Effect Of Hand Preference On Hand Length, Hand Breadth and Shape Indices and Its Role in Sexual Dimorphism: A Study in 300 Kashmiri Pandits

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Abstract: *The hand is the most used and versatile part of body is of great scientific importance to investigators in the field of anthropometry, forensic pathology, orthopedic surgery and ergonomics. The aim of the present study is to provide an authentic database on right and left hand length, hand breadth and hand shape indices of males and females of Kashmiri Pandits community of a particular age and sex. And study its correlation with handedness and sexual dimorphism. The study was conducted on 300 Kashmiri Pandits (150 each of either sex) of age group 18 year and above. The values for hand-length, hand breadth and hand shape indices were calculated for both the hands. Hand preference was constituted after calculation of laterality score established according to Edinburg inventory and five hand-preference determination groups were The results were tabulated and subjected to statistical analyses. Mean values for hand-length handbreadth and hand shape indices in males are more in when assessed by sex. These values were found statistically significant ($p \leq 00.1$). when relationship between laterality score(indicator of hand preference) and hand-length, handbreadth, and shape indices were examined, the values were found to be positively correlated for right hand-length, left hand-length, left shape index but the correlation was no statistically significant. Laterality score was positively correlated in Kashmiri Pandits it was with right hand length, left hand length and left hand shape index. But the correlation was statistically significant in case of right hand breadth ($p \leq 0.01$) and right shape index ($p \leq 0.01$).*
Keywords: *Hand length—hand breadth—hand index-- sexual dimorphism—hand preference.*

I.   Introduction

Increasing frequency of mass disasters' like tsunamis, plane crashes, earthquakes, genocides etc. has created problems in the determination of stature and identification of victims when only fragmented or dismembered human remains are available for investigations (Shahnaz Choudhary et. al 2014)[1], (Dayal MR et. al. 2008)[2], (Krishan et. al.2008)[3],(Barnabas D et. al. 2008)[4] (Jasuja OP et. al. 2004)[5]. In such cases the forensic experts has no choice but to use relatively less precise method of reconstruction e.i. the mathematical method which is workable even if a part of body is available (Bhavna and Nath S, 2007)[6]. For past many ears scientists, anatomists and anthropologists have laid focus on dimensional relativity between various body segments (Abdel Malik AK et. al. 1990)[7], (Bhatnagar DP .et. al 1984)[8]

Accurate sexing of the remains primarily narrows down the pool of possible victim matches. Determination of race sex, age and stature remains 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 estimates the stature from different hand measurements, and small bones of the hands (Jasuja OP and Singh G et. al. 2004)[5]. Although researchers have attempted sex determination from small bones of the hands (Scyheuer and Elkington)[9] few systematic studies are available on determination of sex from the hand dimensions (Williams et al, 2000)[10]. The hand length, hand breadth, hand shape index and other hand dimensions are sexually dimorphic marker (Kanchan et al.2008)[11]. It is influence by prenatal estrogen and testosterone levels. High prenatal levels of androgens (high testosterone/estrogen) which may have an early organizing effect on strength in men, and is likely to be widespread in human groups (fink et al)[12]. Hox A and Hox D genes are responsible for both Gonadal and digital differentiation (Kanchan et. al. 2008)[11]. 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.

The aim of the present study is to provide a database on right and left hand length, hand breadth and hand hand-shape indices of both the hands.

II. Material And Methods

The present study was conducted on 300 subjects of Jammu and Kashmir population (150 of either sex) of age 18 years and above. The subjects belonged to the Kashmiri Pandit community of the state of Jammu and Kashmir in Northern India. Prior informed consent of the study was obtained from subjects in writing both in English and vernacular. 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 Edinburge inventory, which evaluates the direction and degree of hand preference (Oldfield RC et. al. ,1971)[13]. Subjects were asked 10 questions dealing with their hand preferences in: 1) writing 2) drawing 3) throwing balls 4) knife without fork 7) spoon 8) Broom 9) Lightening matches and 10) Opening boxes. Subjects were asked to put a "+" in the column associated with the hand they were used to carry out activity. They were asked to put "+" in the associated column if their preference for one hand was strong; and to put a "+"in both the columns if they are using both hand equally. A "++"in the right column was signed by 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≤ 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 values of the Geschwind laterality score (Tan U, 1998)[14].

Hand length is defined as the distance between the midpoint of the distal wrist crease and the most anterior projecting point i.e. tip of the third digit (Pheasant S, 1990)[15].

Hand breadth is the distance between the outside projections of the ends of second and fifth metacarpals of the hand, with fingers extended and together (Pheasant S, 1990)[15].

Shape index is hand breadth multiplied by hundred and divided by hand length (Napier J, 1990)[16].

The measurements were taken from both hands from palmer 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 hand-length, hand breadth and shape index of the hand in two ethnic groups and hand were evaluated by an unpaired t test. The right-left differences in the hand length, hand breadth and hand shape index in each sex and ethnic group were evaluated by an unpaired t-test. The differences of laterality in hand length, hand breadth and hand shape index taking into account the hand preference were evaluated by paired student t-test. The correlation between the hand preference and the hand length, hand breadth and hand shape index were evaluated by Spearmann correlation analysis.

Fig 1. Hand Length Measurement.
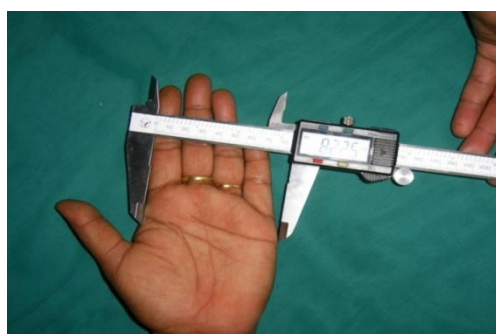
Fig. 2 Hand breadth measurement.

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

Table 2. Distribution of subjects by hand preference and sex in Kashmiri Pandits

Hand Preference	Male (n)	Percentage (%)	Female (n)	Percentage (%)	Total (n)	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 3. Interpretation of defining values of the hand length, hand breadth and hand shape index by sex.

Hand	Male	Female	p-value
Right hand length	181.79±8.92	170.84±9.57	≤0.001
Left hand length	182.63±9.15	170.70±12.00	≤0.001
Right hand breadth	82.99±5.44	75.82±6.23	≤0.001
Left hand breadth	81.25±4.99	74.94±10.09	≤0.001
Right hand S.I	43.05±1.65	43.32±2.06	≤0.001
Left hand S.I	44.05±2.55	43.15±2.13	≤0.001

Table 4. Significance of right-left differences by sex in Kashmiri Pandits.

Right-left differences in Males and females			p-value
Hand Length	1.39±-1.14	0.14±-243	≤0.001
Hand breadth	1.74±-0.45	0.88±-3.80	≤0.001
Hand S.I	0.17±-0.07	-1.00±-0.9	≤0.001

Table 5. Right and left hand length, hand breadth and hand shape indices in five groups evaluated by hand preference in Kashmiri Pandits.

Hand Preference		Right hand	Left hand	p-value
Strong right	Hand length	176.43±10.77	176.19±12.00	>0.05
	Hand breadth	79.85±7.05	78.38±9.08	≤0.01
	Hand S.I	45.07±7.05	42.98±1.72	≤0.01
Weak right	Hand length	176.39±1139	177.70±12.65	≤0.05
	Hand breadth	77.93±6.05	77.37±5.86	>0.05
	Hand S.I	44.20±2.47	43.49±2.39	>0.05
Ambidextrous	Hand length	171.20±17.10	171.51±8.95	>0.05
	Hand breadth	75.44±3.56	74.67±3.56	>0.05
	Hand S.I	44.11±2.26	43.58±1.51	>0.05
Weak left	Hand length	180.95±5.87	179.65±7.71	>0.05
	Hand Breadth	80.15±1.34	79.65±2.05	>0.05
	Hand S.I	44.30±0.71	44.45±0.64	>0.05
Strong left	Hand length	177.31±10.46	177.83±10.66	>0.05
	Hand breadth	76.45±5.40	75.79±5.43	>0.05
	Hand S.I	43.10±1.51	42.70±3.01	>0.05

III. Results

The distribution of subjects by hand preference and sex in Kashmiri Pandits are shown in tables 2 and 3. Table 4 shows the sexual difference observed in Kashmiri Pandits by and hand. The difference in values of Hand length, hand breadth and hand shape index in males and females were found to be highly significant. When the right-left difference of hand length, hand breadth and hand shape index was interpreted by sex, it was found to be significant (Table 5).

When the groups formed by evaluation of hand preference were examined individually in Kashmiri Pandits (Table 6). Hand length, hand breadth and shape index were higher on right side, but the difference between right and left side was statistically significant only in hand breadth and shape index. In weak right handed individuals, hand breadth and shape index were higher on the right but the difference was statistically insignificant whereas hand length mean value is higher on left side but difference was statistically significant only in hand length. In ambidextrous individuals, the values of hand breadth and shape index were higher on right but the difference was statistically insignificant where as the value of hand length is higher on the left side, but the difference was statistically insignificant. 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 whereas value of shape index was higher on the left side but difference was statistically insignificant. In strong left handed subjects, mean values of hand breadth, shape index where higher on the right side, but the difference was not statistically significant where as the mean value of hand length was higher on left but the difference was insignificant.

Table 6. Relationship between Geschwind score and hand length, hand breadth, and hand shape index (Spearman correlation coefficient analysis) in both ethnic groups.

Hand Parameters in Kashmiri pandits	Spearman correlation coefficient	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 hand S.I	0.151	0.009
Left hand S.I	0.031	0.589

When the relationship between Geschwind score (laterality score) and hand length, hand breadth and hand shape index were examined (Table 7) by spearman correlation coefficient analysis indicate that laterality score was positively correlated with right hand length 0.074, left hand length 0.075, left hand breadth 0.157, left hand shape index 0.031. But the correlation was statistically significant in case of hand breadth $p \leq 0.01$ and right hand shape index ≤ 0.01.

IV. Discussion

The human hand is the most used and versatile part of the body 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 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 RM et. al.1984)[17]

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 tools 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 SK, et. al.2003)[18].

The present study was done to provide a database for hand anthropometry in two different endogamous groups & study its correlation with hand preference. 600 subjects were included in the study out of which 300 were Haryanvi Brahmins (150 of either sex) and 300 were Kashmiri Pandits (150 of either sex). Eight hand measurements were taken and hand preference was determined using Edinburgh inventory. Questionnaires of hand preference are frequently used to identify handedness groups because (1) they are easier to administer than behavioral measures and (2) they provide the basis for assignment of individuals to handedness groups. (Corey Dm, Hurly Mm et. al.2001)[19]. The data was recorded, tabulated and subjected to statistical analysis. The readings were compared with the previously published data.

Table 7. Comparative evaluation of hand length in males and in females

AUTHOR	POPULATION	MALES		FEMALES		p value
		RIGHT	LEFT	RIGHT	LEFT	
Kulaksiz and Gozil[20]	Ankara (Turkey)	186.92±8.31	187.34±8.10	171.19±7.64	171.44±7.65	<0.001
Kar et al[18]	West Bengal	175.1±8.5	175.9±8.8	160.9±7.0	160.6±7.5	<0.001
Oomen et al[21]	Karnataka	190.60±7.30	190.62±7.10	173.28±8.90	172.46±8.70	<0.001
Agnihotri et al[22]	Mauritius	188.91±8.80	189.00±8.70	172.20±9.20	172.20±9.30	<0.001
Krishan & Sharma[23]	Himachal Pradesh (Rajputs)	182.4±9.00	182.1±9.1	168.3 ± 8.00	168.00±8.30	<0.001
Danborno &Elukpo [23]	Zaria,Nigeria	198.5±8.60	199.30±9.30	185.10±6.60	185.21±7.70	≤0.001
Ibeachu et al[25]	University of Port Harcourt Nigeria	190.2±0.8	190.9±0.7	176.2±0.7	176.9±0.7	<0.001
Krishan et al[26]	Himachal Pradesh	182.70±9.00	182.10±9.00	168.10±8.00	167.70±8.00	≤0.001

In Kashmiri Pandits, the mean hand length values in males were 181.79±8.92 on right side and 183.63±9.15 on left side and in females it was 170.84±9.57 on right side and 170.70±12.00 on left side.

The mean values were more in males as compared to females and the difference in values between males and females was significant on both the sides in both the endogamous groups. This is in agreement with the studies done by Kulaksiz and Gozil[20], Kar et al[18], Oomen et al[21] (in males), Agnihotri et al[22], Krishan & Sharma [23], Danborno & Elukpo[24], Ibeachu et al[25], Krishan et al[26](Table 9).

In the present study, values of mean hand length were found to be higher on the left side in males of Haryanvi Brahmins and Kashmiri Pandits which is in agreement with the studies of Kulaksiz and Gozil[20] and Danborno & Elukpo[24] and in contradiction to the study of Krishan & Sharma[23].The values were slightly higher on the left side in females of Haryanvi Brahmins which is in consonance with the studies of Kulaksiz and Gozil[20], Oomen et al[21], Danborno & Elukpo[24] & Ibeachu et al[25]. In Kashmiri Pandits females, the values were the values were slightly more on the right side which is in consonance with the studies done by Kar et al[18], Oomen et al[21], Krishan & Sharma [23] (Table 9).

Table 8. Comparative evaluation of hand breadth in males and in females

AUTHOR	POPULATION	MALES		FEMALES		p value
		RIGHT	LEFT	RIGHT	LEFT	
Kulaksiz & Gozil (2002)[20]	Ankara (Turkey)	85.54±3.99	84.61±4.31	76.61±4.12	75.64±3.93	<0.001
Kar et al[18]	West Bengal	82.3±0.44	80.3±0.41	73.0±0.35	70.7±0.35	≤0.001
Agnihotri et al(2006)[22]	Mauritius	84.50±4.00	84.20±4.00	74.8±3.8	74.2±3.7	<0.001
Danborno & Elukpo (2009)[24]	Zaria,Nigeria	89.00±9.50	86.80±9.20	78.20±4.90	77.20±4.60	<0.001
Krishan et al (2011)[26]	Himachal Pradesh (Rajputs)	82.30±3.90	80.90±4.30	74.00±4.20	72.90±4.30	<0.001
Ibeachu et al(2011)[25]	University of Port Harcourt, Nigeria	85.8±0.3	84.3±0.3	76.9±0.3	75.8±0.3	<0.001
Present study	Kashmiri Pandits	82.99±5.44	81.25±4.99	75.82±6.23	74.94±10.09	≤0.001

In Kashmiri Pandits, the mean hand breadth values in males were 82.99±5.44 on right side and 81.25±4.99 on left side and in females it was 75.82±6.23 on right side and 74.94±10.09 on left side.

The values were more in males as compared to females and the difference in values between males and females was highly significant on both the sides in both the present endogamous population . This is in agreement with the studies done by Kulaksiz and Gozil[20], Kar et al[18], Agnihotri et al[22], Danborno & Elukpo[24], Ibeachu et al[25], Krishan et al[26].

In the present study, values of mean hand breadth were found to be higher on the right side in both males and females in Kashmiri Pandits. These results coincided with the studies done by Kulaksiz and Gozil[20], Kar et al[18], Agnihotri et al[22], Danborno & Elukpo[24], Ibeachu et al[25], Krishan et al[26] (Table 10).

Table 9. Comparative evaluation of hand shape index in males and in females.

AUTHOR	POPULATION	MALES		FEMALES		p value
		Right	Left	Right	Left	
Kulaksiz and Gozil[20]	Ankara (Turkey)	45.80±1.88	45.19±2.03	44.78±2.08	44.15±1.99	<0.001
Danborno and Elukpo [24]	Nigerian	44.92±5,15	43.65±5.15	42.27±2.67	41.74±2.34	<0.001
Present study	Kashmiri Pandits	43.05±1.65	44.05±2.55	43.32±2.06	43.15±2.13	≤0.001

In Kashmiri Pandits, the mean hand length values in males were 43.05±1.65 on right side and 44.05±2.55 on left side and in females it was 43.32±2.06 on right side and 43.15±2.13 on left side. The mean

values were more in males as compared to females. The difference in values between males and females was highly significant on both sides which coincided with the studies done by Kulaksiz and Gozil[20] & Danborno and Elukpo[24] (Table 9).

In the present study, values of mean shape index not in consonance with the studies done by Kulaksiz and Gozil[20] & Danborno and Elukpo[24]. The values of shape index were more in the left hand in males and in the right hand in females (Table 9).

V. Conclusion

In present study, hand breadth was significantly greater in right hand as compared to the left indicates right handed individuals have broader right when compared to left. Whereas hand length was more in left hand as compared to right in Kashmiri Pandits indicating that activity has little effect on hand length.(table4)

In Kashmiri Pandits, left shape index was higher in men whereas right shape index was higher in women indicating that Kashmiri Pandits males have wider and coarse left hand whereas females have narrower left hand (table 6).

All the parameters were found to be sexually dimorphic in this ethnic group (table 5).

Hand preference wise investigation of all the five groups in Kashmiri Pandits shows that hand length was significantly greater in the left hand as compare with right in strong and weak right hand groups(table6) whereas in left hand preference groups displayed irregular properties.

In Kashmiri Pandits, there were no significant differences in right and left hand length values in various hand preference groups. In Kashmiri Pandits, hand breadth was significantly higher on the right side in strong right handed individuals (table 6) and in rest of the groups though the values were higher on the right side but the differences were insignificant on two sides.

Shape index value were significantly higher on the right side in strong right hand preference groups in Kashmiri Pandits (table 6 and 7) and weak right hand preference group, the values were more on the right hand preference group (table 5) and in weak right hand preference group, the values were more on right, but the difference between sides was insignificant. 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.

Thus hand preference has a potent influence on hand length, hand breadth, and shape index and environmental and genetic factors and anatomical asymmetry may play a role in determination of potency.

Left-handed groups displayed irregular characteristics with regard to all the three parameters.

1. A baseline data on hand anthropometry has been established in males and females of this endogamous group (Kashmiri Pandits) which will be helpful to anthropologists and forensic experts in cases of mass disasters for personal identification.
2. Since the mean values of hand parameters were significantly different between males and females, right handers and left handers, hence the hand tools should be designed separately to fit the males and females in this endogamous population (Kashmiri Pandits).
3. Since majority of the subjects use their right hand, it is usually found to be shorter and noticeably wider than the left hand in this endogamous group irrespective of handedness of an individual.
4. Males usually have broader and coarser hands as compared to females. In Kashmiri Pandits this is true only for the left hands. This suggests that environmental factors are also influential in hand anthropometric measurements.
5. Hand breadth and shape index were found to be greater in the right hand disrespected to preference groups in Kashmiri Pandits.
6. No significant difference in hand parameter values on right and left hand were obtained among ambidextrous subjects.
7. Left hand preference groups displayed irregular and heterogeneous characteristics with regard to hand parameters.
8. When relationship between laterality score and hand parameters was examined the values for right hand breadth, right shape index, right and left were found to be indicators of hand preference in Kashmiri pundits.

References

[1]. Choudhary S, Singh H and Gupta N. Estimation of stature from combined length of forearm and hand in jammu region of india. Internet journal of basic and applied sciences, 2014;3(1):8-10.
[2]. Dyal MR, Steyn M and Kuykendell KL. Stature Estimation from bones of South African Whites. South Afri Jr Sci;2008,104(3&4):124-8.
[3]. Krishan K. Determination of stature from foot and its segments in north Indian population. Am JR Forensic Med and Path;2008:29(4):296-303.
[4]. Barnabas D and Elukpo A. Sexual dimorphism in hand and foot length, indices, stature-ratio and relationship to height in Nigerians. Internet Jr Forensic Sci ;2008,3(1):1-10.

[5].   Jasuja OP & Singh G. Estimation of stature from and Phallenge length. J ind a\Asso Forensic Med. 2004;26(3):100-6.
[6].   Bhavna and Nath S. estimation of stature from on the bases of lower limb. Anthropologists; 2007,3:219-22.
[7].   Abdel Malek AK,Ahmad AM Sharkawi SSA and Hamid NMA. Prediction of stature from hand measurements.Forens Sc Int ;1990,46:181-7.
[8].   Bhatnager DP, Thapar SP and Batish NK. Identification of personal height from the somatometery of the hand Punjabi males. Forensic Sc int ;1984, 24:137-41.
[9].   Scyheuer JL, Elkington NM. Sex determination from matacarpals and first proximal phalanx. J Forensic sci,1993;38:769-78.
[10]. Williams TJ, Peptone ME, Christensen SE, Cooke BM, Huberman AD, Breedlove, NJ, Breedlove TJ, Jordan CL and Breedlove SM. Finger-length ratio and sexual orientation. Nature, 2000; 404-456.
[11]. Kanchan T, Kumar GP and Menezes RG. Index and ring finger ratio- a new sex determinant in south Indian population. Forensic Sci Int. 2008;181(53):153-4.
[12]. Fink B, Thanzami V, Seydel H and Mnning JT. Digit ratio and hand grip strength in Germen and Mezzos men: cross-cultural evidence for organizing effect of prenatal testosterone on strength. American Journal Of Human Biology. Oct 2006;18(6):776-82.
[13]. Oldfield RC. The assessment and analysis of handedness: The Edinburgh inventory. Neuropsycholgia.1971;(9):97-113.
[14]. Tan U. The distribution of hand preference in normal men and women. Intern Journal Neuroscience. 1987;41:35-55.
[15]. Pheasent S. Anthropometrics: an introduction. British standard institution, United Kingdom; 1990: pp 18-9.
[16]. Napier J. Hands. Prinston University Press, New Jersy;1990:25-7.
[17]. Malina RM & Buschang PH. Anthropometric asymmetry in normal and mentally retarded males. Annals of Human Biology. 1984:11(6):515-31.
[18]. Kar SK, Ghosh S, Manna I, Banerjee S & Dhara P. An investigation of hand anthropometry of agricultural workers. J. Hum. Ecol.2003;14(1):57-62.
[19]. Corey Dm, Hurly Mm & Foundas Al. Right and left handedness defined: A multivariate approach using hand preference and hand performance measures. Neuropsychology & Behavioral Neurology.2001;14(3):144-52
[20]. Kulaksiz G and Gozil R. The effect of hand preference on hand anthropometric measurements in healthy individuals. Ann Anat. May 2002; 184(3):257-65.
[21]. Oommen A, Mainker A and Oommen T. A study of correlation between hand length and foot length in humans. J.Anat.Soc. India.2005;54 (2): 55-7.
[22]. Agnihotri AK , Purwar B, Jeebun N, Agnihotri S. Determination of sex by hand dimensions. The Internet Journal Of Forensic Science.2006;1(2).
[23]. Krishan K & Sharma A. Estimation of stature from dimensions of hands and feet in north Indian population. Journal of Forensic And Legal Medicine.2007;14(2007):327-32.
[24]. Danborno B, Adebisi SS, Adelaiye AB &Ojo SA. Estimation of Height and weight from the Lengths of Second and Fourth Digits in Nigerians. The Internet Journal of Forensic Science.2009;3(2).
[25]. Ibeachu PC, Abu EC & Didia BC. Anthropometric sexual dimorphism of hand length, breadth and hand indices of university of Port-Harcourt students. Asian Journal of Medical Sciences.2011;3(8):146-50.
[26]. Krishan K, Kanchan T and Sharma A. Sex determination from hand and foot dimensions in north Indian population. J forensic sci. 2011;56(2):454-9.