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Original Article

Sexual Dimorphism of Digit Ratio (2D:4D) in Madhya Pradesh

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Abstract

Introduction: The ratio between the length of the 2nd and 4th digit (2D:4D) is sexually dimorphic, with mean male 2D:4D lower than mean female 2D:4D, which will prove useful to determine sex when more reliable means of sex estimation are not available during medicolegal examination.

Aims: To find out whether 2D:4D ratio of Madhya Pradesh region shows sexual dimorphism in both right and left digit ratio measuring dermatoglyphics lengths.

Materials and Methods: A total of 620 adults (310 males and 310 females) of the age group 18-25 were studied. The length of the index and ring finger were measured and 2D:4D ratios were calculated and statistically analyzed.

Results: There was a significant difference ($P < 0.0001$) in 2D:4D ratio with an overall accuracy of 83.55%. The final result of the analysis shows that 85.8% of males and 81.3% of females were sexed correctly.

Conclusion: We conclude that 2D:4D ratio is sexually dimorphic and suggests that the 2D:4D ratio is a constant feature among different age groups in different population.

Key words: 2D:4D ratio, Digit ratio, Prenatal androgen exposure, Sexual dimorphism

INTRODUCTION

Identification of human remains is the key element in forensic investigations consisting of determination of age, sex and stature assessment and also comparison with ante mortem data from fragmentary and dismembered remains.[1] Morphological and anthropometric relationship that exists between different part of the body and sex of an individual has been of great interest to forensic experts, anthropologists, and medical scientist for a long time because of the increase in the cases of mass disasters, explosions and assault cases and other catastrophic events causing mass deaths.[1-3] It, therefore, implies that accurate sexing of human remains has the potential to narrow down the search to a particular sex and gives the right direction to the ongoing forensic investigation.[4,5] Studies have focused on the role of hand and foot measurements in establishing the biological profile of individuals in forensic investigation because the dismembered remains includes the terminal parts of the human body such as hands and feet in cases of mass disasters.[3,6-11]

Hand analysis has intrigued humans throughout history. In recent times two aspects of human hand have drawn attention for observation and analysis including dermatoglyphic ridge pattern and secondly, finger lengths and their ratios.[12] Besides the lengths of the fingers such as index finger length and ring finger length, finger ratios have also been used for predicting sex of an individual. The finger ratio is an established sexually dimorphic biometric population marker.[13-15] This ratio is negatively related to prenatal testosterone and positively related to estrogen. If 2nd and 4th digit (2D:4D) in adults is a correlate of prenatal sex steroids we should expect it to be sexually dimorphic, the dimorphism should be present in young children and once established in early neonatal life digit ratio assumed

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to be stable in later life[16-18] and it is genetically controlled by the HOX genes which also control the differentiation of the urogenital system and may, therefore, indirectly influence the prenatal production of testicular androgen and the development of the digits.[16,19] There is evidence that sexual dimorphism in digit ratios develops in utero between the 13th and 14th week of gestation,[16,20,21] under the influence of parental androgens and estrogens.[22,23]

It has been observed that India, as a country, consists of a large number of ethnic and indigenous elements, varied geographical conditions and these have enormous amounts of ethnic and genetic diversity[4,5] which differ with race, sex and geographical locations.[24] Literature on the index and ring finger ratio in sex prediction has shown variable results in terms of its forensic significance. It is observed that the index finger length and ring finger length ratios differ between populations and its utility appear to be limited in forensic case work.[17,25] Apparently, the need to estimate sex of an individual using a part of the hand or fingers arises when only part of a hand is available for examination. Such studies are lacking for one of the largest indigenous populations of India.[9] Therefore, there is a need for regional studies in the process of identification of human remains as the human species inhabit diverse environments all over the earth and exhibit a lot of racial and ethnic variations.

The purpose of this study is to extend the research in the people of Madhya Pradesh as to best of our knowledge to encourage the work on different population and also the study group includes a larger number of subjects than the previous studies so that the results of statistical calculation can be as accurate as possible. As per above, this study has been undertaken to investigate sexual dimorphism in the lengths of index and ring fingers and to derive models for estimating sex using these measurements and to confirm 2D:4D as a proposed faithful postnatal biomarker for gestational exposure of testosterone.

MATERIALS AND METHODS

This study was conducted on 620 individuals (310 males and 310 females) residing in MP. India for at least two generations, belonging to age group of 18-25 years having no disease or deformity of the digits which were measured anthropometrically in respect to their sex and digit lengths 2D:4D. The subjects were Medical, Dental, and Physiotherapy students of Government Medical Colleges of Madhya Pradesh.

Methodology

Dermatoglyphic lengths of 2D:4D of both hands were taken and their ratios were calculated. The length was measured from proximal crease at the base of the finger to the tip of the finger in the midline on the palmar aspect of the hand using vernier calipers (Figure 1) without exerting pressure by a single experienced observer and protruding finger nails were excluded.[17] Prior informed written consent was obtained from each subject. Subjects were asked to remove any jewelry or rings that would interfere while obtaining the finger length measurements. Measurements were taken twice for accuracy and to take out mean in a well-lighted room.

Statistical Evaluation

Data thus were compiled, tabulated and analyzed statistically on Word Excel and SSP softwares. Descriptive statistics (mean ± standard deviation) of the 2D:4D for the left and right hands were tabulated for both males and females. Data obtained was analyzed using Student *t*-test and *P* values were calculated. Analysis of variance and discriminant function analysis were also done on the data.

RESULTS

Table 1 shows the mean value of lengths of 2D, 4D and 2D:4D ratio in the right and left hands in males and females obtained by measuring dermatoglyphics lengths using vernier calipers. The sex differences for all parameters were highly significant ($P < 0.001$).

The Graph 1 compares the 2D:4D ratio in the right and left hands of both males and females with mean 2D:4D ratio of 0.973 in males as compared to 2D:4D ratio of 1.01 in females.

Statistical calculations of males and females have been summarized in Table 2, which shows comparison of mean of 2D:4D ratio in the right and left hands of both males and females. Students *t*-test and analysis of variance have

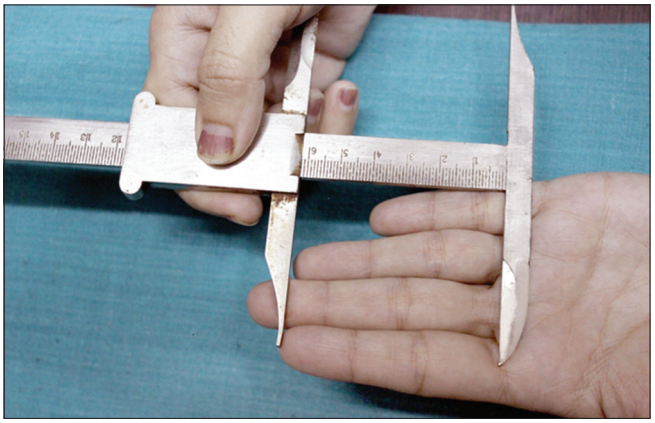


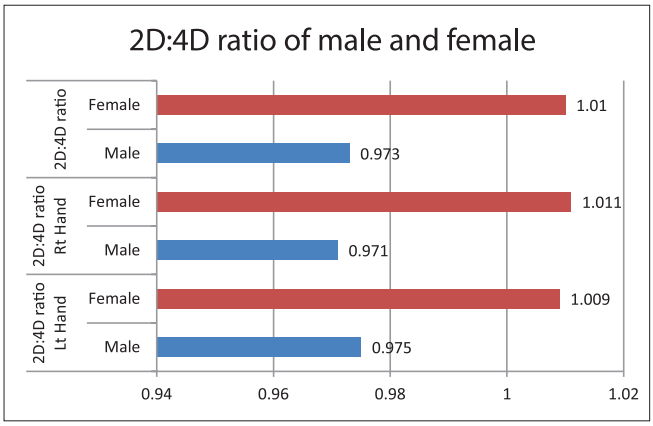
Figure 1: The measurement of index finger using vernier calipers

been applied and *P* values and *t* values were calculated which were highly significant (<0.05) in terms of sexual differences.

By discriminant function analysis it was found that 2D:4D ratio could be used to study sexual dimorphism with an overall accuracy of 83.55%. The final result of the analysis shows that 85.8% of males and 81.3% of females were sexed correctly.

DISCUSSION

Sexual dimorphism in the absolute length of fingers has been demonstrated in various studies.[3,26-28] The morphological gender difference has been reported with male fingers being significantly longer as compared to female fingers.[3,14,26-29] In females, the index and ring fingers tend to be almost of equal length, whereas in males the ring finger tends to be much longer than the index finger. The 2D:4D ratio is lower in men as compared to women. Lower index and ring finger ratio have been considered "masculine" and higher ratios as "feminine." Thus, the index and ring finger ratio becomes a significant parameter for determining sex.[3,26] The sex difference in 2D:4D ratio is independent of the body size, as it is not significantly related to the height and age in either sex.[14,27,29] The 2D:4D 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.[17,25,30,31] High concentrations of fetal testosterone indicate a low 2D:4D ratios, which, therefore, indicate a high prenatal testicular activity. On the other hand, 2D:4D is positively correlated with estrogen in men and women.[23,28,32]



Graph 1: 2D:4D ratio of male and female

Table 1: Statistics of 2D and 4D of right and left hand of male and female

Parameter	Males (*n*=310)	Females (*n*=310)	*P*
2D right	7.19±0.33	6.61±0.33	0.000
2D left	7.24±0.35	6.61±0.34	0.000
4D right	7.41±0.31	6.54±0.32	0.000
4D left	7.43±0.33	6.55±0.35	0.000
2D:4D right	0.97±0.03	1.01±0.03	0.001
2D:4D left	0.97±0.03	1.01±0.03	0.001
Mean 2D:4D	0.97±0.02	1.01±0.03	0.000

2D: Length of index finger, 4D: Length of ring finger, *n*: Number of subjects

Besides sexual dimorphism, index and ring finger ratio shows significant ethnic and population differences.[30,33] The extent of sex differences, however, varies in different studies and population groups. A number of studies have reported the existence of significant sex differences in 2D, 4D and its ratio in different ethnic populations and its bilateral variations among individuals belonging to different Indian ethnic groups.[13-15,26,27,29] Considerable overlapping in the frequency distributions of index and ring finger ratios were observed among both sexes in the study population. In general, a lower IFL and RFL ratio has been reported among females.[14,29,34,35] In this study, 2D:4D ratio in females is significantly higher than males in both hands. This observation agrees with earlier reports as by many authors.[27,36-39]

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.[40] In this 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;

Table 2: Statistics of 2D:4D ratio of male and female

Statistics	2D:4D ratio right hand		2D:4D ratio left hand		2D:4D ratio	
	Male	Female	Male	Female	Male	Female
Mean	0.9708	1.0111	0.975	1.0088	0.973	1.0100
SD	0.0264	0.0339	0.0267	0.0284	0.0250	0.0269
95% confidence interval	0.9708±0.0043	1.0111±0.0055	0.9734±0.0043	1.0088±0.0046	0.9721±0.0040	1.0100±0.0043
P value (two-tailed)	1.25×10^{-25}*		3.05×10^{-24}*		1.53×10^{-29}*	
Are means significantly different? (*P*<0.05)	Yes		Yes		Yes	
t value	*t*=11.52		*t*=11.16		*t*=12.62	
F value	132.61		123.54		159.27	
Pooled variance	0.0009		0.0008		0.0007	

*Significant. SD: Standard deviation

consequently, the boys have 2 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. Our study is consistent with the early hypothesis that fetal hormones affect 2D:4D ratios.[23,38,39,41,42]

There are some limitations of this study. As this study is conducted on live adult population, the findings of this study thus, should not be applied on children, adolescents, and elderly individuals. The dimensions of fingers are likely to alter after death with rigor setting in and with putrefactive changes occurring later. Therefore, the observations of this study can be applied only in the human remains that are relatively fresh and not having post-mortem changes. The findings may not be suitable for dry, decomposed and bloated bodies that affect hand dimensions.

CONCLUSION

It is concluded that the sexual dimorphism of 2D:4D ratio is a constant feature among different age-group in different populations. The 2D:4D ratio is smaller in human males than in females. Estimation of sex from 2D:4D ratio is a supplementary approach when extremities or other body parts are not available for examination. This study has highlighted the application of 2D:4D ratio to determine sex among individuals belonging to the Madhya Pradesh population of India when more reliable means of sex estimation are not available during medicolegal investigations; also useful for human biologists and physical anthropologists for determination of sex from the fragmentary remains of hand and also in ergodesign applications of hand tools and devices. Studies on estimation of sex from finger lengths in different age groups and among different populations and ethnic groups need to be encouraged. No particular ethnic groups have been included, in the study, but combinations of variegated ethnic groups are considered. Therefore, this study has better applicability when applied on the same population.

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