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Correlation of Stature with Anthropometric Measurements of Upper Limb in Himachal Pradesh

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ABSTRACT

The correlation between stature and upper limb anthropometric measurements holds significant relevance in fields such as forensic anthropology, medicolegal investigations, and reconstructive surgery. This study has been conducted on 100 students of Maharishi Markandeshwar University of Himachal Pradesh between age group 18-25 years. Measurements including arm length, forearm length, hand length, wrist circumference, and other upper limb dimensions were taken bilaterally using precise anthropometric instruments such as Stadiometer, Sliding vernier caliper, Digital vernier caliper, non-elastic thread/tape.
The results revealed significant positive correlations ($p < 0.05$) between stature and all measured parameters. Left-side measurements generally showed stronger correlations, with left wrist circumference ($r=0.697$, $r = 0.697$, $r=0.697$) and left-hand length ($r=0.669$, $r = 0.669$, $r=0.669$) being the most predictive. The study highlights the potential of upper limb dimensions as reliable predictors of stature, particularly in medicolegal and forensic contexts. The findings underscore the utility of upper limb dimensions in forensic investigations, particularly in identifying individuals from fragmented remains, and contribute to anthropometric databases for regional populations. This study establishes a robust framework for stature estimation using upper limb measurements, aiding in forensic and clinical applications.

Keywords: Anthropometry, Stature, Correlation, Upper Limb.

INTRODUCTION

Anthropometry, a fundamental tool in biological anthropology, has long been recognized for its applications in forensic sciences and continues to find increasing utility in medical disciplines, particularly forensic medicine [1]. Stature estimation, a critical aspect of personal identification, is predominantly influenced by genetic factors, though environmental, nutritional, socioeconomic, and climatic elements also play significant roles in shaping its relationship with anatomical measurements. Notably, distal limb bones are more susceptible to external stressors compared to proximal body parts, highlighting the intricate interplay of various factors on human morphology [2].

Estimating height is essential for evaluating growth patterns in children, determining nutritional indices for both children and adults, and for the prediction and standardization of various physiological parameters, including lung capacity, muscle strength, glomerular filtration rate, metabolic rate, and appropriate drug dosage adjustments in clinical settings. The principle behind stature estimation lies in the relatively consistent relationship between an individual's height and the dimensions of different body parts. Past research has employed measurements from various body segments, including upper and lower limbs as well as hand and foot dimensions, to accurately estimate stature [3].

The study of dimensional relationships between body segments and stature has been a focal point of interest for scientists, anatomists, and anthropologists for decades. Anthropometric characteristics such as age, sex, shape, and form are closely interlinked and vital for constructing a biological profile, especially in cases involving unknown, decomposed, or fragmented human remains [4].

Stature estimation from upper limb dimensions not only aids in forensic identification but also contributes to ergonomic applications, including the design of clothing, gloves, and biomedical prostheses. The integration of limb anthropometry into forensic and ergonomic fields underscores its indispensable role in both scientific inquiry and practical applications [5].

The purpose of present study is to study the correlation of stature with Anthropometric Measurements of Upper Limb in Himachal Pradesh.

MATERIALS AND METHODS

This study has been conducted on 100 students of Maharishi Markandeshwar University of Himachal Pradesh between age group 18-25 years as participants. Informed consents were taken from participants.

INCLUSION CRITERIA:

- 18-25 years of age with informed consent and having no gross structural deformity.

EXCLUSION CRITERIA:

- Subject having genetic disorder.
- Trauma/ surgery.
- Subject having congenital anomalies affecting stature or upper limb dimensions.
- Subject with endocrine causes.
- Subjects with structural deformity.

METHODOLOGY

Following instruments were used for anthropometric measurements of Stature and Upper limb.

1. Stadiometer: It is used to measure vertical height for stature estimation.
2. Sliding vernier caliper: It is used to measure hand length, palm length.
3. Digital vernier caliper: It is used to measure wrist width, palm width.
4. Non-elastic thread/tape: It is used to measure wrist circumference.

Somatometric Landmarks

1. **Acromion process-** Highest point of shoulder.
2. **Olecranon process-** Upper end of Ulna.
3. **Styloid process of Radius-** Distal end of the radius.
4. **Styloid process of ulna-** Distal end of ulna.
5. **Wrist joint–** Lower end of radius and upper part of scaphoid.

MEASUREMENTS

All measurements were taken from the right & left sides to the nearest 0.1 cm as under: -

1. Standing height(H): Height measured from the vertex to the floor bare footed in anatomical position by stadiometer [Figure 1 (A)].
2. Upper Arm Length (arm length (UAL) – distance between the acromion process of scapula and olecranon process of ulna with elbow flexed at 90 degrees & shoulder fully adducted by sliding

vernier caliper, measured in cm [Figure 1 (B)].

3. Forearm Length (forearm length (FAL) – distance between the olecranon process of ulna and radial styloid process with elbow flexed at 90 degrees by using sliding verniercaliper [Figure 1 (C)].
4. Upper extremity (upper extremity (UE) – distance between from the acromion process of scapula to the most distal point of the third finger [Figure 1 (D)].
5. Third finger length (third finger length (TFL) – distance between the most distal point of thirdfinger and proximal flexion line at base of third finger on palmar surface [Figure 1 (E)].
6. Palm length (palm length (PL) – distance between transvers flexion line of the wrist joint and proximal point of the third finger [Figure 1 (F)].
7. Hand Length (hand length (HL) – distance between distal wrist crease and tip of the middle finger and, measured in cm [Figure 1 (G)].
8. Hand width (hand width (HW) – distance between the distal end of fifth and second metacarpal bone [Figure 1 (H)].
9. Wrist width (wrist width (WW) – distance between the ulnar styloid process and radial styloid process by using digital vernier caliper [Figure 1 (I)].
10. Wrist Circumference (wrist circumference (WC) –The wrist circumference measured around the wrist using non elastic tape [Figure 1 (J)].

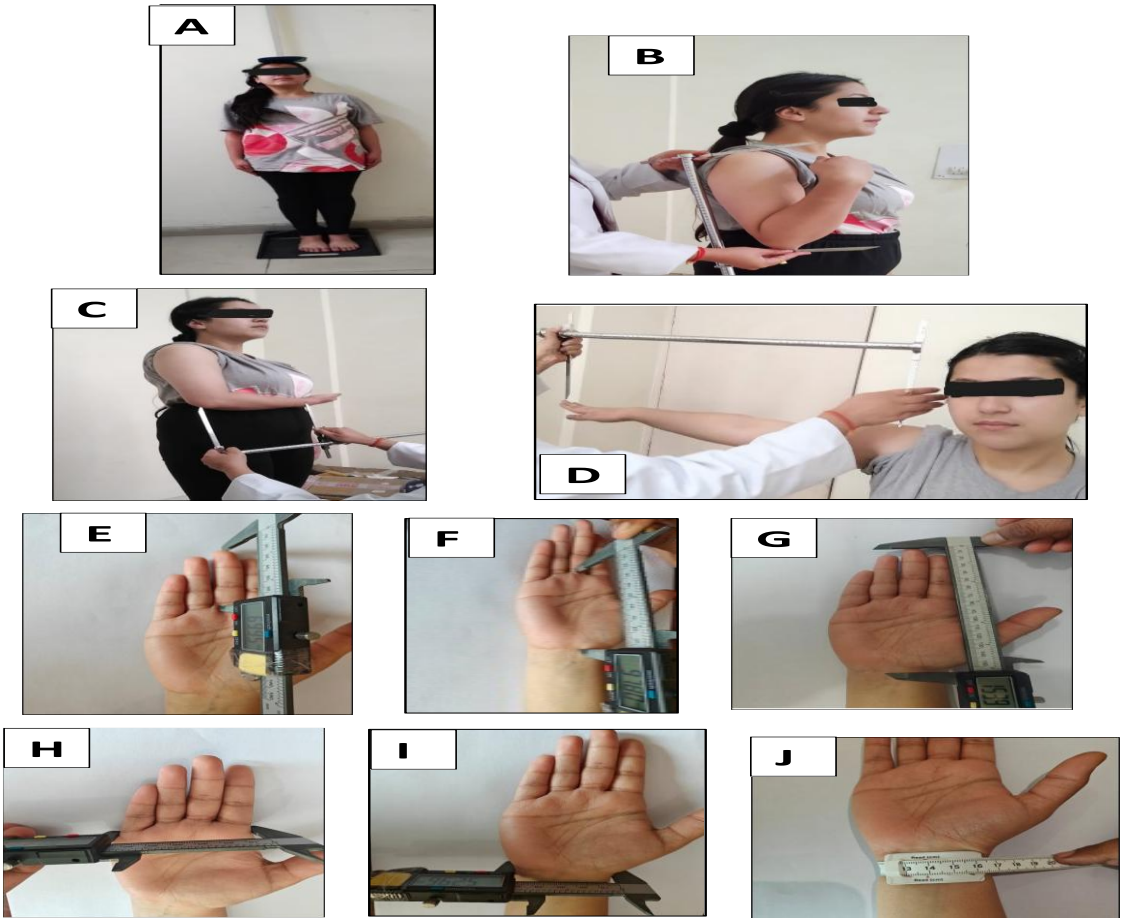

Figure 1: Various Measurements taken: (A) Stading Height (B) Arm Length (C) Forearm Length (D) Upper Extremity Length (E) Third Finger Length (F) Palmar Length (G) Hand Length (H) Hand Width (I) Wrist Width (J) Wrist Circumference.

RESULTS

Table 1: Descriptive statistic for Stature and selected anthropometric parameters of the upper limb.

Parameters	N	Mean	Std. Deviation
Standing Heights (cm)	100	164.2	9.75697
Right Arm Length (cm)	100	34.3310	3.70072
Left Arm Length(cm)	100	34.0870	3.61363
Right Fore Arm Length(cm)	100	26.3840	2.58335
Left Fore Arm Length(cm)	100	25.8360	2.03651
Right Upper Extremity Length(cm)	100	71.5430	7.89684
Left Upper Extremity Length(cm)	100	71.2750	7.78660
Right Palmar Length(cm)	100	10.1110	1.06286
Left Palmar Length(cm)	100	10.0400	1.10362
Right Third Finger Length(cm)	100	7.5520	.65605
Left Third Finger Length(cm)	100	7.5400	.67135
Right Hand Width(cm)	100	7.7040	.86116
Left Hand Width(cm)	100	7.6550	.87333
Right Wrist Width(cm)	100	6.0738	1.75019
Left Wrist Width(cm)	100	6.0342	1.71502
Right Wrist Circumference(cm)	100	15.7090	1.88348
Left Wrist Circumference(cm)	100	15.7250	1.49979
Right Hand Length(cm)	100	17.6770	1.34344
Left Hand Length(cm)	100	17.6630	1.38860

Descriptive statistics for study group in table above. Values obtained from respondents showing standing height range with mean ± SD i.e. 164.2±9.7,Arm length(right ,left) with mean ± SD i.e. 34.33 ± 3.7,34.08±3.61, forearm length(right, left) with mean ± SD i.e. 26.3 ± 2.58, 25.8 ± 2.03 Upper extremity length(right, left) with mean ± SD i.e. 71.5 ± 7.89, 71.2 ± 7.78, Palmar length(right ,left) with mean ± SD i.e. 10.11 ± 1.06, 10.04 ± 1.10, Third finger length (right ,left) with mean ± SD i.e. 7.5 ± .65 , 7.54 ± .67, Hand width(right ,left) with mean ± SD i.e, 7.7 ±.86, 7.65 ±..87 Wrist width(right ,left) with mean ± SD i.e. 6.07 ±1.75, 6.03 ±1.71 ,Wrist circumference(right ,left) with mean ± SD i.e. 15.7 ± 1. 88, 15.7 ± 1.49 and hand length with mean ± SD i.e. 17.7±1.34, 17.6±1.38 [Table 1].

Table 2: Correlations between Stature and Upper Limb measurements.

Parameters	r	P value
Right Arm Length (cm)	.410**	.000
Left Arm Length(cm)	.387**	.000
Right Fore Arm Length(cm)	.411**	.000
Left Fore Arm Length(cm)	.541**	.000
Right Upper Extremity Length(cm)	.603**	.000
Left Upper Extremity Length(cm)	.609**	.000
Right Palmar Length(cm)	.594**	.000
Left Palmar Length(cm)	.619**	.000
Right Third Finger Length(cm)	.564**	.000
Left Third Finger Length(cm)	.546**	.000
Right Hand Width(cm)	.591**	.000
Left Hand Width(cm)	.620**	.000
Right Wrist Width(cm)	.367**	.000
Left Wrist Width(cm)	.352**	.000
Right Wrist Circumference(cm)	.625**	.000
Left Wrist Circumference(cm)	.697**	.000
Right Hand Length(cm)	.660**	.000
Left Hand Length(cm)	.669**	.000

****. Correlation is significant at the 0.05 level (2-tailed).**

The table presents the correlation coefficients (r) of various anthropometric measurements with stature, indicating their predictive strength. Both right and left arm lengths show moderate correlations, with the right arm (r=0.410r = 0.410) slightly more correlated than the left (r=0.387r = 0.387). Forearm lengths exhibit moderate-to-strong correlations, with the left forearm (r=0.541r = 0.541) being a better predictor than the right (r=0.411r = 0.411). Upper extremity lengths are among the strongest predictors, with r=0.603r = 0.603 for the right and r=0.609r = 0.609 for the left. Palmar lengths also have strong correlations, with the left (r=0.619r = 0.619) slightly outperforming the right (r=0.594r = 0.594). Third finger lengths show moderately strong correlations, with the right (r=0.564r = 0.564) slightly higher than the left (r=0.546r = 0.546). Hand widths are strongly correlated, particularly for the left hand (r=0.620r = 0.620). Wrist widths have weaker correlations compared to other parameters, with the right (r=0.367r = 0.367) slightly stronger than the left (r=0.352r = 0.352). Wrist circumferences, however, are strongly correlated, especially the left wrist (r=0.697r = 0.697) compared to the right (r=0.625r = 0.625). Hand lengths exhibit strong correlations, with the left (r=0.669r = 0.669) slightly higher than the right (r=0.660r = 0.660) [Table 2]. Overall, measurements on the left side tend to show slightly stronger correlations with stature, with key predictors including left upper extremity length, wrist circumference, and hand length, while wrist widths are the least predictive.

DISCUSSION

The comparison of the present study's findings with those of previous studies conducted in various regions provides valuable insights into regional and population-specific anthropometric differences. The current study, based on a population from Himachal Pradesh, shows correlations of arm length, forearm length, and upper extremity length with stature that are consistent with findings from regions like Iran (Akhlaghi et al.) [6] and Saudi Arabia (Ahmed et al.) [1], though with slight variations. For example, the correlation of arm length with stature in the present study (r=0.410r = 0.410 for the right arm) is lower than those reported for Saudi Arabian males (r=0.684r = 0.684) and Sudanese males (r=0.698r = 0.698) [Table 3].

Forearm length in the present study (r=0.541r = 0.541 for the left side) aligns more closely with data from Turkey (Uzun et al.) [9] and Sudan but shows weaker correlations compared to Saudi Arabia (r=0.727r = 0.727). The upper extremity length correlation (r=0.609r = 0.609 on the left) is slightly lower than values reported in Madhya Pradesh (Jyothrmayi and Thaduri, 2023) [10] and Iran but remains comparable overall. Hand length and width in the present study also exhibit high correlations with stature, similar to findings from Saudi Arabia and Nigeria, though the present study records stronger associations for the left hand (r=0.669r = 0.669 and r=0.620r = 0.620, respectively) [Table 3].

Wrist circumference and palmar length in the present study are notable, with correlations (r=0.697r = 0.697 and r=0.619r = 0.619, respectively) higher than those in Turkey, indicating stronger predictive potential in the Himachal population. Interestingly, wrist width correlations in the present study are weaker (r=0.367r = 0.367 for the right side), contrasting with higher values reported in Sudan (r=0.522r = 0.522 for males) [Table 3]. These differences could stem from genetic, environmental, or lifestyle variations between populations.

Overall, the present study findings enrich the anthropometric literature, demonstrating both alignments and disparities with prior research, highlighting the influence of regional and demographic factors on body proportions. These observations underscore the importance of region-specific data for applications such as ergonomics, forensic analysis, and health assessments.

Table 3: Comparison of correlations (r) between stature and upper Limb Parameters in different populations.

Author	Year	Sex	Arm length	Forearm length	Upper Extremity Length	Hand length	Hand width	Wrist width	Wrist circum-ference	Palmar length
Akhlaghi et al. (Iran)	2012	Male	0.602	0.354	0.635	0.696	0.310	-	-	-
		Female	0.669	0.299	0.735	0.724	0.509	-	-	-
Ahmed et al. (Sudan)	2013	Male	0.698	0.725	-	0.602	0.358	0.522	-	-
		Female	0.643	0.722	-	0.615	0.431	0.327	-	-
Ugbem et al. (Nigeria)	2016	Male	0.206	0.543	-	0.609	0.583	-	-	-
		Female								
Ahmed et al. (Saudi Arabia)	2021	Male	0.684	0.727	-	0.630	0.515	0.454	-	0.581
		Female	-	-	-	-	-	-	-	-
Hussain et al. (Bangladesh)	2021	Male	-	-	-	-	-	-	-	-
		Female	0.224	0.511	-	0.220	-	-	-	-
Uzun et al. (Turkey)	2021	Male	0.497	0.486	0.675	0.339	0.248	0.317	0.675	0.303
		Female	0.575	0.549	0.768	0.309	0.260	0.314	0.572	0.310
Jyothrmayi and Thaduri (Madhya Pradesh)	2023	Male	-	-	0.722	0.488	-	-	-	-
		Female	-	-	0.637	0.480	-	-	-	-
Present Study (Himachal)	2024	Right	0.410	0.411	0.603	0.660	0.591	0.367	0.625	0.594
		Left	0.387	0.541	0.609	0.669	0.620	0.352	0.697	0.619

CONCLUSION

There is significant positive correlation ($p<0.05$) between Stature and upper limb. These Anthropometric measurements used by anatomist, forensic anthropologist, forensic pathologist, archeologist and forensic medicine investigators use them as alternative method under circumstances when difficulties are encountered in DNA analysis for economic or other reasons, such as war and mass disasters. Stature of a person is a substantial parameter in forensic inspection and anthropological studies, and the morphometry of the upper limb affords remarkable evidence in crime scene examination which helps in criminal stature' estimation. This study represents an ultimate and powerful correlation between the stature and upper limb. it will assist in medicolegal situations in establishing personal identification while only some remains of the body are found.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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