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Determination of Gender from The Ratio of Length of Index Finger and Ring Finger (2DL:4DL) in Nepalese Adults

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Abstract **Original Research Article**

The determination of gender from recovered body parts is a crucial component when creating the identification profile of an individual in forensic humanitarian and medicolegal cases. The ratio of length of index finger (2DL) and ring finger (4DL) has been proposed to exhibit sexual dimorphism. The anthropometrical features being population specific, and because of paucity of literature in this geography, we carried out this study on a cross-sectional sample of 250 Nepalese adults whose 2DL and 4DL were measured; 2DL:4DL ratio were calculated; Sectioning-point based on the ratio for both genders were derived; and finally a Cut-off point to discern male and female gender was obtained. It was found that 2DL:4DL ratio ≤ 0.99 was of a male hand while those > 0.99 was of a female hand. Thus, we can discern the gender on the basis of 2DL:4DL ratio in this population.

Keywords: Finger, gender, identification, investigation, medico-legal, ratio.

INTRODUCTION

When mutilated or dismembered body parts are found, identification of the deceased has invariably been a challenge and is one of the major procedures in forensic humanitarian and medico-legal investigations [1]. These are particularly encountered in situation of mass disasters like earthquakes, aircraft crashes, landslides or in specific cases of homicides, where the body of the deceased is mutilated to conceal the identity of the victim [2]. In such cases, if gender could somehow be determined from those mutilated or fragmented body parts, it would be of great medicolegal importance for overall identification of the deceased.

Determination of gender using anthropometric measurements has been widely covered in many studies where the measurement of the upper extremities, lower extremities, fingers, toes, etc has been used [3-6].

The significance of morphometric and skeletal examination of hand and foot dimensions in gender determination has been stated in the studies done by Jasuja *et al.*, and abib SR *et al*. [7, 8].

Studies using hand measurements for sex determination have been performed in several races, like Daborno B *et al.* did in Nigerians and Kanchan T *et al.* did in north and south Indians [9, 10].

Therefore, the determination of gender from recovered peripheral body parts like hands and fingers is a crucial constituent when creating the identification profile of an individual [11]. Epiphyseal union occurs earlier in females as compared to males as epiphyseal integration age differs in males and females. Researches on gender determination from ratio of length of index finger (2DL) and length of ring finger (4DL) in South Indian adults and adolescents have found statistically significant findings [12, 13]. The ratio of 2DL and 4DL has been suggested as sexually dimorphic phenotypic trait [12-17]

The absence of literature on the matter of sexual dimorphism from 2DL:4DL in Nepalese adults has incited the author to carry out this study. The study was conducted to determine if sexual dimorphism exists in Nepalese adults with respect to 2DL and 4DL ratio and to find out the Sectioning-point and Cut-off point for discerning gender on the basis of 2DL and 4DL ratio. This research study is valuable for identification

of deceased in forensic humanitarian and medicolegal cases involving Nepalese adults.

MATERIALS AND METHODS

The study was carried out from October 2018 to March 2019 on a cross-sectional sample of 250 Nepalese MBBS and BDS third and fourth year students of Universal College of Medical Sciences (UCMS), Bhairahawa, Nepal. The participants were from various places of Nepal, but were living in Bhairahawa at the time of the study. The study was approved by the Institutional Research Committee (IRC) of UCMS, Bhairahawa and therefore has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. The participants were explained regarding the research study and measurement procedures and were assured about the confidentiality of the data and measurements they provided. Participation was voluntary after taking informed consent. Participants with any medical history of hand disease, injury, deformity were excluded from the study.

Measuring Procedure

Weiner and Lourie measurement technique was used [18].

1. Measuring 2DL and 4DL:- The hands of the subjects were placed on a flat surface with palm facing upward and forearm in line with the middle finger. Fingers were extended maximally and kept close to each other. Digit length was measured in centimeters with the help of a sliding vernier caliper from both left and right hands of each subject.
    a. Length of Index finger (2DL) was measured as the distance between the mid-point of metacarpo-phalangeal crease at the base of index finger to the tip of the index finger.
    b. Length of the Ring finger (4DL) was measured as the distance between the mid-point of metacarpo-phalangeal crease at the base of ring finger to the tip of the ring finger.

    The measurements were taken twice to avoid intra-personal variation and by two persons to avoid inter-personal variance. The mean of the measurements were then taken as final measurement.

2. 2DL:4DL Ratio: 2DL:4DL ratio was calculated by dividing length of the index finger with the length of the ring finger in centimeters (cm).

    2DL:4DL Ratio = 2DL (in cm)/4DL (in cm)

3. Sectioning-point: Sectioning-point was derived in both genders as the mean 2DL:4DL ratios for each gender.

4. Cut-off point: A final Cut-off point was calculated based on the Sectioning-point interpretation.

Statistical Analysis

The obtained data were tabulated and statistically analyzed using the SPSS® for Windows, Version 12.0. Descriptive statistics (mean, standard deviation, range, standard error) for 2DL and 4DL were calculated. Student's t-test was used to observe the gender differences for the variables at $p < 0.05$ as level of significance.

RESULTS AND DISCUSSION

Table-1: Descriptive statistics: Length (in cm) of index finger (2DL) and ring finger (4DL) among adult Nepalese males and females

Variables (cm)	Males (n = 150)				Females (n= 100)			
	Right hand		Left hand		Right hand		Left hand	
	2DL	4DL	2DL	4DL	2DL	4DL	2DL	4DL
Min	6.43	6.71	6.46	6.57	6.23	6.21	6.24	6.25
Max	7.98	8.14	7.95	8.04	7.48	7.41	7.45	7.42
Mean	7.37*	7.54*	7.36*	7.49*	6.78*	6.69*	6.76*	6.7*
S.D.	0.3325	0.3254	0.3376	0.3297	0.2455	0.2234	0.2401	0.2287
S.E.	0.0271	0.0265	0.0275	0.0269	0.0245	0.0223	0.0240	0.0228
M.D.	0.17		0.13		0.09		0.06	

S.D. = Standard deviation, S.E. = Standard Error, M.D. = Mean Difference between 2DL and 4DL. * p value < 0.001.

Descriptive statistics for the obtained data were calculated for right & left hands in males and females as shown in Table-1. The right 2DL in males ranged from 6.43 cm to 7.98 cm (mean 7.37 ± 0.33 cm S.D) and the right 4DL ranged from 6.71 cm to 8.14 cm (mean 7.54 ± 0.32 cm S.D), the left 2DL ranged from 6.46 cm to 7.95 cm (mean 7.36 ± 0.34 cm S.D) and 4DL ranged from 6.57 cm to 8.04 cm (mean 7.49 ± 0.32 cm S.D). The Mean Difference between 4DL and 2DL for right hand was 0.17 and 0.13 for the left hand which was statistically significant ($p < 0.001$) for the gender. We also found that the means of 2DL and 4DL were lesser for the left hand as compared to the right hand in males.

The right 2DL in females ranged from 6.23 cm to 7.48 cm (mean 6.78 ± 0.25 cm S.D) and the right 4DL ranged from 6.21 cm to 7.41 cm (mean 6.69 ± 0.22 cm S.D), the left 2DL ranged from 6.24 cm to 7.45 cm (mean 6.76 ± 0.24 cm S.D) and the 4DL ranged from 6.25 cm to 7.42 cm (mean 6.7 ± 0.23 cm S.D). The Mean Difference between 4DL and 2DL for right hand was 0.09 and 0.06 for the left hand which was statistically significant ($p < 0.001$) for the gender. We also found the mean of 2DL to be higher for right hand and the mean of 4DL to be higher for the left hand in females.

The mean difference between the right 2DL in males & females was 0.59 cm and between the left 2DL in males & females was 0.6 cm. The mean difference between the right 4DL in males & females was 0.85 cm and between the left 4DL in males & females was 0.79 cm. It was observed that the males have significantly higher values than females for mean right and left 2DL as well as right and left 4DL. In overall data observation, in males the mean of 4DL was greater than the mean of 2DL whereas in females the mean of 2DL was higher than the mean of 4DL. However, the difference in both right and left 4DL between male & female is more than the difference in both right and left 2DL.

Table-2: Descriptive statistics: 2DL and 4DL ratio among adult Nepalese males and females

Variables (cm)	2DL:4DL			
	Right hand		Left hand	
	Males (n = 150)	Females (n = 100)	Males (n = 150)	Females (n = 100)
Min	0.9202	0.9807	0.9093	0.9881
Max	1.1144	1.0530	1.1057	1.0327
Mean	1.01*	1.0132*	1.0055*	1.0084*
S.D	0.0503	0.0118	0.0563	0.0077
S.E	0.01006	0.00119	0.01126	0.000773
S.P.	1.0116		1.00695	

S.D. = Standard deviation, S.E. = Standard Error, S.P. = Sectioning-point, * p value < 0.001.

Descriptive statistics for the ratio of 2DL and 4DL for both hands of males and females are shown in Table-2. In males, the ratio of 2DL and 4DL calculated ranged from 0.92 to 1.11 (mean 1.01 ± 0.0503 S.D.) for right hand and 0.9 to 1.1 (mean 1.0055 ± 0.0563 S.D.) for the left hand. In females, the ratio of 2DL and 4DL calculated ranged from 0.98 to 1.05 (mean 1.0132 ± 0.0118 S.D.) for right hand and 0.98 to 1.03 (mean 1.0084 ± 0.0077 S.D.) for the left hand. The ratio of 2DL and 4DL for left and right hands show statistically significant sexual dimorphism (at p value < 0.001).

Based upon the mean 2DL:4DL ratio for males and females, a Sectioning-point was derived to differentiate male and female hands.

Sectioning-point = (mean 2DL:4DL ratio in males + mean 2DL:4DL ratio in males)/2

The Sectioning-point for right hand was 1.0116 and that of the left hand was 1.00695 for 2D:4D ratio. Through trial and error, a Cut-off point of 0.99 was derived to determine sexual dimorphism from 2DL:4DL ratio.

Table-3: Analysis of sectioning point for the percentage accuracy of 2DL:4DL ratio

Analysis of sectioning point for the percentage accuracy (0.99)			
Variable		Male (n=150)	Female (n=100)
2DL:4DL Ratio	Left Hand	90.67	88
	Right Hand	89.34	91

Based upon Sectioning-point analysis in the data obtained from total participants, the percentage accuracy of gender determination is presented in Table-3. When the ratios obtained below or equal to 0.99 were considered males and the ratios obtained above 0.99 were considered females, it was found that 2DL:4DL ratios are able to establish sexual dimorphism in approximately 90.67% males and 88% females for left hand and 89.34% males and 91% females for right hand. We therefore state that 2DL:4DL ratio can determine gender in Nepalese population. When the ratio is below or equal to 0.99, it is indicative of a male while the ratio above 0.99 is indicative of a female.

Studies have shown that in overall observation, males' index and ring finger lengths are significantly longer than females' index and ring fingers [8, 14, 19, 20, 25, 26]. We too found similar results when 2DL and 4DL were compared. It was found in studies that in both the sexes there was a slight difference in 2DL and 4DL and consequently the 2DL:4DL ratio was nearly 1. This 2DL:4DL ratio becomes 1 in cases where both the index finger and the ring finger are of equal length. The gender difference in these ratios is not dependent on the age of the person or the stature of the individual [21]. It was revealed by Manning et al. that 2DL:4DL ratio is

the lone trait which observably elucidates the dimorphism in gender [22-24].

However, the degree of dimorphism in gender differs with race, ethnicity, geography etc. and genes, environment, climate, food, lifestyle may have a function in morphological dimension of hands; therefore a study has to be population specific to find out the Sectioning-point in that population [25, 26]. Keeping this in mind we obtained a Sectioning-point 2DL:4DL ratio that would differentiate the gender by simple measurements and calculations. The sectioning-point 2DL:4DL ratio obtained was based upon the frequency distribution of 2DL:4DL ratio across the total sample. We further derived a Cut-off point of 0.99 to differentiate gender for our study. The 2DL:4DL ratio ≤ 0.99 was of a male hand while those > 0.99 was of a female hand. A cutoff of 0.97 was derived by Kanchan *et al*., in south Indian population [14]. Dey S and Kapoor AK derived a cut-off point of 0.99 in north Indian population [25]. The variations in this Cut off point may be due to differing hand morphological dimensions relating to different populations as stated above. We also tested the accuracy of the Cut-off point and found that 2DL:4DL ratio accurately determine 90.67% males and 88% females for the left hand and 89.34% males and 91% females for the right hand.

CONCLUSION

Determination of gender is one of the most essential information to be achieved from index and ring fingers' length and this study reveals that sexual dimorphism subsists in 2DL:4DL ratio. This study will be of immense help in establishing identification in medico-legal and humanitarian cases involving Nepalese adults. Moreover, exacting skill or sophisticated instruments are not required and therefore can be easily done. However, we recommend that further researches with larger sample sizes and in specific races and ethnic groups in Nepal are essential to substantiate the utility of 2DL:4DL ratio in the determination of gender for forensic medico-legal and humanitarian cases involving this population.

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