

Metacarpal lengths & ratios as a marker of sexual dimorphism in population of Haryana and Jammu & Kashmir. A radiological study

Vishram Singh^a, Tarsem Kumar^{b,*}, M.K Mattoo^c

^a Dept. of Anatomy, Santosh Medical University Ghaziabad, NCR–Delhi, India

^b Santosh Medical University, Ghaziabad, NCR-Delhi, India

^c Dept anatomy Sukhmani Dental College & Hospital Dera Bassi Punjab, India

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ABSTRACT

Introduction: This study was designed to compare and detect possible differences between the metacarpal length (MCL) and all metacarpal length ratios in left - and right hands of female and male individuals of Haryanvi and J&K populations.

Materials and methods: Metacarpal lengths (MCL) of 143 subjects were measured after obtaining X-ray of both the hands, followed by calculating the ratio of each digit to the others (1MCL:2MCL, 1MCL:3MCL, 1MCL:4MCL, 1MCL:5MCL, 2MCL:3MCL, 2MCL:4MCL, 2MCL:5MCL, 3MCL:4MCL, 3MCL:5MCL, and 4MCL:5MCL).

Results: All the metacarpals can arranged according to their mean digit lengths in increasing order there to obtain formulae i.e MCL1(49.77) < MCL5(57.21) < MCL4(61.67) < MCL3(69.74) < MCL2(72.46) & MCL1 (49.40) < MCL 5(57.21) < MCL4(61.31) < MCL3(68.33) < MCL2(72.31) for right and left hands of north Indian males respectively. MCL1(45.67) < MCL5(51.81) < MCL4(56.47) < MCL3(64.26) < MCL2(66.60) & MCL1(45.42) < MCL5(51.26) < MCL4(56.09) < MCL3(63.25) < MCL2(66.21) for right and left hands of females respectively.

Discussion: Metacarpal length is known to enhance potential, particularly in sporting activities Male and females of north Indian population have difference MCL for their both the hands, hence dimorphism is established. It is especially necessary to measure metacarpal length of the hand for practical reasons. In handball and basketball, the longer is the metacarpal length, the better the accuracy of the shot or throw. Longer metacarpals may help to stabilize digits when throwing objects, and this would increase throwing accuracy. In turn, this would give more of an advantage in sporting activities.

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1. Introduction

All individuals are alike in measurable traits whether they are identical twins (homozygote) which undergoes drastic change from birth to death, in healthy state as well as diseased state, such factors has influence on skeletal development of individuals.¹

For medico legal investigations, determination of sex, statures and identity of individual from dismembered remains appeared at the site seen of mass disasters, explosions, plane crashes and holocausts (genocides). The problems encountered in such cases to conceal the identity of victims. Especially when hands and foot recovered and brought for examination, somatometric measurements of hand, osteological and radiological examinations are helpful in determination of primary factors (sex, age, and stature),

especially sexing of encountered part from such places narrow down the pool of possible victim matches.^{2,3,4} Determination of race, age and stature remain in foremost criteria in establishing population specific data based on anthropometric measurements in various population groups.⁵ Anthropometric studies on various populations came with conclusion that, even the same individuals shows different values for their right and left half of the body. This is because of effect of directionality and degree of hand preference which is functional property of hand, when we measured the hands of healthy individuals.^{6,7} Because of difference in environmental factors especially the activities of individuals and their hands, hormones, and asymmetry of brain play important role in effect of handedness and hand anthropometric measurements.⁸ Trotter & Glesser established and developed mathematical methods, use of which are still continue, their studies were based on American population groups comparisons with different statures. The basic principal used was to compare the measured part of skeleton to the equivalent in living individuals or cadavers.⁹

* Corresponding author.

E-mail address: trsmkumar2@gmail.com (T. Kumar).



Fig. 1. Showing Computerized radiographic system (Care-stream Direct View Vita CR).

Present study aimed to Provide a database for metacarpal lengths of both the hands in two populations, determining the sex of individuals from metacarpal measurements & all metacarpal lengths helpful in identifying the metacarpals of the same person, if found scattered.

2. Material and methods

Present study was carried out on 143 healthy students and employers of Haryana (35 M & 35 F) and Jammu & Kashmir (36 M & 37 F) of aged between 20 and 45 yrs; at radiology department of Shri Sukhmani Dental college and Hospital at Derabassi Pb Fig. 1. Individuals with hand anomalies affecting hand measurements were excluded. Females with pregnancy were excluded to avoid irradiating a fetus; a 'pregnancy rule' was observed carefully.¹⁰

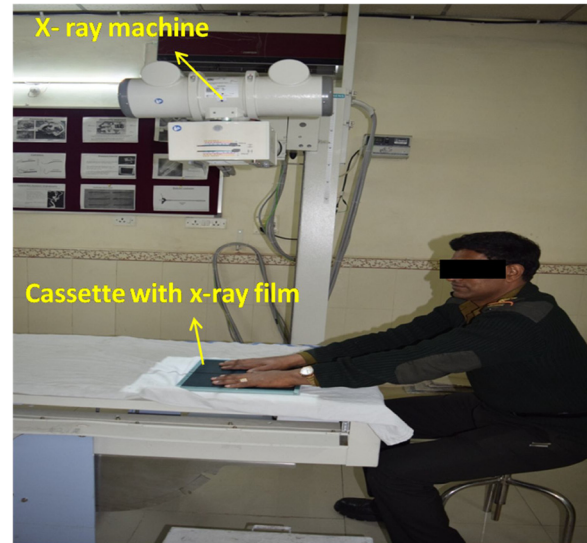


Fig. 2. Showing the positioning of hands of the subject during x-ray.

2.1. Procedure for obtaining X-ray

A Computerized radiographic system with (CPU) and X-ray machine, 500 Milli Ampere (as shown in Figs. 2 and 3, used for all the anthropometric measurements except for the body height. X-ray radiograph of both the hands done by

placing palms & the digits fully stretched touching on flat hard surface of radiographic plate and 2nd to 5th digits adducted and thumb slightly extended. The source of X-rays positioned on dorsum of hands at 100 cm distance to obtain P/A view of hands. Measurements from X- ray exported to a computer using Konica



Fig. 3. X-ray radiograph with hand measurements.

2006 MERGE eMED program which allowed us to obtain anthropometric measurements of normal skeleton of hands.¹¹

2.2. Metacarpal lengths

Metacarpal lengths are the interarticular distance was measured as the distance between the midpoint of the basis and distal tip point of all the metacarpals and phalanges^{11,12,13,14} (proximal, middle and distal) (as shown in Fig. 2). Subsequently, the ratio of each metacarpal length to the others (1 MCL:2MCL, 1MCL:3MCL, 1MCL:4MCL, 1 MCL:5MCL, 2MCL:3MCL, 2MCL:4MCL, 2MCL:5MCL, 3MCL:4MCL, 3 MCL:5MCL, and 4MCL:5MCL) was calculated. The measurements were performed by a single researcher to avoid human error.

2.3. Statistical analysis

The data obtained was recorded in MS-Excel® and subsequently analyzed. The results for continuous variables were recorded as mean ± SD. The difference between mean values of two groups was performed using unpaired *t*-test and the difference between two values of same group was performed using paired-*t* tests. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

Present study was carried out on 143 healthy students and employees from Haryana and Jammu & Kashmir of ages between 20 and 45 yrs. Metacarpal lengths (MCL) were measured after obtaining the X-ray of both the hands, followed by calculating the ratio of each metacarpal to the others (1MCL:2MCL, 1MCL:3MCL, 1MCL:4MCL, 1MCL:5MCL, 2MCL:3MCL, 2MCL:4MCL, 2MCL:5MCL, 3MCL:4MCL, 3MCL:5MCL, and 4MCL:5MCL). Metacarpal lengths of right hands show slightly higher values in males than their left hands, but; differences are insignificant. However when the values for metacarpal lengths of right and left hands of males and females were compared (Table 1), which show higher in males and difference are highly significant.

The mean values of the right metacarpal lengths show higher values for both the sexes. But, the males show higher values for both the hands than their counterpart. These differences are highly significant (Table 2) which shows the sexual dimorphism in this population.

The metacarpal length ratios showing trends in Haryanvi male and females right and left hands (Table 3); which may be useful for the determination of skeletal pattern of hand in this population.

The metacarpal length ratios showing trends in population of Jammu and Kashmir male and females right and left hands (Table 4) which might useful to determine the skeletal pattern of hand in the this population.

Table 1
Mean values of Metacarpal lengths (mm) in Haryanvi population.

Metacarpal lengths	Males	Females	pvalue
1Rt MCL	49.77 ± 3.05	45.67 ± 2.94	<0.001
2 Rt MCL	72.46 ± 2.31	66.60 ± 4.73	<0.001
3 Rt MCL	69.74 ± 2.93	64.26 ± 6.47	<0.001
4 Rt MCL	61.67 ± 2.79	56.47 ± 3.64	<0.001
5 Rt MCL	57.21 ± 2.49	51.81 ± 3.55	<0.001
1Lft MCL	49.40 ± 3.20	45.42 ± 2.83	<0.001
2Lft MCL	72.31 ± 2.90	66.21 ± 4.21	<0.001
3Lft MCL	68.33 ± 2.79	63.25 ± 4.01	<0.001
4Lft MCL	61.32 ± 2.38	56.09 ± 3.85	<0.001
5Lft MCL	57.21 ± 4.90	51.26 ± 3.66	<0.001

Table 2
Mean values of metacarpal lengths (mm) in population of Jammu and Kashmir.

Metacarpal lengths	Males	Females	pvalue
1Rt MTC	47.54 ± 2.54	43.15 ± 2.47	<0.001
2 Rt MTC	69.39 ± 3.03	63.43 ± 2.93	<0.001
3 Rt MTC	65.49 ± 3.59	60.56 ± 3.05	<0.001
4 Rt MTC	58.45 ± 3.00	53.98 ± 3.29	<0.001
5 Rt MTC	55.45 ± 3.88	50.75 ± 6.15	<0.001
1Lft MTC	47.16 ± 2.57	42.73 ± 2.18	<0.001
2Lft MTC	69.17 ± 2.72	63.24 ± 3.05	<0.001
3Lft MTC	65.80 ± 2.31	60.32 ± 3.17	<0.001
4Lft MTC	58.30 ± 2.43	53.47 ± 2.82	<0.001
5Lft MTC	55.54 ± 3.34	48.90 ± 2.20	<0.001

4. Discussion

The long bone shafts stay preserved and intact, but their epiphyses decay and damage due to overlying fragile cancellous layer of bone. Whereas, the miniature long bones viz., metacarpals and phalanges often remain complete.¹⁵ Hence, a good option for obtaining accuracy anthropometrically and radio-osteologically when measured.

Many a times, body parts, such as, a foot or a hand are brought for postmortem examinations to anthropometry and forensic medicine.³ The relations with other body parts, especially limbs are also used to establish stature and sex of a victims.⁹ Thus it becomes necessary to find the importance of metacarpal bone lengths and their relation to the stature and sex of various populations. So, in this study both the populations have higher metacarpal lengths for males than their counterpart females. Their differences are highly significant which might be used as marker of sexual dimorphism.

The findings of the present study are more or less similar to that of AlQahtani¹⁶ & Meadows¹⁷ (Table 5). The study of AlQahtani has shown same trend and similarity in metacarpal length values as in present study that is MCL 1st = 48.00 ± 4.0, MCL 2nd = 70.00 ± 4.0, MCL 3rd = 68.00 ± 4.0, MCL 4th = 62.00 ± 4.0, MCL 5th = 57.00 ± 4.0. If arranged in increasing order 1st MCL < 5th MCL < 4th MCL < 3rd

Table 3
showing all metacarpal lengths ratios of right and left hands of Haryanvi population.

All Metacarpal length ratios	Rt male Haryanvi	Lft male Haryanvi	Rt female Haryanvi	Lft female Haryanvi
1MCL:2MCL	0.686	0.683	0.685	0.685
1MCL:3MCL	0.713	0.722	0.721	0.718
1MCL:4MCL	0.807	0.805	0.808	0.809
1MCL:5MCL	0.869	0.863	0.881	0.886
2MCL:3MCL	1.039	1.058	1.052	1.046
2MCL:4MCL	1.174	1.179	1.179	1.180
2MCL:5MCL	1.266	1.263	1.290	1.291
3MCL:4MCL	1.130	1.114	1.120	1.127
3MCL:5MCL	1.219	1.194	1.220	1.233
4MCL:5MCL	1.077	1.071	1.089	1.094

Table 4
Showing Metacarpal lengths ratios of right and left hands in population of J&K.

All Metacarpal length ratios	Rt Male J&K	Lft Male J&K	Rt Female J&K	Lft Female J&K
1MCL:2MCL	0.685	0.681	0.680	0.675
1MCL:3MCL	0.725	0.716	0.712	0.708
1MCL:4MCL	0.813	0.809	0.799	0.799
1MCL:5MCL	0.857	0.849	0.850	0.873
2MCL:3MCL	1.059	1.051	1.047	1.048
2MCL:4MCL	1.187	1.186	1.175	1.182
2MCL:5MCL	1.251	1.245	1.249	1.293
3MCL:4MCL	1.120	1.128	1.121	1.128
3MCL:5MCL	1.181	1.184	1.193	1.233
4MCL:5MCL	1.054	1.049	1.063	1.093

Table 5
comparison of right and left metacarpal lengths (mm) of Haryanvi individuals and individuals of Jammu & Kashmir with the previous studies in both the sexes.

Author	Study Group	MC Length	p value				
			Males		Females		
			Right	Left	Right	Left	
Lee Meadows ¹⁷	White population	1 ST MCL	46.62 ± 3.06	46.12 ± 2.98	43.10 ± 2.92	43.01 ± 2.96	<0.001
		2 ND MCL	66.33 ± 4.02	66.47 ± 4.08	62.68 ± 4.49	62.28 ± 4.11	≤0.001
		3 RD MCL	65.02 ± 3.68	64.89 ± 3.75	61.08 ± 4.30	60.65 ± 4.20	<0.001
		4 TH MCL	57.89 ± 3.61	58.09 ± 3.73	54.62 ± 3.96	54.18 ± 3.78	<0.001
		5 TH MCL	53.01 ± 3.13	53.46 ± 3.37	49.95 ± 3.41	49.73 ± 3.36	<0.001
	Black population	1 ST MCL	49.54 ± 3.11	49.30 ± 2.80	44.22 ± 2.66	44.53 ± 2.70	<0.001
		2 ND MCL	71.20 ± 4.01	71.15 ± 4.08	65.58 ± 3.98	66.04 ± 4.25	<0.001
		3 RD MCL	70.19 ± 4.15	70.16 ± 4.21	64.38 ± 4.01	64.57 ± 3.76	≤0.001
		4 TH MCL	62.20 ± 3.66	62.30 ± 4.01	57.08 ± 3.70	56.95 ± 3.65	<0.001
		5 TH MCL	57.22 ± 3.54	57.34 ± 3.57	52.03 ± 3.17	52.30 ± 3.10	<0.001
Present study	Haryanvi population	1 ST MCL	49.77 ± 3.05	49.40 ± 3.20	45.65 ± 2.94	45.42 ± 2.83	<0.001
		2 ND MCL	72.46 ± 2.31	72.31 ± 2.90	66.60 ± 4.73	66.21 ± 4.21	<0.001
		3 RD MCL	69.74 ± 2.93	68.33 ± 2.79	64.26 ± 6.47	63.25 ± 4.01	<0.001
		4 TH MCL	61.67 ± 2.79	61.32 ± 2.38	56.47 ± 3.64	56.09 ± 3.85	≤0.001
		5 TH MCL	57.21 ± 2.49	57.21 ± 4.90	51.81 ± 3.55	51.26 ± 3.66	<0.001
	J&K population	1 ST MCL	47.54 ± 2.54	47.16 ± 2.57	43.15 ± 2.47	42.73 ± 2.18	<0.001
		2 ND MCL	69.39 ± 3.03	69.17 ± 2.72	63.43 ± 2.93	63.24 ± 3.05	<0.001
		3 RD MCL	65.49 ± 3.59	65.80 ± 2.31	60.56 ± 3.05	60.32 ± 3.17	<0.001
		4 TH MCL	58.48 ± 3.00	58.30 ± 2.43	53.98 ± 3.29	53.47 ± 2.82	<0.001
		5 TH MCL	55.45 ± 3.88	55.54 ± 2.19	50.75 ± 6.15	48.90 ± 2.20	<0.001

MCL < 2nd MCL for both hands which shows that 1st is smallest and 2nd metacarpal is longest of all the five metacarpals.

5. Conclusion

In conclusion the length ratios of metacarpals for right and left hands of males and females in both the populations can be utilized for differentiating one person from the other.

The metacarpals can also be arranged according their ascending order in both the sexes as well as same sex of both the populations Viz. 1MCL < 5MCL < 4MCL < 3MCL < 2MCL.

Conflict of interest

None

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