

EFFECT OF HANDEDNESS ON THE ASYMMETRY OF THE HAND IN KASHMIRI PANDITS

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ABSTRACT

Introduction: No two individuals are exactly alike in their measurable traits; even genetically identical twins (monozygotic) differ in some respects. Although human body appears to be bilaterally symmetric, researchers have noticed the presence of skeletal and morphological asymmetries in human body for long time. This is due to the effect of directionality and degree of hand preference, a functional property of hand, on anthropometric measurement of hand in healthy individuals. In the present study, the aim is to provide an authentic database on right and left hand measurements in males and females of Kashmiri Pandits and to study the effect of handedness on it.

Materials and Methods: The present study was conducted on 300 Kashmiri Pandits (150 of either sex of age 18 years) and above. Six hand measurements: Hand length, hand breadth, palmar length, shape index, digit index, palmar length/ width ratio were taken with a digital sliding caliper. Handedness was determined according to Edinburgh Inventory which evaluates the direction and degree of hand preference.

Results and Conclusion: The mean values of hand parameters were significantly different between males and females, right handers and left handers. Hand breadth and shape index were found to be greater in the right hand but the palmar length/ width ratio was found to be high for the left hand in strong and weak right hand preference groups in Kashmiri Pandits. No significant difference in hand parameter values on right and left hand were obtained among ambidextrous subjects. Left hand preference groups displayed irregular and heterogenous characteristics with regard to hand parameters.

KEY WORDS: Hand Anthropometry, Handedness, Asymmetry.

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INTRODUCTION

Identification of an individual is the mainstay in forensic investigations. With increasing frequency of mass disasters either natural or in cases of war, act of terrorism 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, mutilated and fragmentary remains is vital [1].

Studies in the past have reported a fair possibility of determining sex from skeletal remains and different body parts. The personal identification from extremities become increasingly important in cases of mass disasters, where there is a likelihood of receiving feet and hand 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 [2].

Although human body appears to be bilaterally symmetric, researchers have noticed the presence of skeletal and morphological asymmetries in human body for long time. Bilateral asymmetry is defined as the difference between the measurements of the left and right side of the human body. Most of the studies focusing on bilateral asymmetry have been conducted on the long bones of the extremities using specimens prepared from cadavers [3,4], a few others have been conducted on the living as well as on radiographic and photon absorption metric measurements of the living [5,6].

These studies demonstrated the existence of bilateral asymmetry in the anthropometric dimensions, bones, teeth, dermatoglyphic patterns, rate of maturation or growth of the skeletal components, and various characters of the skull bone, face, etc. These variations have been demonstrated in embryos, fetuses, infants, children, adolescents, and in adults [7]. Bilateral variations in upper and lower limb bones are attributable to difference in mechanical stress and strain over different bones during its growth, and referred to as directional asymmetry. Genetic factors, availability of minerals and vitamins and hormonal regulation also play a vital role in the development of asymmetries in the body [8].

Anthropometric studies have revealed that, in comparison of two halves of the body, the values belonging to the right half are different than those of left half. This is due to effect of directionality and degree of handed preference, a functional property of hand, on anthropometric measurement of hand in healthy individuals [9]. The aim of the present study is to provide a database on right and left hand anthropometric measurements in Kashmiri Pandits and evaluating its sex differences.

AIMS AND OBJECTIVES

To provide authentic database on right and left hand measurements in males and females of

Kashmiri Pandits.

To study the correlation between handedness and hand asymmetry in Kashmiri Pandits.

To study sexual dimorphism in hand anthropometric measurements in Kashmiri Pandits.

MATERIALS AND METHODS

The present study was conducted on 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 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.

A digital sliding caliper (300mm) was used for all the hand anthropometric measurements. All measurements were taken on both hands from palmer side with digits fully stretched touching on flat hard surface and 2nd to 5th digits adducted and thumb slightly extended. All the data so obtained was recorded, tabulated and statistically analyzed.

Somatometric Measurement (in mm)

Hand Length: It is defined as distance between the midpoint of the distal wrist crease and the most anterior projecting point i.e. the tip of the third digit.¹⁰

Hand Breadth: The distance between the outside projections of the distal end of second and fifth metacarpals of the hand, with fingers extended and together.¹⁰

Palmar Length: The palmar length is defined as the distance between the midpoint of the distal wrist crease and the midpoint of the proximal digital crease.¹¹

Shape Index (Length-width index, hand index): Hand breadth X100/Hand length.¹²

Digit Index (Phalangeal index): Third digit length X100/ hand length.¹² Third digit length was

measured on the ventral surface of the hand from the basal crease of the digit to the tip.

Palmar Length/Width Ratio: Palmar length / palmar width (palmar width=hand width) [11].

Handedness was determined according to Edinburgh Inventory which evaluates the direction and degree of hand preference [14,15]. 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
10. Opening boxes

Subjects were asked to put a "+" in the column 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 "+" in both column if they are using both hand equally. A "++" in right column was assigned 10 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 d" Geschwind score d" +100 (right hand preference decreases and left hand preference increases going from +100 to -100). Hand preference was evaluated in 5 groups, depending on the value of the Geschwind laterality score.¹³

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

OBSERVATIONS

Table 1: Description Of Subjects By Hand Preference And Sex In Kashmiri Pandits.

Hand Preference	Male (n)	Percentage (%)	Female (n)	Percentage (%)	Total (n)	Total (%)
Strong right	130	87.3	115	76.6	245	81.6
Weak right	12	7.5	24	16	37	12
Ambidextrous	2	1.3	7	3.3	9	3
Weak left	1	0.3	3	2	2	1.6
Strong left	5	2.6	2	1.6	7	2.3
Total	150	100	150	100	300	100

In Kashmiri Pandits, 282 subjects were right handed, 9 were left handed and 9 were ambidextrous.

Table 2: Interpretation Of Hand Parameters (Mm) By Sex In Kashmiri Pandits.

PARAMETERS		Sex		p value
		Male	Female	
Hand Length	Right	181.79 ± 8.92	170.84 ± 9.57	≤ 0.001***
	Left	183.63 ± 9.15	170.70 ± 12.00	≤ 0.001***
Hand Breadth	Right	82.99 ± 5.44	75.82 ± 6.23	≤ 0.001***
	Left	81.25 ± 4.99	74.94 ± 10.09	≤ 0.001***
Palmar Length	Right	103.59 ± 7.14	95.72 ± 7.39	≤ 0.001***
	Left	103.88 ± 8.23	97.21 ± 9.02	≤ 0.001***
Shape Index	Right	43.05 ± 1.65	43.32 ± 2.06	≤ 0.001***
	Left	44.05 ± 2.55	43.15 ± 2.13	≤ 0.001***
Digit Index	Right	43.04 ± 1.65	43.32 ± 2.06	> 0.05
	Left	42.69 ± 1.57	43.10 ± 1.88	≤ 0.05*
Palmar Length /Width Ratio	Right	1.25 ± 0.10	1.28 ± 0.08	≤ 0.01**
	Left	1.26 ± 0.081	1.31 ± 0.10	≤ 0.001***

Hand length, hand breadth, palmar length was found to be higher in men and the difference between males and females was statistically highly significant. The values of shape index, palmar length/width ratio were higher in women and the difference was statistically highly significant. Digit index was also higher in women but the difference was statistically less significant on left side and insignificant on right side (Table 2).

The values of hand length, hand breadth, shape index were higher on right side, but the difference between right and left side was statistically significant only in hand breadth, shape index and finger index. Palmar length and palmar length/width ratio values were higher on the left side and the difference was statistically

significant only in palmar length /width ratios (Table 3).

Table 3: Right And Left Hand Parameters (Mm) In Strong Right Handed Kashmiri Pandits.

PARAMETERS	RIGHT HAND (X ± SD)	LEFT HAND (X ± SD)	p value
Hand Length	176.43±10.77	176.19±12.00	>0.05
Hand Breadth	79.85±7.05	78.38±9.08	≤0.01**
Palmar Length	99.51±8.37	100.50±9.57	>0.05
Shape Index	45.07±7.05	43.83±2.45	≤0.001***
Finger Index	43.25±1.82	42.98±1.72	≤0.01**
Palmar Length/ Width Ratio	1.24±0.14	1.28±0.10	≤0.001***

Table 4: Right And Left Hand Parameters (Mm) In Weak Right Handed Kashmiri Pandits.

Parameters	Right hand (x ± SD)	Left hand (x ± SD)	p value
Hand Length	176.39±11.39	177.70±12.65	≤0.05*
Hand Breadth	77.93±6.05	77.37±5.86	>0.05
Palmar Length	100.77±7.73	100.56±7.83	>0.05
Shape Index	44.20±2.47	43.49±2.39	>0.05
Finger Index	42.85±1.99	42.28±1.71	>0.05
Palmar Length/ Width Ratio	1.29±0.08	1.30±0.08	>0.05

In weak right handed persons, hand breadth, palmar length, shape index and finger index were higher on the right side but the difference was statistically insignificant. Hand length and palmar length/width ratios were higher on left side but the difference was statistically significant only in hand length (Table 4).

Table 5: Right And Left Hand Parameters (Mm) In Ambidextrous Kashmiri Pandits.

PARAMETERS	RIGHT HAND (X ± SD)	LEFT HAND (X ± SD)	p value
Hand Length (In mm)	171.20±17.10	171.51±8.95	>0.05
Hand Breadth (In mm)	75.44±3.56	74.67±3.56	>0.05
Palmar Length	98.20±7.70	101.79±7.33	>0.05
Shape Index	44.11±2.26	43.58±1.51	>0.05
Finger Index	42.99±2.31	42.91±2.18	>0.05
Palmar Length/ Width Ratio	1.29±0.09	1.29±0.06	>0.05

In ambidextrous individuals, the values of hand breadth, shape index, finger index was higher on right side but the difference was statistically insignificant. The values of hand length and palmar length were higher on the left side, but the difference was statistically insignificant. The difference in right & left values of palmar length/width ratio was statistically insignificant (Table 5).

Table 6: Right And Left Hand Parameters (Mm) In Weak Left Handed Kashmiri Pandits.

PARAMETERS	RIGHT HAND (X ± SD)	LEFT HAND (X ± SD)	p value
Hand Length (In Mm)	180.95±5.87	179.65±7.71	>0.05
Hand Breadth (In Mm)	80.15±1.34	79.65±2.05	>0.05
Palmar Length	103.80±1.98	105.95±15.20	>0.05
Shape Index	44.30±0.71	44.45±0.64	>0.05
Finger Index	44.85±1.91	45.40±2.69	>0.05
Palmar Length/ Width Ratio	1.30±0.00(a)	1.30±0.00(a)	-

t cannot be computed because the standard error of the difference is 0.

In weak left handed subjects, the values of hand length and hand breadth were higher on the right side, but the difference was statistically insignificant. The values of palmar length, shape index and finger index were higher on the left side but the difference was not statistically significant. The mean values of palmar length/width ratios were the same on the right and left side (Table 6).

Table 7: Right And Left Hand Parameters (Mm) In Strong Left Handed Kashmiri Pandits.

PARAMETERS	RIGHT HAND (X ± SD)	LEFT HAND (X ± SD)	p value
Hand Length (In Mm)	177.31±10.46	177.83±10.66	>0.05
Hand Breadth (In Mm)	76.45±5.40	75.79±5.43	>0.05
Palmar Length	99.34±10.09	99.47±6.83	>0.05
Shape Index	43.10±1.51	42.70±3.01	>0.05
Finger Index	42.41±2.23	42.51±0.95	>0.05
Palmar Length/Palmar Width	1.29±0.091	1.31±0.11	>0.05

In strong left handed subjects, mean values of

In strong left handed subjects, mean values of hand breadth, shape index were higher on the right side, but the difference was not statistically significant. The mean values of hand length, palmar length, finger index, palmar length/width ratios were higher on the left side, but the difference was not statistically significant (Table 7).

Table 8: Relationship Between The Gecshwind Score (Laterality Score) And Hand Parameters (Spearman Correlation Coefficient Analysis) In Kashmiri Pandits.

PARAMETERS	SPEARMAN COEFFICIENT OF CORRELATION	COEFFICIENT OF SIGNIFICANCE
Right Hand Length	0.074	0.199
Left Hand Length	0.075	0.194
Right Hand Breadth	0.157	0.007**
Left Hand Breadth	0.095	0.101
Right Palmar Length	0.041	0.474
Left Palmar Length	0.075	0.198
Right Shape Index	0.151	0.009**
Left Shape Index	0.031	0.589
Right Digit Index	0.06	0.301
Left Digit Index	0.102	0.077
Right Palmar Length/ Width Ratio	-0.15	0.009**
Left Palmar Length/Width Ratio	-0.118	0.041*

Table 8 shows that laterality score was positively correlated with right hand length (0.074), left hand length (0.075), left hand width (0.157), right palmar length (0.041), left palmar length (0.075), left shape index (0.031), right hand digit index (0.060) and left hand digit index (0.102). But the correlation was statistically significant in case of right hand breadth ($p \leq 0.01$) and right hand shape index ($p \leq 0.01$). Laterality score was negatively correlated with right palmar length/width ratio (0.150), left palmar length/width ratio (-0.118). But the correlation was statistically significant in case of right palmar length/width ratio ($p \leq 0.01$) and left palmar length/width ratio. ($p \leq 0.05$).

DISCUSSION

The results of the present study was compared with previously done studies. The right and left mean hand lengths and hand breadths were

more in males as compared to females and the difference in values between males and females was significant in the present study (Table 2). This is in agreement with the studies done by Kulaksiz and Gozil, [14] Kar et al, [16] Oomen et al [17] (in males), Agnihotri et al, [18] Krishan & Sharma, [19] Danborno & Elukpo, [20] Ibeachu et al, [21] and Krishan et al. [22].

In the present study, values of mean hand length were found to be higher on the left side in males of Kashmiri Pandits (Table 2) which is in agreement with the studies of Kulaksiz and Gozil [14] and Danborno & Elukpo [20] and in contradiction to the study of Krishan & Sharma [19]. In Kashmiri Pandits females, the values were slightly more on the right side which is in consonance with the studies done by Kar et al [16], Oomen et al [17] and Krishan & Sharma [19]. The values of mean hand breadth were found to be higher on the right side in both males and females in Kashmiri Pandits (Table 2). These results coincided with the studies done by Kulaksiz and Gozil [14], Kar et al [16], Agnihotri et al [18], Danborno & Elukpo [20], Ibeachu et al [21] and Krishan et al. [22].

The difference in values of mean palmar length between males and females was highly significant on both the sides in Kashmiri Pandits. The values of mean palmar length were found to be higher on the left side in males of Kashmiri Pandits (Table 2). These results coincided with the study done by Kar et al. [16] In case of Kashmiri Pandit females, the values were more on the left side which is in contradiction to the results of Kar et al. [16] where the values of mean palmar length was more on the right side in females.

The mean values of shape index were more in males as compared to females. The difference in values between males and females was highly significant on both the sides which coincided with the studies done by Kulaksiz and Gozil [14] & Danborno and Elukpo [20]. The values of shape index were more in the left hand in males which is in contradiction with the studies done by Kulaksiz and Gozil [14] & Danborno and Elukpo [20] and the values were more in the right hand in females (Table 2). In Kashmiri Pandits, the values of digit index were more in females as compared to males and the difference in

values between males and females was statistically significant and the values of mean digit index were found to be higher on the right side in both males and females in Kashmiri Pandits (Table 2). These results are in consonance with the study done by Kulaksiz and Gozil [14]. The mean values of measurements in different hand preference groups of the present study were compared with mean values in the study done by Kulaksiz and Gozil [14].

In strong right handed group, the values of mean hand length were more on right side in Kashmiri Pandits (Table 3) which is in contrast to the study done by Kulkasiz & Gozil [14]. In weak right handed group, the values of mean hand length were more on left side in Kashmiri Pandits. Hand breadth was observed to be noticeably greater in right hand in those with strong & weak right hand preference ($p < 0.01$) in Kashmiri Pandits (Table 3, 4) which is in accordance with the results shown by Kulkasiz and Gozil [14]. In rest of the hand preference groups in the present study & also in the study done by Kulaksiz & Gozi [14], the mean values of hand length and hand breadth showed irregular results indicating no systematic correlation in these groups. The shape index was found to be higher in the right hand in strong and weak right hand preference groups in Kashmiri Pandits (Table 3, 4) and these results were similar to the study done by Kulkasiz and Gozil [14]. Thus, the right hand was coarser than the left hand in persons with right hand preference. In ambidextrous and left handed groups (Table 5, 6, 7) the shape index values were more on the right side in Kashmiri Pandits and in the study of Kulkasiz and Gozil [14]. In weak left handed groups, the shape index values were more in the left hand in the two studies (Table 6) whereas in strong left handed group, the values were more in the right hand in Kashmiri Pandits (Table 7) which is in contrast to the results of Kulkasiz & Gozil [14] where values were more in on the left side. This difference in results could be because of the less number of left handed subjects taken in the present study.

In Kashmiri Pandits, the mean values of digit index was found to be higher in the right hand in all the hand preference groups except for strong left handed group where mean values

were more in the left hand. These results were in accordance with the results of Kulkasiz & Gozil [14]. When correlation between Geschwind score (laterality score) and hand parameters was examined, the values were found to be significant for right hand breadth, right hand shape index, right and left palmar length/width ratio in Kashmiri Pandits (Table 8). This is not in consonance with the study of Kulkasiz & Gozil [14] where correlation was found to be significant in case of left hand shape index and right hand digit index.

CONCLUSION

In Kashmiri Pandits, 282 subjects were right handed, 9 were left handed and 9 were ambidextrous (Table 1). The left shape index was higher in men whereas right shape index, digit index, palmar length/width ratio was higher in women indicating that Kashmiri Pandit males have wider and coarser left hand whereas females have narrower left hand (Table 2).

In Kashmiri Pandits, all parameters were found to be sexually dimorphic except for digit index (Table 2). Thus there are differences in anthropometric dimensions of hand in males & females, right & left handers and also in different populations and endogamous groups. Thus, a baseline data on hand anthropometry of the has been established in males and females of Kashmiri Pandits which will be helpful to anthropologists and forensic experts in cases of mass disasters for personal identification and also for designing ergonomically compatible hand tools. In the present study, hand preference was investigated in five groups based on hand usage strength and its effect on right and left hand parameters was determined. In Kashmiri Pandits, there were no significant differences in right and left hand length values in various hand preference groups except in case of weak right handed individuals.

In Kashmiri Pandits, hand breadth was significantly higher on the right side in strong right handed individuals (Table 3) and in rest of the groups though the values were higher on the right side but the differences were insignificant on the two sides. Shape index values were significantly higher on the right side in strong right hand preference groups in

Kashmiri Pandits (Table 3) and in weak right hand preference group, the values were more on the right but the difference between right and left side was insignificant (Table 4). In left handed groups, the values were more in the left hand in weak left handed and in the right hand in strong left handed groups in Kashmiri Pandits but the difference in values on the two sides were not significant (Table 6, 7).

In Kashmiri Pandits, palmar length/width ratio was significantly higher in the left hand in strong right hand preference groups (Table 3) whereas in weak right handed individuals also the ratio was higher in the left hand but the difference was not significant (Table 4). In rest of the groups the values were almost equivalent or more in the left hand as compared to the right.

In Kashmiri Pandits, finger index values were significantly greater on the right side in strong right handed groups (Table 3), insignificantly higher on the right side in the weak right handed and ambidextrous groups (Table 4, 5) and insignificantly higher on the left side in left hand preference groups indicating some effect of hand preference on finger index. No significant difference in hand parameter values on right and left hand were obtained among ambidextrous subjects.

Thus, hand preference has a potent influence on some of the hand measurements and environmental and genetic factors and anatomical brain asymmetry may play a role in determination of degree of potency. Left handed groups displayed irregular and heterogenous characteristics with regard to hand parameters. The heterogeneity observed may be because of less number of left handed subjects in the present study and could also be a consequence of differing etiology of left handedness (left hemisphere damage, familial failure of brain dominance development). The lesser number of left handed subjects in the present study may be because of forced conversion of left handed to either ambidextrous or right handed individuals due to cultural and religious factors. People who normally use their left hands attempt to use their right hands because of influence of their families and environment and sometimes out of necessity. These variations in degree of hand usage may result in heterogeneity in hand

anthropometric measurements in left handed persons.

When correlation between Geschwind score (laterality score) and hand parameters was examined, the values for right hand breadth, right hand shape index, right and left palmar length/width ratio were found to be significant in Kashmiri Pandits (Table 8). Thus, it was determined that right hand breadth and right shape index values increased with increasing tendency towards right hand preference and right & left palmar length/width ratio values increased with increasing tendency towards left hand preference in Kashmiri Pandits.

Conflicts of Interests: None

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