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Effect of hand preference on second to fourth digit ratio and its role in sexual dimorphism: a study in 300 Haryanvi Brahmins and 300 Kashmiri Pandits

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SUMMARY

The 2nd to 4th digit ratio (2D:4D) is a sexually dimorphic biometric marker, related to prenatal estrogen and testosterone levels in-utero and determined genetically by HOX genes. The prenatal effects of testosterone on development of brain hemispheres are considered as a key factor in etiology of left-handedness. Besides sexual dimorphism, 2D:4D ratio shows significant ethnic and population differences. The aim of the present study is to provide an authentic database on right and left 2D:4D ratios in two different ethnic groups of a particular age and sex, and study its correlation with handedness and sexual dimorphism. The study was conducted on 300 Haryanvi Brahmins (150 each of either sex) and 300 Kashmiri Pandits (150 each of either sex) of the age group of 18 years and above. The values for 2D:4D ratio was calculated for both the hands. Hand preference was established according to Edinburgh Inventory and five hand-preference determination groups were constituted after calculation of laterality score. The results were tabulated and subjected to statistical analysis. Mean values for 2D:4D ratio in both the ethnic groups were found to be higher in females than in males. When the values of 2D:4D ratio were assessed by sex, the values were found to be statistically significant ($p<0.001$). When relationship between laterality score (indicator of hand preference) and 2D:4D were examined, the values were found to be significant only in Haryanvi Brahmins (males) on the right side.

Keywords: Digit ratio – 2D:4D – Sexual dimorphism – Hand preference

INTRODUCTION

Identification of victims from dismembered human remains has always been a challenge in medico-legal investigations. This problem is encountered in cases of mass disasters and explosions, 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 is helpful in the determination of primary indicators of identification such as sex, age and stature (Scheuer and Elkington, 1993; Smith, 1996; Williams et al., 2000; Case, 2007; Kanchan et al., 2008). Accurate sexing of the remains primarily

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narrows down the pool of possible victim matches. Determination of race, sex, age, and stature remain the foremost criteria in establishing population-specific data based on anthropometric measurements in various population groups.

Extensive work has been carried out by different researchers to estimate the stature from different hand measurements, and small bones of the hand (Jasuja and Singh, 2004; Krishan and Sharma, 2007). Although researchers have attempted sex determination from small bones of the hand (Scyheuer and Elkington, 1993; Smith, 1996; Kanchan et al., 2008), a very few systematic studies are available on determination of sex from the hand dimensions (Williams et al., 2000). The 2D:4D ratio is a sexually dimorphic marker (Kanchan et al., 2008). It is influenced by prenatal estrogen and testosterone levels. High prenatal levels of androgens (high testosterone /estrogen) determine lower values of 2D:4D and vice versa. Hox A and Hox D genes are responsible for both gonadal and digital differentiation (Kanchan et al., 2008). Left handedness is associated with high levels of androgens. High intrauterine levels of testosterone impede the growth of certain regions of the left hemisphere which leads to right hemisphere language dominance and increase in left handedness. 2D:4D ratio predicts disease predisposition particularly that are dependent on sex hormones.

The aim of the present study is to provide a database on right and left 2D:4D ratios in adult individuals from two different North-Indian ethnic groups (Haryanvi Brahmins and Kashmiri Pandits), evaluating its sex differences and studying its correlation with handedness.

MATERIALS AND METHODS

The present study was conducted on 300 Haryanvi Brahmins (150 of either sex) and 300 Kashmiri Pandits (150 of either sex) of age 18 years and above. The subjects belonged to the Brahmin caste community of the state of Haryana in Northern India and the Pandit caste community of the state of Jammu and Kashmir in Northern India. Prior informed consent for this study was obtained from subjects in writing, both in English and vernacular. The study followed the guidelines of the Institutional ethical committee. The subjects with any apparent, physical hand anomalies, inflammation, trauma, deformities and surgery were excluded because of their unsuitability for this investigation. Subjects having any genetic, psychological, neurological or chronic diseases affecting hand parameters were excluded from the study.

Hand Preference determination: Handedness was determined according to Edinburgh Inventory, which evaluates the direction and degree of hand preference (Oldfield, 1971). Subjects were asked 10 questions dealing with their hand preferences in: 1) Writing 2) Drawing 3) Throwing balls 4) Using scissors 5) Using tooth brush 6) Knife without fork 7) Spoon 8) Broom 9) Lighting matches and 10) Opening boxes.

Subjects were asked to put a "+" in the col-

Table 1. Determination of hand preference by direction and degree by Geschwind score

HAND PREFERENCE	GESCHWIND SCORE	
	Minimum value	**Maximum value**
RIGHT HAND		
Strong	+80	+100
Weak	+20	+75
Ambidextrous	-15	+15
LEFT HAND		
Weak	-75	-20
Strong	-100	-80

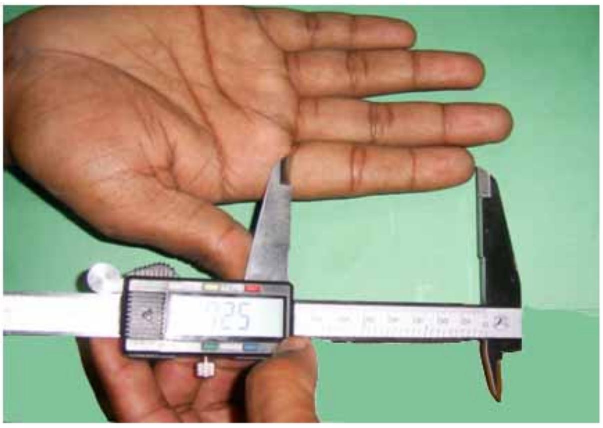

Fig. 1. Measurement of the 2nd digit length.

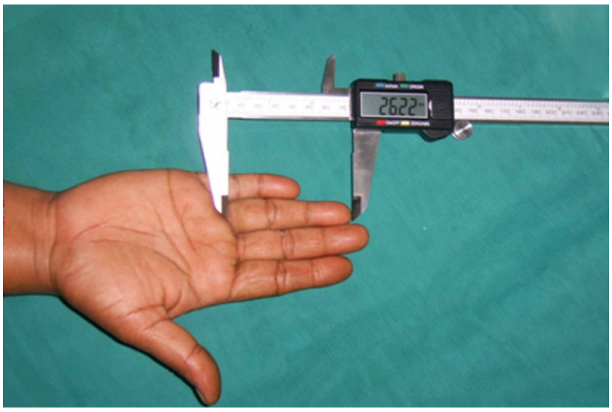

Fig. 2. Measurement of the 4th digit length.

umn associated with the hand that they were used to carry out activity. They were asked to put "++" in the associated column if their preference for one hand was very strong; and to put a "+" in both columns if they are using both hand equally. A "++" in right column was assigned10 points, a "+" in the right column 5 points, a "++" in the left column -10 points and a "+" in the left column -5 points. The resultant sum of these points had been used to determine the Geschwind (laterality) score, an indicator of the direction and degree of hand preference. -100 ≤ Geschwind score ≤ +100 (right hand preference decreases and left hand preference increases going from +100 to -100). Hand preference (Table 1) was evaluated in 5 groups depending on the value of the Geschwind laterality score (Tan U, 1998).

2D:4D ratio: It is defined as the ratio between the lengths of the index finger (second digit) and the ring finger (fourth digit). Finger length is the distance between the proximal flexion crease of the finger to the tip of the respective finger (Figs. 1 and 2). The measurements were taken from both hands from palmar side with digits fully stretched touching a flat hard surface and 2nd to 5th digits adducted with the thumb slightly extended. A digital sliding caliper (300 mm) was used to take all the measurements. All the data obtained were recorded, tabulated and subjected to statistical analysis using SPSS 13 PC + program. The sexual differences in the 2D:4D ratios in each ethnic group and hand were evaluated by an unpaired t test. The right-left differences in 2D:4D ratios (2D:4D right hand – 2D:4D left hand) in each sex and ethnic group were evaluated by an unpaired t test. The differences of laterality in 2D:4D ratios taking into account the hand preference were evaluated by paired student t-test. The correlation between the hand preference and the 2D:4D ratios were evaluated by

Table 2. Distribution of subjects by hand preference and sex in Haryanavi Brahmins

Hand Preference	Male (n)	Percentage (%)	Female (n)	Percentage (%)	Total (n)	Total (%)
Strong Right	123	82	110	73.3	233	77.67
Weak Right	25	16.67	29	19.3	54	18
Ambidextrous	1	0.6	2	1.3	3	1
Weak Left	0	0	2	1.3	2	0.67
Strong Left	1	0.6	5	3.3	6	2
Total	150	100	150	100	300	100

Table 3. Distribution of subjects by hand preference and sex in Kashmiri Pandits

Hand Preference	Male	Percentage	Female	Percentage	Total	Total
Strong Right	131	87.33	115	76.67	246	82
Weak Right	13	8.67	24	16	37	12.33
Ambidextrous	2	1.33	7	4.67	9	3
Weak Left	1	0.6	1	0.67	2	0.67
Strong Left	5	3.3	3	2	8	2.67
Total	150	100	150	100	300	100

Table 4. Interpretation of defining values of 2D:4D ratio by sex, hand and ethnic group

	Hand	MALE	FEMALE	p-value
Haryanavi Brahmins	Right	0.928 ± 0.057	0.953 ± 0.059	≤0.001
	Left	0.934 ± 0.051	0.946 ± 0.061	>0.05
Kashmiri Pandits	Right	0.930 ± 0.062	0.978±0.149	≤0.001
	Left	0.919 ± 0.086	0.989±0.100	≤0.001

Spearmann correlation coefficient analysis.

RESULTS

The distribution of subjects by hand preference and sex in Haryanavi Brahmins and Kashmiri Pandits are shown in Tables 2 and 3. Table 4 shows the sexual differences observed in each ethnic group and hand. The difference in values of 2D:4D ratio in males and females was found to be highly significant in both the ethnic groups except for left hand 2D:4D ratio in Haryanavi Brahmins. When the right-left difference of 2D:4D ratios was interpreted by sex, it was found to be insignificant in both the ethnic groups (Table 5).

When the groups formed by evaluation of hand preference were examined individually in Haryanvi Brahmins (Table 6), 2D:4D ratios were higher in right hand in strong right hand preference group, and were higher in the left hand in left hand preference groups. In weak right hand preference group, the values were higher in the left hand. The values were same on both the sides in ambidextrous group In Kashmiri Pandits (Table 7), the values of 2D:4D ratio was higher on the right side in strong right handed, strong left handed and ambidextrous individuals. The values were higher on the left side in weak right handed

Table 5. Significance of right-left differences by sex in each ethnic group

	Right-Left difference		p-value
	Male	Female	
Haryanavi Brahmins	-0.010± 0.668	0.007±0.081	p>0.05
Kashmiri Pandits	0.01±0.093	-0.01±0.178	p>0.05

Table 6. Right and left 2D:4D ratio in five groups evaluated by hand preference in Haryanvi Brahmins

Hand preference	Right hand	Left hand	p-value
Strong right handed	0.945±0.061	0.943±0.054	>0.05
Weak right handed	0.925±0.480	0.944±0.070	>0.05
Ambidextrous	0.933±0.058	0.933±0.058	>0.05
Weak left handed	0.901±0.141	0.900±0.000	>0.05
Strong left handed	0.943±0.053	0.929±0.049	>0.05

Table 7. Right and left 2D:4D ratio in five groups evaluated by hand preference in Kashmiri Pandits

Hand preference	Right hand	Left hand	p-value
Strong right handed	0.956±0.113	0.953±0.088	>0.05
Weak right handed	0.939±0.157	0.986±0.080	>0.05
Ambidextrous	0.960±0.0516	0.950±0.053	>0.05
Weak left handed	0.950±0.071	0.950±0.071	>0.05
Strong left handed	0.957±0.053	0.857±0.351	>0.05

Table 8. Relationship between Geschwind score and 2D:4D ratio (Spearmann correlation coefficient analysis)

Ethnic group	2D:4D ratio	Coefficient of correlation	P value
Haryanvi Brahmins	Right	0.128	<0.05*
	Left	0.097	>0.05
Kashmiri Pandits	Right	-0.078	>0.05
	Left	-0.085	>0.05

*p<0.05 Significant

group and the values were same on two sides in weak left handed group. However, these differences are not statistically significant.

When the relationship between Geschwind score (laterality score) and 2D:4D ratio was examined by Spearmann correlation coefficient analysis, the correlation was found to be not significant except in case of right 2D:4D ratio in Haryanvi Brahmins (Table 8), which is lower than 0.05.

DISCUSSION

The human hand is the most frequently used and versatile part of the body, and is of great scientific importance to investigators in the field of anthropometry, forensic pathology, orthopedic surgery, and ergonomics. Asymmetries tend to be more pronounced in adults than in children. They are generally more pronounced in the upper than in the lower extremities, and tend to be right side oriented i.e. right side tends to be larger than the left. Some evidence suggests that the latter is true even when handedness is controlled (Malina and Buschang, 1984).

The assessment of the physical dimension of the human hand provides a metric description to ascertain human-machine compatibility in the design of manual systems for the bare and gloved hand (e.g., design of the hand tools, knobs and controls, personal equipment, consumer appliances in the home and industry). Today, there is a growing demand among professional hand-tool users to have ergonomically designed products .To design any product for human use, engineers have to rely on anthropometric data. Otherwise, the resulting product may turn out to be ergonomically incompatible (Kar et al., 2003).

The personal identification from extremities becomes more important in cases of mass disasters, where there is a likelihood of recovering feet (often enclosed in shoes) and hands separated from the body. With regard to personal identification of dismembered hand and foot, somatometry of hand and foot, and its osteologic and radiologic examination can help in the determination of primary indicators of identification, such as sex, age and stature (Manning et al., 1998). The present study was aimed to study the sex differences and the effect of hand preference on 2D:4D ratio. The present data were compared with the previously reported studies both in males and females (Table 9 and 10).

The values of 2D:4D ratios were found to be significantly higher in females than in males in the present study, coinciding with the results of Williams et al. (2000) and Peters et al. (2002), but not with the results of Manning et al. (2000) and Buffa et al. (2007), who found that the values were almost similar in males and females (Table 9). When the values of 2D:4D ratio were compared separately on the right and left side in males and females, the values were again found to be higher in females (Putz et al., 2004; Kanchan et al., 2008; Kyriakidis and Papaioannidou, 2008); and the difference was statistically significant (Table 10), except in case of Haryanvi Brahmins on left side (Lutchmaya et al., 2004). The variation of digit ratios among population groups could be attributed to different digit pattern expression, which may reflect differences in the in-

Table 9. Comparative evaluation of 2D:4D ratios in males and in females

AUTHOR	POPULATION	N	SEX	2D:4D
Manning et al. (1998)	English	400	M F	0.98 1.00
Manning et al. (2000)	Finnish	24 27	M F	0.93 0.95
Manning et al. (2000)	Zulu	60 60	M F	0.95 0.95
Manning et al. (2000)	Jamaican	78 73	M F	0.93 0.94
Williams et al. (2000)	American	108 146	M F	0.96 0.97
Peters et al. (2002)	Canadian	98 402	M F	0.95 0.97
Buffa et al. (2007)	Sardinian	63 83	M F	0.98 0.98
Present study (2012)	Haryanavi Brahmins Kashmiri Pandits	150 150 150 150	M F M F	0.93 0.95 0.92 0.98

Table 10. Comparative studies evaluating 2D:4D ratios on the right and left side in males and females

AUTHOR	POPULATION	N	SEX	2D:4D	p-value
Lutchmaya et al. (2004)	Cambridge, UK		M F M F	0.936(RIGHT) 0.946(RIGHT) 0.926(LEFT) 0.929(LEFT)	>0.05* >0.05 *
Putz et al. (2004)	Pittsburgh University	230 120	M F M F	0.949(RIGHT) 0.974(RIGHT) 0.955(LEFT) 0.979(LEFT)	<0.0001* <0.0001*
Kanchan et al. (2008)	South Indian	150 150	M F M F	0.956(RIGHT) 0.987(RIGHT) 0.955(LEFT) 0.990(LEFT)	<0.001* <0.001*
Kayriakidis and Papaioannidou (2008)	Greek	60 60	M F M F	0.974(RIGHT) 1.002(RIGHT) 0.973(RIGHT) 1.001(LEFT)	<0.001* <0.001*
Present study (2012)	Haryanavi Brahmins	150 150	M F M F	0.93(RIGHT) 0.95(RIGHT) 0.94(LEFT) 0.95(LEFT)	<0.0001 >0.05
	Kashmiri Pandits	150 150	M F M F	0.93(RIGHT) 0.99(RIGHT) 0.92(LEFT) 0.99(LEFT)	<0.0001 <0.0001

*p values given by authors of quoted studies.

fluence of genetic or environmental parameters.

Right-Left difference in 2D:4D ratio was not statistically significant in males and females in the present study and these results are similar to earlier studies (Manning et al., 2000; Putz et al., 2004). Studies (Manning et al., 2000; Fink et al., 2004) examined the relationship between lateralized hand performance and 2D:4D ratio, and established that low 2D:4D ratio in right hand correlated with a tendency towards faster performance or skill with the left hand relative to the right. Low right 2D:4D ratio was reported to be associated with left hand preference (Voracek et al., 2006; Manning and Peters, 2009; Stoyanov et al., 2009), whereas 2D:4D ratio did not correspond with the type of handedness (Choudhary et al., 2005; Boets et al., 2007). In the present study, no significant correlation was observed between right and left 2D:4D ratio and handedness in two North-Indian ethnic groups except in right 2D:4D ratio in Haryanvi Brahmins.

Conclusion

The mean 2D:4D values were higher in females than in males in both North-Indian ethnic groups. The difference between males and females was highly significant in Kashmiri Pandits and in Haryanavi Brahmins on the right side. When right-left difference was assessed by sex, it was not statistically significant. Right 2D:4D ratio increased with increasing degree of right hand preference in Haryanavi Brahmin population. Hand preference did not influence the 2D:4D ratio and environmental and genetic factors may play a role in determination of degree of potency.

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