



ORIGINAL ARTICLE

# Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians

Khaled E. Aboul-Hagag <sup>a,\*</sup>, Soheir A. Mohamed <sup>a</sup>, Maha A. Hilal <sup>a</sup>,  
Eman A. Mohamed <sup>b</sup>

<sup>a</sup> Forensic Medicine and Clinical Toxicology Department, Faculty of Medicine, Sohag University, Egypt

<sup>b</sup> Community Medicine Department, Faculty of Medicine, Sohag University, Egypt

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## KEYWORDS

Forensic anthropology;  
Personal identification;  
Sex determination;  
Hand dimensions;  
Hand index;  
Finger length

**Abstract** *Background:* Identification of human remains is an imperative element of any medico-legal investigation, and a challenging task for forensic experts and physical anthropologists worldwide.

*Aim:* The aim of this study was to determine sex (male/female) by hand dimensions and index and ring finger length ratio in Upper Egyptians.

*Materials and methods:* Five hundred students (250 males and 250 females) above age 18 years were examined. Hand length, breadth and hand index (breadth divided by length  $\times$  100), as well as index and ring finger ratio were estimated.

*Results:* The average hand length was found to be about 1.3 cm greater in males than females. Hand index  $\leq 40.55$  is suggestive of females and  $> 40.55$  is suggestive of males. The index and ring finger ratio is found to be higher in females. Index and ring finger ratio  $\leq 0.976$  is suggestive of males, and ratio  $> 0.976$  is suggestive of females.

*Conclusion:* This study may prove useful to determine the sex of an isolated hand when it is subjected for medicolegal examination.

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## 1. Introduction

Identification of an individual is the mainstay in forensic investigations. With the increasing frequency of mass disasters, either natural or in cases of war, acts of terrorism, bombing and traffic accidents, it is common to find dismembered human remains and peripheral parts of the body. In cases of mass disasters and assault cases where body is dismembered to conceal the identity of the victim, identification of dismembered, mutilated and fragmentary remains is vital. Among the primary parameters of identification viz. race, sex, age and stature, determination of sex is one of the foremost criteria in establishing the identity of an individual. Accurate sexing of

\* Corresponding author.

E-mail address: [dr\\_ksayed@yahoo.com](mailto:dr_ksayed@yahoo.com) (K.E. Aboul-Hagag).



the remains primarily narrows down the pool of possible victim matches.<sup>1-3</sup>

Age of epiphyseal fusion varies in both sexes. Thus sex determination from hand dimensions can immensely help the forensic scientists in identification of human remains.<sup>2</sup> An individual hand when recovered and brought for examination, can provide valuable information about the stature, sex, and age of the person. Extensive work is carried out by different researchers to estimate the stature from different hand measurements, fingers and phalanges length and small bones of the hand using statistical equations and formulae.<sup>4-12</sup> Some studies have estimated sex from hand dimensions and index finger length (IFL)-ring finger length (RFL) ratio (IFL/RFL).<sup>2,13-15</sup>

The present study has been conducted to investigate the sexual dimorphism of the hand dimensions as well as IFL/RFL ratio in Upper Egyptians.

## 2. Materials and methods

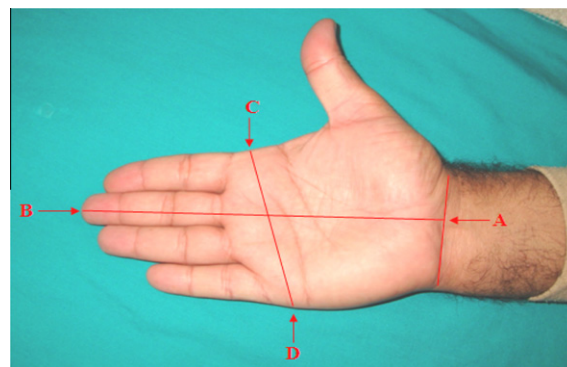
This study was conducted in the Department of Forensic Medicine & Clinical Toxicology, Faculty of Medicine, Sohag University. According to standard ethics drawn by the Faculty's ethical committee for human experimentation, 500 medical students (250 males and 250 females) studying at the Faculty of Medicine – Sohag University – above age 18 years were examined. Hand length, breadth and hand index (breadth divided by length  $\times 100$ ), IFL, RFL as well as IFL/RFL ratio were estimated.

Measurement technique for measuring the hand length, IFL, RFL hand breadth was taken following the methods recommended by Weiner and Lourie.<sup>16</sup> These measurements are taken in cm with the help of Anthropometer and Sliding caliper, respectively. All the measurements were taken by one observer in order to avoid inter-observer bias.

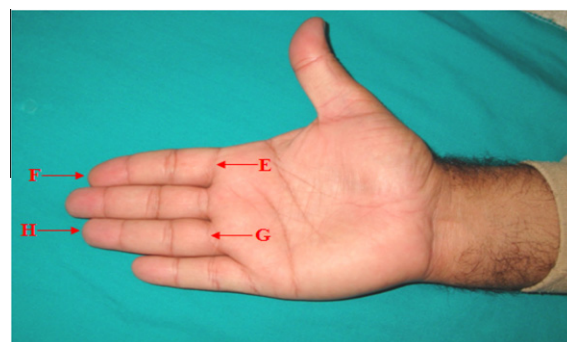
The hand was placed on a flat surface with palm facing upwards and the fingers extended and close to each other. Care was taken to see that there was no abduction or adduction at the wrist joint, i.e., the forearm was directly in line with the middle finger.

- The hand length was measured as straight distance between distal crease of wrist joint and the most anterior projecting point, i.e., tip of middle finger (Fig. 1).
- The breadth of hand was measured as straight distance from the most laterally placed point on the head of 2nd metacarpal bone to the most medially placed point located on the head of 5th metacarpal bone, Fig. 1.
- The hand index was computed by dividing the hand breadth by hand length and multiplied by 100.
- The index finger length was obtained between the tip of the index finger to the Metacarpo-phalangeal crease (Fig. 2).
- The ring finger length was obtained between the tip of the ring finger to the distal Metacarpo-phalangeal crease (Fig. 2).
- The IFL/RFL ratio was computed by dividing the index finger length by the ring finger length.

The subjects with any disease, deformity, injury, fracture, amputation or history of any surgical procedures of the hand, index or ring fingers of either hand were excluded from the study.



**Figure 1** Human hand illustrating the landmarks; hand length (A–B) and hand breadth (C–D).



**Figure 2** Human hand illustrating the landmarks of IFL (E:F) and RFL (G:H).

### 2.1. Statistical analysis

The data obtained were analyzed statistically using SPSS (Statistical program for Social Sciences, version 9.0) computer software. Mean, standard deviation (SD) and standard error (SE) were calculated. *T*-test was performed to compare the hand length, breadth and hand index, IFL and RFL and IFL/RFL ratio in the two hands and between both sexes; *p* value  $< 0.05$  was considered as significant. Average of mean hand index and IFL/RFL ratio of both sexes was taken for sex determination of the sample, and termed as “sectioning point”.<sup>2</sup> A dividing line (cut-off point) for hand index and IFL/RFL ratio between the two sexes was arrived at, based on sectioning point analysis, and by “trial and error”.

$$\text{Sectioning point} = \frac{\text{mean male value} + \text{mean female value}}{2}$$

## 3. Results

### 3.1. Hand length

Descriptive statistics for hand length of both sexes are shown in Table 1. In males, the right hand length varied from 17.50 cm to 22.1 cm (mean 19.4740 cm and SD 0.9216) and left hand length varied from 17.20 cm to 22.00 cm (mean 19.4952 cm and SD 0.9210). In females, the right hand length varied from 16.00 cm to 20.10 cm (mean 18.1316 cm and SD

**Table 1** Measurements (cm) of hand length in males and females.

Sex	Male		Female	
	Rt hand	Lt hand	Rt hand	Lt hand
Minimum	17.50	17.20	16.00	16.10
Maximum	22.10	22.00	20.10	20.10
Mean	19.4740*	19.4952*	18.1316*	18.1660*
SD	0.9216	0.9210	0.9023	0.9134
SE	0.05829	0.05825	0.05707	0.05777

SD: standard deviation; SE: standard error.

\*  $p \leq 0.05$  (for corresponding male–female values).

0.9023) and left hand length varied from 16.10 cm to 20.10 cm (mean 18.1660 cm and SD 0.9134). The hand length differed significantly for corresponding male–female values ( $p \leq 0.05$ ) in both hands but the difference between right and left hand length was not significant in both sexes. The average hand length was found to be about 1.3 cm greater in males than females.

### 3.2. Hand breadth

Descriptive statistics for hand breadth of both sexes are shown in Table 2. In males, the right hand breadth varied from 7.10 cm to 9.10 cm (mean 8.1316 cm and SD 0.3927) and left hand breadth varied from 7.10 cm to 9.10 cm (mean 8.1436 cm and SD 0.3961). In females, the right hand breadth varied from 6.20 cm to 8.20 cm (mean 7.166 cm and SD 0.3970) and left hand breadth varied from 6.30 cm to 8.40 cm (mean 7.1736 cm and SD 0.4070). The hand breadth differed significantly for corresponding male–female values ( $p \leq 0.05$ ) in both hands but the difference between right and left hand breadth was not significant in both sexes. The average hand breadth was found to be about 0.9 cm greater in males than females.

### 3.3. Hand index

Descriptive statistics for hand index of both sexes are shown in Table 3 and Figs. 3–6. In males, the average hand index ranged from 37.4359 to 47.5936 for the right hand (average 41.78085, SD 1.5059) and from 38.0952 to 47.8495 for the left hand (average 41.79377, SD 1.4413). In females, it ranged from 35.1351 to 43.1818 for the right hand (average 39.53885, SD 1.5012) and 35.1351 to 43.4783 (average 39.50797, SD

**Table 2** Measurements (cm) of hand breadth in males and females.

Sex	Male		Female	
	Rt hand	Lt hand	Rt hand	Lt hand
Minimum	7.10	7.10	6.20	6.30
Maximum	9.10	9.10	8.20	8.40
Mean	8.1316*	8.1436*	7.166*	7.1736*
SD	0.3927	0.3961	0.3970	0.4070
SE	0.02484	0.02505	0.02511	0.02574

S.D.: standard deviation; S.E.: standard error.

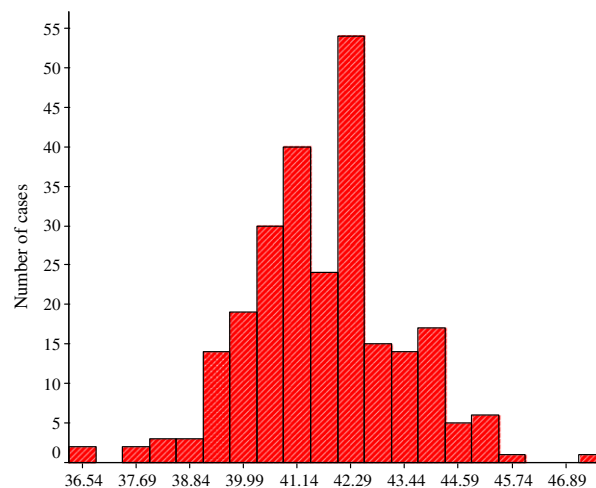
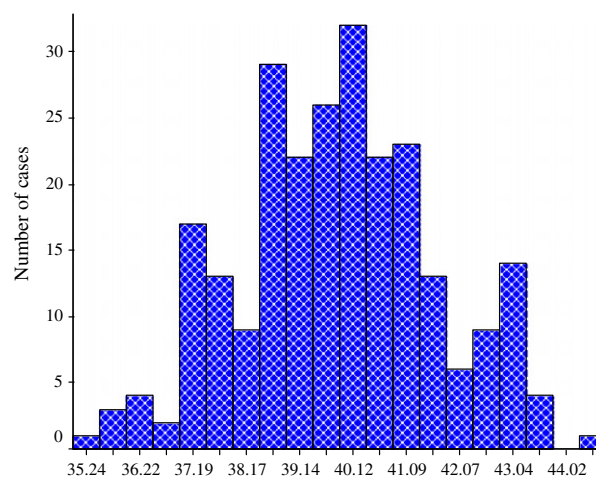
\*  $p \leq 0.05$  (for corresponding male–female values).

**Table 3** Descriptive statistics of the hand index.

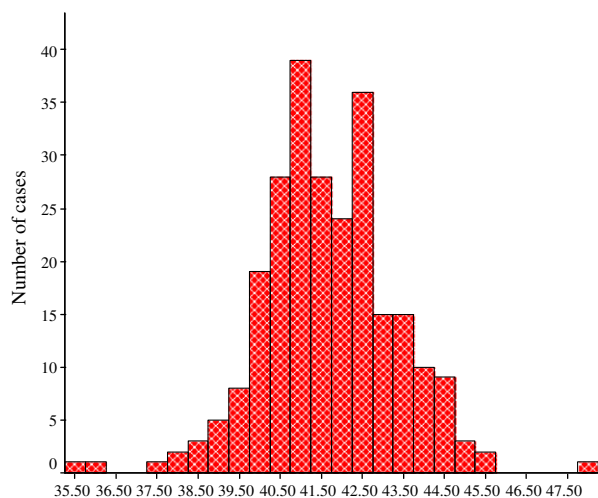
Sex	Rt hand index		Lt hand index	
	Male	Female	Male	Female
Minimum	37.4359	35.1351	38.0952	35.1351
Maximum	47.5936	43.1818	47.8495	43.4783
Mean	41.78085*	39.53885*	41.79377*	39.50797*
SD	1.5059	1.5012	1.4413	1.5937
SE	0.0952	0.0949	0.0912	0.1008
SP	40.65985		40.65087	

SD: standard deviation; SE: standard error; SP: sectioning point.

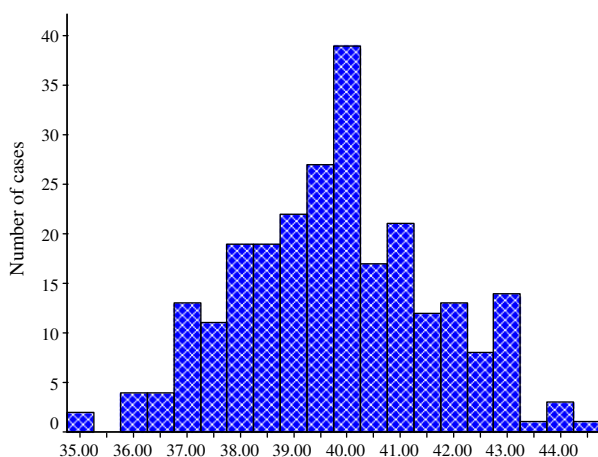
\*  $p \leq 0.05$  (for corresponding male–female values).

**Figure 3** Distribution of the index of right hand in males.**Figure 4** Distribution of the index of right hand in females.

1.5937) for the left hand. The hand index differed significantly for corresponding male–female values ( $p < 0.05$ ) in both hands; but the difference between right and left hand index was not significant in both sexes.



**Figure 5** Distribution of the index of left hand in males.



**Figure 6** Distribution of the index of left hand in females.

Based on the mean hand index for both sexes, 40.65985 for right hand and 40.65087 for left hand were derived as the 'sectioning point' for the hand index to discriminate male and female hands. By trial and error, a cut-off point of 40.55 was derived to determine sexual dimorphism of the hand index. The index accurately determines sex in 80.0% males and females for the right hand, and in 81.2% males and 78.0% females for the left hand, when all the cases with ratios below and equal to 40.55 were considered females and those above 40.55 were considered males.

### 3.4. Index and ring finger length

Descriptive statistics for IFL and RFL of both sexes are shown in Table 4. In males, the right index finger length varied from 6.30 cm to 9.0 cm (mean 7.8068 cm and SD 0.4189) and right ring finger length varied from 6.50 cm to 9.30 cm (mean 8.0720 cm and SD 0.4240), left index finger length varied from 6.70 cm to 8.90 cm (mean 7.8524 cm and SD 0.4214), left ring finger length varied from 7.0 cm to 9.30 cm (mean 8.1112 cm and SD 0.4136).

In females, the right index finger length varied from 6.10 cm to 8.20 cm (mean 7.1304 cm and SD 0.4076) and right ring finger length varied from 6.1 cm to 8.5 cm (mean 7.2192 cm and SD 0.4159), left index finger length varied from 6.10 cm to 8.50 cm (mean 7.1308 cm and SD 0.4279), left ring finger length varied from 6.1 cm to 8.50 cm (mean 7.2216 cm and SD 0.4354). The index finger length and ring finger length differed significantly for corresponding male–female values ( $p \leq 0.05$ ).

### 3.5. IFL/RFL ratio

Descriptive statistics for IFL/RFL ratio of both sexes are shown in Table 5, (Figs. 7–10). In males, the index/ring ratio varied from 0.87356 to 1.02817 (mean 0.9672006 and SD 0.0142) for the right hand and it varied from 0.92771 cm to 1.02817 (mean 0.9680413 and SD 0.0116) for the left hand. In females, the index/ring ratio varied from 0.90909 to 1.076920 (mean 0.9878215 and SD 0.0140) for the right hand and it varied from 0.95890 to 1.03226 (mean 0.9875326 and SD 0.0125) for the left hand. The index/ring ratio differed significantly for corresponding male–female values ( $p \leq 0.05$ ).

Based on the mean index and ring finger ratio for both sexes, 0.97751105 for right hand and 0.97778695 for left hand were derived as the 'sectioning point' for the index and ring finger ratio to discriminate male and female hands. By trial and error, a cut-off point of 0.976 was derived to determine sexual dimorphism of the ratio. The index and ring finger ratio accurately determines sex in 90.4% males and 85.6% females for the right hand, and in 88.8% males and 80.4% females for the left hand, when all the cases with ratios below and equal to 0.976 were considered males and those above 0.976 were considered females.

## 4. Discussion

Identification of human remains is an essential element of any medicolegal investigation. DNA technology has simplified the issue of sex determination to a great extent, but technology has its limitations with regard to skilled man power, time and financial issues involved, especially in developing countries and in cases when DNA analysis cannot be performed. Various techniques in forensic anthropology are still most commonly employed for identification of human remains.

It is not uncommon to find the peripheral parts of the body such as hand and foot in mass disasters, and assault cases where the body is dismembered to conceal the identity of the victim. When an individual hand is recovered and brought for examination, somatometry of the hand, osteological and radiological examination can help in the determination of primary indicators of identification such as sex, age and stature.<sup>15</sup> In the present study, an attempt has been made to find the sexual dimorphism of the hand dimensions and IFL/RFL ratio among Upper Egyptians.

In our study, the hand dimensions in males are found to be statistically larger than females. The results of the present study are similar to the earlier observations that female hand dimensions are consistently smaller than those of the males in different human populations.<sup>1,4,11,13,14</sup> Although our findings are similar to those reported earlier, the mean value of hand measurements differs from that reported in earlier



**Table 4** Measurement of IFL and RFL in males and females.

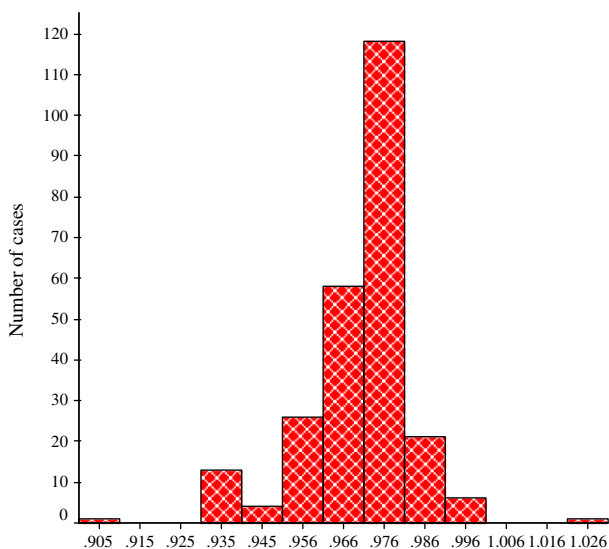
Sex	Male				Female			
	Rt hand		Lt hand		Rt hand		Lt hand	
	IFL	RFL	IFL	RFL	IFL	RFL	IFL	RFL
Minimum	6.30	6.50	6.70	7.0	6.10	6.10	6.10	6.1
Maximum	9.0	9.30	8.90	9.30	8.20	8.50	8.5	8.5
Mean	7.8068*	8.0720*	7.8524*	8.1112*	7.1304*	7.2192*	7.1308*	7.2216*
SD	0.4189	0.4240	0.4214	0.4163	0.4076	0.4159	0.4279	0.4354
SE	0.02649	0.02682	0.02665	0.02633	0.02578	0.02630	0.02706	0.02754

S.D.: standard deviation; S.E.: standard error.  
 IFL: index finger length; RFL: ring finger length.  
 \*  $p \leq 0.05$  (for corresponding male–female values).

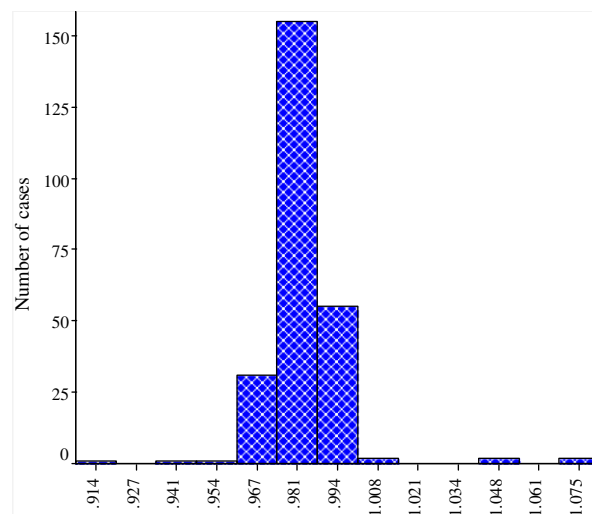
**Table 5** Descriptive statistics: IFL/RFL ratio.

Sex	Rt hand		Lt hand	
	Male	Female	Male	Female
Minimum	0.87356	0.90909	0.92771	0.95890
Maximum	1.02817	1.07692	1.02817	1.03226
Mean	0.9672006	0.9878215*	0.9680413	0.9875326*
SD	0.0142	0.0140	0.0116	0.0125
SE	0.000895	0.000884	0.000732	0.000789
SP	0.97751105		0.97778695	

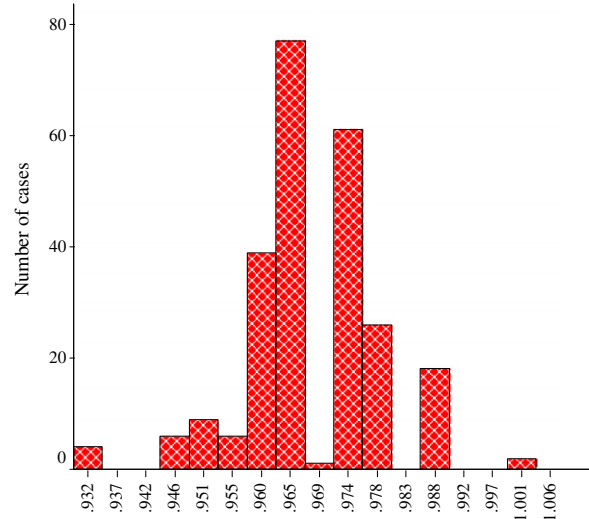
S.D.: standard deviation; S.E.: standard error; SP: sectioning point.  
 \*  $p \leq 0.05$  (for corresponding male–female values).



**Figure 7** Distribution of the right IFL/RFL ratio in males.



**Figure 8** Distribution of the right IFL/RFL ratio in females.

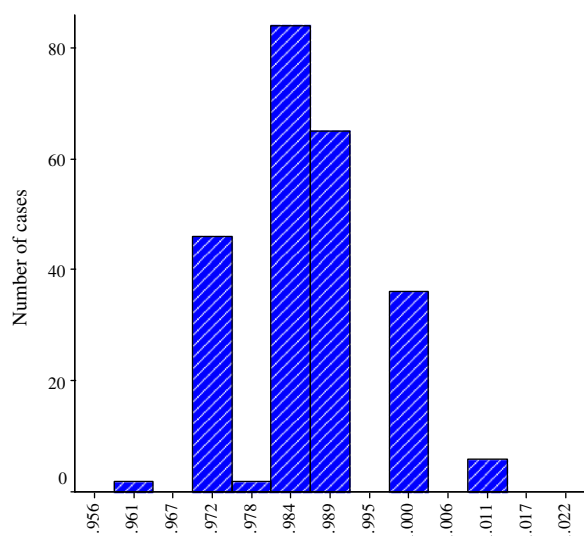


**Figure 9** Distribution of the left IFL/RFL ratio in males.

studies. In comparison to study in Mauritius,<sup>14</sup> the hand was longer and broader in the present study; shorter and narrower in comparison to studies carried out on Indian population.<sup>1,11,13</sup>

The observations can be attributed to the population and ethnic differences between the study population and the other earlier studies. Population differences in anthropological studies have been noted and it is well realized that they need to be

studied separately. Earlier studies have observed that various hand measurements tend to differ in various ethnic groups.<sup>17</sup>



**Figure 10** Distribution of the left IFL/RFL ratio in females.

However, owing to variability of dimensions according to the build of a person, individual parameters like hand length and breadth are not always reliable sex discriminators. The sex difference in the ratios of these parameters is independent of the body size, as the ratios are not significantly related to height and age in either sex.<sup>18</sup> Thus sexing by indices is more reliable since the relative growth of bony components are supposed to be proportional to each other. Various indices and ratios are derived to determine sex of human remains. Most of these indices incorporate a parameter expected to have a larger value in males and another parameter that is expected to be relatively or absolutely greater in females.<sup>19</sup>

In the present study, the hand index in males is found to be statistically larger than females in both hands. Similar result was obtained by Kanchan and Rastogi<sup>13</sup> and Agnihotri et al.<sup>14</sup>; but the average hand index is greater than that obtained by Kanchan and Rastogi<sup>13</sup> and smaller than that obtained by Agnihotri et al.<sup>14</sup> This can be attributed to the population and ethnic differences between the study population and the other earlier studies. The other above mentioned studies did not report the hand index so could not be compared.

The present study suggests that cut off point index of 40.55 and less is suggestive of female for both hands, while index of more than 40.55 is suggestive that of male origin. The cutoff point of this study is slightly greater than that obtained by Kanchan and Rastogi<sup>13</sup> but Agnihotri et al.<sup>14</sup> did not mention the cutoff point and his observation was based on the mean values of hand index in different age groups from which a deviation point was determined for the sex differentiation.

As far as the bilateral asymmetry for hand is concerned, there was no significant difference for hand length, breadth and index and the mean differences were trivial in both sexes. These findings are compatible with those arrived at by Krishan and Sharma<sup>1</sup>; Habib and Kamal 2010,<sup>8</sup> who suggested that there were no significant bilateral differences in hand length in either sexes.

In the human hand, the middle finger is the longest and the thumb is the shortest, followed by the little finger. The relative length of the index and ring fingers makes a disputable point.<sup>2,3</sup> Sexual dimorphism in the extent and length of the fingers has been documented from interdigital ratios, i.e., the

various possible ratios for different finger lengths. The sex difference in these ratios is independent of the body size, as the ratios are not significantly related to the height and age in either sex Lippa.<sup>18</sup> In females, the index and ring fingers tend to be almost equal in length, whereas in males the ring finger tends to be much longer than the index finger. Thus, the index and ring finger ratio becomes a significant parameter for determining sex.<sup>2,3</sup>

In our study, the index and ring fingers are significantly longer in males than females. Morphological sex differences in the absolute length of fingers have been demonstrated in various studies, male fingers being longer when compared with females.<sup>2,3,8,20</sup> Sex difference in the length of the ring finger is found to be larger as compared with the length of the index finger, similar to a study by Lippa<sup>18</sup>; Krishan et al.,<sup>3</sup> Habib and Kamal.<sup>8</sup>

The index and ring finger ratio as a sexually dimorphic trait is established early in life and remains fairly stable postnatal; it does not change with age and growth in a population group.<sup>21</sup>

Males have been reported to have lower index and ring finger ratio than females. Lower index and ring finger ratio have thus been considered "masculine" and higher ratios as "feminine". Besides sexual dimorphism, index and ring finger ratio shows significant ethnic and population differences.<sup>21,22</sup>

In the present study, the mean index and ring finger ratio in males is significantly lower than females in both hands. These findings are in agreement with the observations in other studies,<sup>8,16,23</sup> where on average males demonstrated lower digit ratios than females. The extent of sex differences however, varies in different studies and population groups. Cutoff point derived for sex differentiation was (0.0976) slightly larger than that observed in South Indian adult and adolescent population (0.9700).<sup>2,16,23</sup> Our study confirms the observations of other researchers that the sex differences in the index and ring finger ratio can be a useful sex indicator especially when DNA analyses cannot be performed.

In the present study, males show higher mean values in each anthropometric dimension than among females. These statistically significant differences may be attributed to the early maturity of girls than boys; consequently, the boys have two more years of physical growth. The difference with other studies can be attributed to the population and ethnic differences between the study population and the other earlier studies.

## 5. Conclusions

It is concluded that hand dimensions and IFL/RFL ratio prove useful to determine the sex of an isolated hand when it is subjected for medicolegal examination. The study suggests that the hand index of 40.55 and less is indicative of female, and index of more than 40.55 is indicative of male; IFL/RFL ratio of 0.976 and less is indicative of male, and a ratio of more than 0.976 is indicative of female. The sexual dimorphism of hand dimensions and IFL/RFL ratio is a constant feature among different age-groups in Upper Egyptian population.

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