100) / Total cases

**3. Results:**

The demographic and clinical data of the Table 1 is showing descriptive statistics of all the cases. It is evident from the table that for Hand dimensions as well as for Hand index, mean with standard deviation of right side are more than their respective value of left side. However, as shown in table 2, statistically there is no significant bilateral difference in hand length and hand index ($P>0.05$) but hand breadth of right side is significantly more than hand breadth of left side ($P<0.05$). However, the bilateral difference in hand breadth is relatively small, on an average it is 0.17 cm for males and 0.15 cm for females.

It is evident from the table 1, that for hand dimensions as well as for hand index, mean with standard deviation of male cases are more than their respective value of female cases. Gender difference in hand dimensions and hand index is statistically confirmed by applying t-test as shown in table 3. Highly significant gender difference is found in hand dimensions and hand index ($P<0.001$).

As there is no significant bilateral difference in hand length and hand index and bilateral difference in hand breadth is small, there is no need to derive cut off points specific to right or left hand (4). So, combined right and left hand measurements are used to derive cut off points as shown in table 4.

Cut off points for Hand length, breadth and index are 17.2, 7.7and 44.6 respectively and their accuracy to differentiate sex are

**Table 1:** Descriptive statistics (Mean±SD)

| Parameter | Male cases (IN cm) | Female cases (IN cm) |
|---|---|---|
| right hand length | 17.98 ± 0.95 | 16.65 ± 0.84 |
| left hand length | 17.80 ± 0.98 | 16.57 ± 0.87 |
| right hand breadth | 8.26 ± 0.53 | 7.27 ± 0.33 |
| left hand breadth | 8.09 ± 0.60 | 7.15 ± 0.43 |
| right hand index | 45.96 ± 1.85 | 43.72 ± 1.69 |
| left hand index | 45.48 ± 2.55 | 43.17 ± 2.58 |

**Table 2:** Statistical comparison of right and left sidedhand dimensions and hand index.

| Cases | Parameters | Mean (IN cm) | | T value | p value* |
|---|---|---|---|---|---|
| | | Right | Left | | |
| Male | hand length | 17.98 | 17.80 | 1.347 | 0.180 (NS) |
| | hand breadth | 8.26 | 8.09 | 2.162 | 0.032 (S) |
| | hand index | 45.96 | 45.48 | 1.534 | 0.127 (NS) |
| Female | hand length | 16.65 | 16.57 | 0.614 | 0.540 (NS) |
| | hand breadth | 7.27 | 7.15 | 2.336 | 0.020 (S) |
| | hand index | 43.72 | 43.17 | 1.783 | 0.076 (NS) |

S= significant; NS= not significant; *P value<0.05 is significant

**Table 3:** Statistical comparison of male and femalehand dimensions and hand index.

| **Parameter** | **Mean (IN cm)** | | **T value** | **p value*** |
|---|---|---|---|---|
| | **Male** | **Female** | | |
| right hand length | 17.98 | 16.65 | 10.566 | 0.000 (S) |
| left hand length | 17.80 | 16.57 | 9.403 | 0.000 (S) |
| right hand breadth | 8.26 | 7.27 | 15.991 | 0.000 (S) |
| left hand breadth | 8.09 | 7.15 | 12.909 | 0.000 (S) |
| right hand index | 45.96 | 43.72 | 8.958 | 0.000 (S) |
| left hand index | 45.48 | 43.17 | 6.369 | 0.000 (S) |

S=Significant; *****P value<0.05 is significant and P value<0.001 is highly significant.

**Table 4:** Calculation of cut off points using combined right and lefthand measurements.

| **Parameter** | **Mean for combined right and left measurements (IN cm)** | | **CUT OFF POINTS*** |
|---|---|---|---|
| | **Male** | **Female** | |
| hand length | 17.87 | 16.61 | 17.2 |
| hand breadth | 8.18 | 7.21 | 7.7 |
| hand index | 45.72 | 43.45 | 44.6 |

*Cut off point = (Mean value for male + Mean value for female) / 2
Value more than cut off point suggests male and value less than that suggests female.

73.25%, 82% and 69.5%, respectively. So, hand breadth is showing highest accuracy in determination of sex, followed by hand length and hand index.

## 4. Discussion:

The human hand is the most used and versatile part of the body. It is of great scientific importance to investigators in the field of forensic anthropometry, especially to develop identification standards using anthropometric measurements of body. Identification of deceased can be problematic when deceased can no longer be recognised due to nature of injuries sustained. In such cases, determination of sex of deceased can play vital role in their identification as it cuts the possible number of matching identities by half. The present study was done with aim to develop sex estimation standards from hand measurements specifically for population in and around Rajkot region of Gujarat.

Several such studies have been carried out in past for population of different parts of world. Table 5 is showing comparison of mean with standard deviation values of hand dimensions and hand index of present study with other similar studies. Table 6 shows comparison of cut off points derived by

**Table 5:** Comparison of mean values of hand dimensions and hand index among different populations.

| Author | Reference | Study Population | Age Range (years) | SEX | Hand Length* (MEAN ± SD) | | Hand Breadth* (MEAN ± SD) | | Hand Index (MEAN ± SD) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Right | Left | Right | Left | Right | Left |
| **Ishak et al.** | 4 | Western Australia | 18-68 | M | 19.54 ± 0.93 | 19.56 ± 0.92 | 9.10 ± 0.48 | 9.04 ± 0.49 | - | - |
| | | | | F | 17.59 ± 0.82 | 17.60 ± 0.82 | 7.93 ± 0.45 | 7.84 ± 0.45 | - | - |
| **Agnihotri et al.** | 5 | Mauritius | 18-30 | M | 18.89 ± 0.88 | 18.90 ± 0.87 | 8.45 ± 0.40 | 8.42 ± 0.40 | 44.02 to 45.05 | 44.15 to 44.80 |
| | | | | F | 17.22 ± 0.92 | 17.22 ± 0.93 | 7.48 ± 0.38 | 7.42 ± 0.37 | 43.06 to 43.79 | 42.65 to 43.56 |
| **Danborno et al.** | 6 | Nigerian | 19-35 | M | 19.85 ± 0.86 | 19.93 ± 0.93 | 8.90 ± 0.95 | 8.68 ± 0.92 | 44.92 ± 5.15 | 43.65 ± 5.15 |
| | | | | F | 18.51 ± 0.66 | 18.52 ± 0.77 | 7.82 ± 0.49 | 7.72 ± 0.46 | 42.27 ± 2.67 | 41.74 ± 2.34 |
| **Aboul-Hagag et al.** | 7 | Egyptian | >18 | M | 19.47 ± 0.92 | 19.50 ± 0.92 | 8.13 ± 0.39 | 8.14 ± 0.40 | 41.78 ± 1.51 | 41.79 ± 1.44 |
| | | | | F | 18.13 ± 0.90 | 18.17 ± 0.91 | 7.17 ± 0.40 | 7.17 ± 0.41 | 39.54 ± 1.50 | 39.51 ± 1.59 |
| **Asha et al.** | 8 | South Indian | 20-30 | M | 19.44 ± 1.13 | 19.38 ± 1.02 | 8.25 ± 0.41 | 8.19 ± 0.37 | 42.53 ± 2.46 | 42.32 ± 2.17 |
| | | | | F | 17.47 ± 1.00 | 17.47 ± 1.01 | 7.31 ± 0.32 | 7.23 ± 0.31 | 41.95 ± 2.49 | 41.47 ± 2.48 |
| | | North Indian | 20-30 | M | 19.53 ± 1.16 | 19.46 ± 1.12 | 8.28 ± 0.46 | 8.17 ± 0.43 | 42.46 ± 2.26 | 42.03 ± 2.09 |
| | | | | F | 17.80 ± 0.93 | 17.74 ± 0.90 | 7.33 ± 0.43 | 7.27 ± 0.41 | 41.25 ± 2.46 | 41.02 ± 2.22 |
| **Present Study** | | In and around Rajkot region of Gujarat (India) | >20 | M | 17.98 ± 0.95 | 17.80 ± 0.98 | 8.26 ± 0.53 | 8.09 ± 0.60 | 45.96 ± 1.85 | 45.48 ± 2.55 |
| | | | | F | 16.65 ± 0.84 | 16.57 ± 0.87 | 7.27 ± 0.33 | 7.15 ± 0.43 | 43.72 ± 1.69 | 43.17 ± 2.58 |

SD=Standard Deviation; M=Male, F=Female

these studies. All of these studies are carried out on adult population. Present study was carried out on cadavers while all other studies were carried out on living population. From the comparison of studies, following findings are derived.

1. As evident from the table 5, mean of hand dimensions and hand index of all studies are different from each other, which substantiate well known fact that different population shows difference in measurements of body parts.

2. All these studies has found that hand dimensions as well as hand index are significantly larger in males compared to females ($P<0.05$), which means that hand dimensions and hand index are showing sexual dimorphism and therefore they are useful parameters to discriminate sex.

3. None of these studies show significant bilateral difference in hand dimensions as well as hand index except present study and study done by Ishak (4), which are showing significant bilateral difference in hand breadth. However, bilateral difference in hand breadth found by both these studies is small. In present study, bilateral difference in hand breadth is 0.17 cm for males and 0.15 cm for females on an average, while in study done by Ishak (4), it is 0.08 cm for males and 0.06 cm for females on an average. As there was no significant bilateral difference in hand length and bilateral difference in hand breadth was small, combined right and left hand measurements

**Table 6:** Comparison ofcut off points* to differentiate sex from hand dimensions and hand index.

| Author | Hand Length | Hand Breadth | Hand Index |
|---|---|---|---|
| Nur-IntaniahIshank et al. | 18.57 | 8.48 | - |
| Agnihotri et al. | - | - | 44 |
| Danborno et al. | - | - | 47 |
| Aboul-Hagag et al. | - | - | 40.55 |
| Asha et al. | - | - | 42 |
| Present Study | 17.2 | 7.7 | 44.6 |

*****Value more than cut off points denotes male and value less than cut off points denotes female

were used to derive cut off points in both these studies.

4. In study done by Ishak (4), hand breadth was able to differentiate sex with the higher accuracy (93.3%), followed by hand length (91.3%). Similar result was found in the present study. For present study, accuracy to differentiate sex using Hand breadth is 82% and using hand length is 73.25%.

5. As evident from the table 6, cut off points derived by all studies are different from each other. This finding justifies need of population specific studies to derive cut off points for hand dimensions and hand index to discriminate sex.

## 5. Conclusion:

From present study, it is concluded that human hand show sexual dimorphism in hand length, breadth and hand index, and therefore they can be used for determination of sex when isolated hand is found. Cut off point to differentiate male and female for hand length, breadth and index are 17.2, 7.7 and 44.6 respectively. Cut off points derived by present study are irrespective of side of hand, so they are useful even in situations where side of isolated hand cannot be determined. Value more than cut off point denotes male and less than that denotes female. Hand breadth is showing highest accuracy in determination of sex, followed by hand length and hand index.

As different population show difference in hand dimensions and index, results of present study are applicable to population in and around Rajkot region of Gujarat. Similar studies should be carried out for other populations to find out population specific cut off points in hand dimensions.

## 6. Acknowledgements:

None

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