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Digit ratio (2D:4D) – An anthropometric marker for sexual dimorphism in J&K population

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ABSTRACT
Introduction: *Forensic anthropology involves the identification of human remains for medico-legal purposes. Estimation of sex is an essential element of medico-legal investigations when identification of unknown dismembered remains is involved.*
Aim and Objectives: *The present study was conducted with an aim to estimate sex from 2D:4D ratio of adult individuals belonging to an indigenous population of Jammu and Kashmir region of Northern India.*
Materials and Methods: *The present study was conducted on a sample of 200 medical students (100 males and 100 females) within the age group of 18-25 years, studying in Government Medical College, Jammu. Only those students were taken who belong to J&K state and have no obvious deformity that can affect the measurements.*
Results: *Males have significantly longer index and ring finger length than females. Sex differences in the length of ring finger are larger than index finger. Again males show significantly lower mean 2D:4D digit ratio (0.975) as compared to females (0.984). The study suggests that ratio below and equal to 0.975 is suggestive of male sex for both hands, while a ratio of more than 0.975 is suggestive female sex for both the hands.*
Conclusion: *This study may prove useful to determine the sex of an isolated hand when it is subjected for medico legal examination.*
Keywords: *Anthropometry, Dimorphism, Digit Ratio, Population.*

INTRODUCTION

Human identification has always been a major concern for forensic investigation and other law enforcement agencies. It has become imperative element while concealing identity of mutilated remains encountered in case of war or in case of natural calamities, in bomb blast, in accidents etc. In such situations identification of the recovered peripheral parts of the body such as hands is vital. The process of identification focuses mainly on

establishing the biological profile by estimating the sex, age and stature [1].

However there is an established fact that age determination from epiphyseal union and stature determination from derived formulae vary with sex. Thus determination of sex is the foremost criterion in identity authentication of an individual among all the primary parameters of identification [2]. In addition to this, identification of sex of human remains can immensely help forensic experts while dealing with dismembered and fragmentary remains and also in criminal investigation by reducing the pool of possible victim matches [3, 4].

Studies have focused on the role of hand and foot measurements in establishing the biological profile of individuals in forensic investigations [5]. Besides the lengths of the fingers such as Index Finger Length (IFL) and ring finger length (RFL), finger ratios have also been used for predicting sex of an individual. The finger ratio is an established sexually dimorphic biometric population marker [6]. This ratio is related to prenatal estrogen and testosterone levels and genetically controlled by the HOX genes [7].

However a few systemic studies are available on sexual dimorphism from relative length of fingers [8]. The paucity of literature on the issue of sexual dimorphism from digit ratio (2D:4D) has prompted the authors to conduct this research work. Further, to our knowledge, there has been no parallel study on sex determination from digit ratio in Kashmir region of J&K state in Northern India. This research study proves beneficial for identity authentication, for criminal investigation and a powerful forensic tool for medico-legal cases. Also the data so collected can be useful as forensic anthropology population data.

MATERIALS AND METHODS

The present study was conducted on a sample of apparently healthy, 200 medical students (100 males and 100 females) within the age group of 18-25 years from Government Medical College-Jammu and Indira Gandhi Dental College-Jammu.

The instrument used for the measurements was Manual Sliding Caliper. Two anthropometric measurements, Index Finger Length (IFL) and Ring Finger Length (RFL) were measured in the study participants using standard procedures and landmarks following Manning et al. [9]. 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.

Index and Ring Finger Length: It is the distance between middle of metacarpo-phalangeal crease (proximal flexion crease) of the index and ring fingers and the extreme projecting point on the tip of index and ring fingers (Fig.1). The finger measurements were taken independently on left and right sides of the participants in centimeters to the nearest millimeter.

Average of mean IFL/RFL ratio of both sexes was taken for sex determination of the sample, and termed as ‘‘sectioning point’’. A dividing line (cut-off point) for IFL/RFL ratio between the two sexes was arrived at, based on sectioning point analysis, and by ‘‘trial and error’’. Sectioning point = mean male value + mean female value

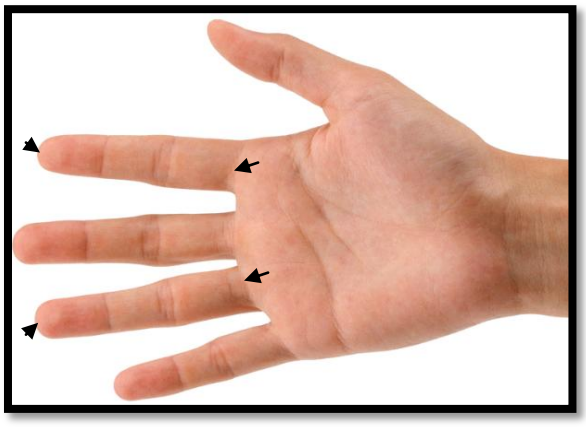

Fig. 1: Hand illustrating the landmarks of IFL&RFL.

OBSERVATIONS AND RESULTS

Table 1: Measurement of IFL and RFL in males and females

	Males				Females			
	Right		Left		Right		Left	
	IFL (cm)	RFL (cm)	IFL (cm)	RFL (cm)	IFL (cm)	RFL (cm)	IFL (cm)	RFL (cm)
Minimum	6.3	6.6	6.2	6.6	6.0	6.2	6.0	6.2
Maximum	8.5	8.5	8.3	8.4	8.2	8.5	8.2	8.5
Mean	7.366*	7.544*	7.321*	7.528*	6.922*	7.022*	6.856*	6.985*
SD	0.455	0.426	0.410	0.423	0.372	0.394	0.371	0.401
SE	0.045	0.042	0.041	0.042	0.037	0.039	0.037	0.040

SD: Standard Deviation; SE: Standard Error; IFL: Index Finger Length; RFL: Ring Finger Length; * $p < 0.05$

In the present study as is depicted in the Table 1 in case of males the mean Right Index Finger Length and Ring Finger Length are 7.366 (SD±0.455) and 7.544 (SD±0.426) , while as the mean Left Index Finger Length and Ring Finger Length are 7.321 (SD±0.410) and 7.528 (SD±0.423). In contrast to this in case of females the mean Right Index Finger Length and Ring Finger Length are 6.922 (SD±0.372) and 7.022 (SD±0.394), while as Left Index Finger Length and Ring Finger Length are 6.856 (SD±0.371) and 6.985 (SD±0.401).

Table 2: Descriptive statistics: IFL/RFL ratio.

	Right Hand		Left Hand	
	Males	Females	Males	Females
Minimum	0.900	0.925	0.873	0.928
Maximum	1.055	1.059	1.039	1.061
Mean	0.977	0.986	0.973	0.982
SD	0.036	0.029	0.033	0.028
SP	0.981		0.977	

SD: Standard Deviation; SE: Standard Error; SP: Sectioning Point.

Descriptive statistics for IFL/RFL ratio of both sexes are shown in Table 2, (Figure 1-4). In males, the index/ring ratio varied from 0.900 to 1.055 (mean 0.977 and SD±0.036) for the right hand and it varied from 0.873 to 1.039 (mean 0.973 and SD 0.033) for the left hand. In females, the index/ring ratio varied from 0.925 to 1.059 (mean 0.986 and SD 0.029) for the right hand and it varied from 0.928 to 1.061 (mean 0.982 and SD 0.028) for the left hand.

Based on the mean index and ring finger ratio for both sexes, 0.981 for right hand and 0.977 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.

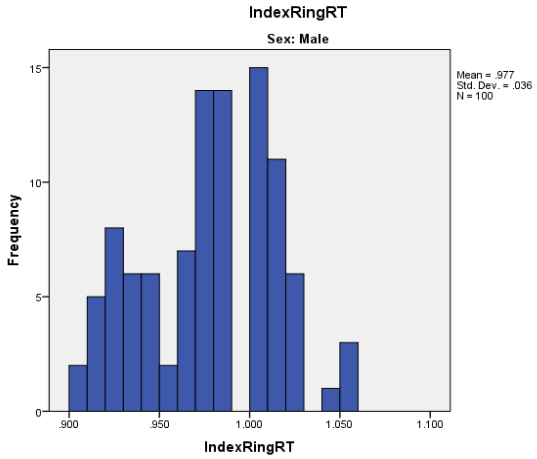

Figure 1: Distribution of right IFL/RFL ratio in males

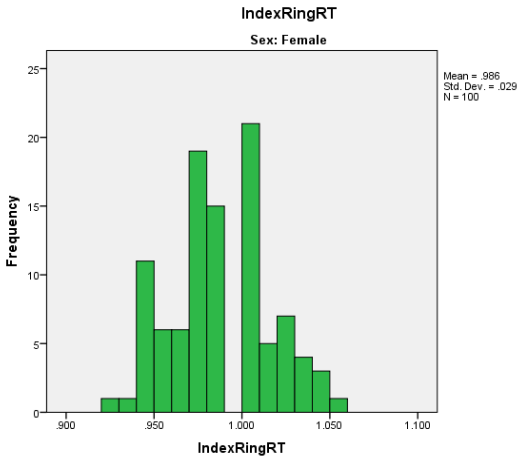

Figure 2: Distribution of right IFL/RFL ratio in females.

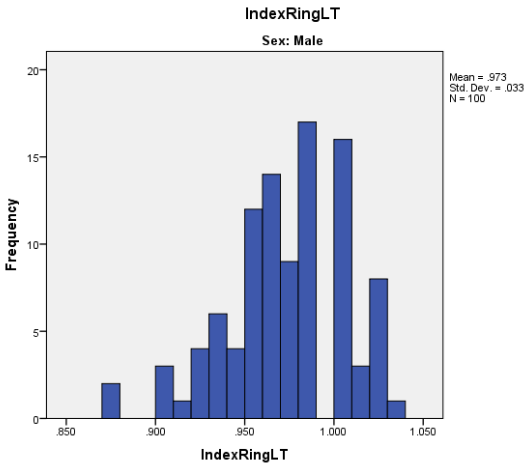

Figure 3: Distribution of left IFL/RFL ratio in males.

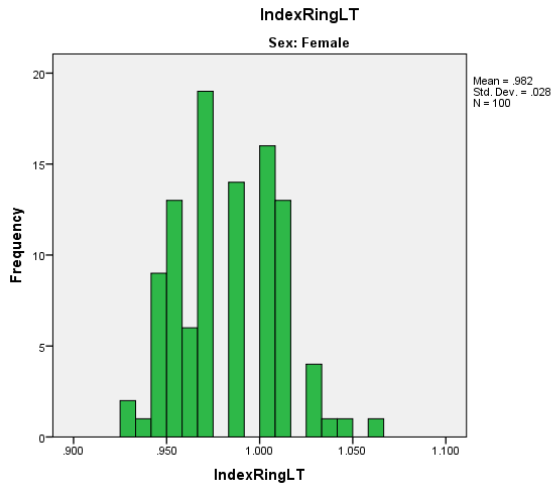

Figure 4: Distribution of left IFL/RFL ratio in females.

DISCUSSION

The concept of 'Digital formula' was first introduced by Frederic Wood Jones in 1920 to demonstrate the typical characteristics of the hand & foot. Jones discovered that in human hands the absolute length of the index finger is usually longer than the ring finger (human digital formula, 2D > 4D), whereas in apes the ring finger is longer than index finger (simian digital formula, 4D> 2D) [10]. In the present study, males as well as females don't depict the typical human digital formula for both right & left hands instead show resemblances with simian digital formula for both the hands. However, males have significantly longer index and ring finger length than females. This result is in accordance with the earlier studies [11, 12]. It was also seen that the sex difference in the length of ring finger was larger than the index finger. This finding was also in accordance with the previous studies.

But considering only these parameters, are not always proof to predict sexual dimorphism accurately due to individual variability of dimensions with respect to body built. Also anthropologists observed a small difference between the length of the index and the ring in both the sexes and therefore the 'ratio' between the length of index & ring finger close to 1 and when both the fingers are of same length, the 'ratio' is exactly one. Ratios are not significantly related to stature or age and thus sex differences in these ratios are independent of body size [13]. Because of these criteria researchers around the world are implementing the concept of 'digit ratio' to study the relative length difference between the index finger (2D) and the ring finger (4D), which results in the formula: digit ratio=2D:4D. Manning et al. demonstrate that 2D:4D is the only trait that measurably explains sexual dimorphism. It reflects prenatal androgen action (such that higher testosterone is associated with lower 2D:4Ds) [9].

In our study, Males show significantly lower mean 2D:4D digit ratio (0.975) as compared to females (0.984). Lower male 2D:4D digit ratio is significantly in accordance with the earlier studies [8, 12]. This is also supported by hormonal studies which indicate that smaller 2D:4D digit ratio has been associated with male – dominant disorders while larger digit ratios are associated with female – dominant disorder [13]. Thus lower digit ratio was considered as ''masculine" and higher digit ratio as ''feminine".

But the extent of sex differences however varies with different population and ethnic groups. Thus sectioning point was calculated for 2D:4D digit ratio to discriminate male and female hands. This cut-off point takes into account the frequency distribution of 2D:4D digit ratio across the sample. Cut-off point of 0.975 was derived to discriminate sex for the current study. Ratio below and equal to 0.975 is suggestive of male hand

whereas those above 0.975 were considered as female hand. A cut-off of 0.97 was also derived by Kanchan et al. [2].

Infact, 2D:4D is a putative marker for prenatal androgen exposure [9] but the sex effect of 2D:4D is of medium size that is the percentage of overlap between the sexes for 2D:4D distribution is moderate and thus it was criticized to be a weak marker or inappropriate for sex determination in medicolegal investigations by Voracek [14].

Hence the technique will be beneficial in situations or only employed in situations where no other means of sexing are available. However it is evident that the predictive potential for sexing increases when index and ring finger lengths are taken into consideration along with 2D:4D Digit ratio.

CONCLUSION

Estimation of sex from the IFL and RFL measurements and there ratio is a supplementary approach when extremities especially hand is available for examination. The present study has highlighted the application of IFL and RFL ratio to determine sex among individuals belonging to the J & K region of India. It is suggested that finger lengths are relatively useful predictors of sex and IFL / RFL ratio could be utilized to estimate sex of the individuals when more reliable means of sex estimation are not available during medico-legal investigations. This study further observes that the models derived for a population group have better applicability when applied on the same population. Studies on estimation of sex from finger lengths in different age groups and among different populations need to be encouraged.

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