Original Article

Indian Journal of Forensic Odontology
Volume 15 Number 2, July-December 2022
DOI: http://dx.doi.org/10.21088/ijfo.0974.505X.15222.3

Anthropometric Measurement of Hand and their Correlation with Sexual Dimorphism: An Application to the Medico Legal Investigation

K Srinivasan

How to cite this article:
K Srinivasan/Anthropometric Measurement of Hand and their Correlation with Sexual Dimorphism: An Application to the Medico Legal Investigation/Indian Journal of Forensic Odontology. 2022;15(2):71–81

Abstract

Background: The estimation of the hand of human beings is a major part for constructing a biological profile that assists with the identification of an individual.

Aim and Objective: This study evaluated the predictive relationships between hand anthropometric dimensions, classified them according to Krogman Hand Index and stature to form a database.

Methods: A randomized study sample of 237 (117 males and 120 females, respectively) volunteer children aged 16-20 years (mean age 19.02) were recruited.

The Objective of the study were evaluated by an individual questionnaire data form, stature, weight, Palm, hand length, hand width, Thumb finger length, hand finger length, hand wrist circumference and hand wrist width were measured by anthropometer, stick, tape measure were estimated according to standardized protocols (International standards, millimetric) and classified according to Krogman index.

Statistical analysis: The data was carried out using SPSS version 21.0 and the data are analyzed statistically with t-Test and Two way Anova.

Results: The results indicate that in male population, the bilateral variation of hand length, hand breadth, palm length, thumb length, ring finger length and little finger length was statistically significant ($p > 0.05$).

On the other hand, in female, bilateral difference of hand length, hand breadth, palm length, index finger length, middle finger length, ring finger length, and little finger length was statistically significant ($p > 0.05$). All hand dimensions were statistically significant ($p < 0.001$).

Keywords: Hand anthropometric; Hand index; Krogman index.

INTRODUCTION

Anthropometry is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body.[1]

Anthropometric measurements vary from one population to another. The degree of access to nutrition and health services may influence the stature of the different populations around the world.[2-3]

Therefore, in the past, the researchers attempted to estimate stature from different body measurements such as foot, footprints, hand, handprint, radials and ulnas, upper limb, lower limb, lumbar vertebrae, cranium, head, and cephalometric facial dimensions etc.[4]

Stature is considered one of the main parameters

Author's Affiliations: Professor, Department of Pedodontics and Preventive Dentistry, CKS Theja Institute of Dental Sciences and Research, Tirupati 517506, Andhra Pradesh, India.

Corresponding Author: K Srinivasan, Professor, Department of Pedodontics And Preventive Dentistry, CKS Theja Institute of Dental Sciences and Research, Tirupati 517506, Andhra Pradesh, India.

E-mail: skskskpedo@gmail.com

Received on: 12.08.2022

Accepted on: 15.09.2022

among these four parameters in Forensic science. Anthropometry, measurement of human body, is an individual tool to estimate the stature of the living individuals.[4]

Stature is an important descriptive characteristic of an individual. Living stature cannot be measured directly in archaeological populations and thus must be estimated by bone. Current stature estimation formulae cannot be used with archaeological populations because the relationships between stature and the length of the various bones used in estimation differ among races and populations. Similarly, secular change in stature makes the use of formulae derived from modem populations on archaeological group's problematic.[5]

Anatomical methods of estimating stature account for the skeletal elements that contribute to an individual's height and provide an estimate of the soft tissue component of stature. These methods give results very close to properly recorded living statures. In populations for which recorded statures or cadaver lengths are unavailable, anatomically estimated statures can be substituted for living statures for the purpose of creating stature estimation formulae.[6]

Anthropometric approaches of the hand and handprint measurements in Forensicinvestigations have been widely demonstrated.[7]

The hand is presented in a large area in cerebral cortex and controlled by a rich nerve network and it is like a psychologic, physiologic, and aesthetic extension of the brain. The hand has a few important functions like perception, management, and self-expression.[8]

The correlation between stature and various hand dimensions such as hand length, hand breadth, palm length, thumb length, index finger length, middle finger length, ring finger length, little finger length has been reported in previous studies. This motivates the Anatomist, Ergonomist and Forensic science researchers to estimate body height from hand dimensions.[9-11]

Zulkifly et al., (2018) found a strong positive correlation ($p < 0.05$) between handprint dimensions and stature on Iban subjects in both sexes. ***Zulkifly et al.***, reported the handprint length as the most reliable estimator of stature; the correlation coefficient between stature and handprint length was ranged between + 0.59 and +0.68.12

Hence, the purpose of this study is to analyze the hand anthropometric data of participants between the ages of 16 to 20 years.

MATERIALS AND METHODS

Aims and objectives

The aims of the study are:

- To provide authentic database on hand measurements in males and females.
- To study correlation of hand anthropometric measurements of both hands.

Research design

This study was a correlational survey of the interface of hand anthropometrics among different gender. Subjects were selected irrespective of their caste, religion, dietary habits, and socio-economic status.

Demographics of the Sample[13]

Demographic information in the form of questionnaire was taken from each subject.

The population for this study included biological ages between 16 to 20 years (mean ± standard deviation: 19.02 ± 2.00) in the 2021-2022.

Age of participants was recorded from their academic records. Body mass was measured to the nearest 0.1 kg by a digital balance (Digital-best India weighing scale).

The Body mass index (BMI) was calculated using formula: [13]

$$BMI\ (kg/m^2) = Wt\ (kg)/Ht^2\ (m).$$

The subjects were examined in terms of stature, Fingers Length, wrist breadth and hand breadth in the right and left side.

Sample size and sampling technique[14]

Before carrying out of the experiment, a power analysis was performed to identify the sample size required to detect significant effects accurately. They were excluded in the present study.

Twenty hand measurements were selected for power analysis and analyzed using the chi square test procedure, where measurements were taken by two investigators. The results of the analysis indicated that all the measurements were reproducible with no significant intra and inter-observer discrepancies.

The Sample Sizes for Two Independent Samples, Dichotomous Outcome for the study was determined by fixing the probability of type I error at 5% and that of type II error at 20%.

Thus, Sample size was predicted using 80%

power at the 5% level of significance in accordance with standard statistical protocol.[13]

$$n \text{ (sample size)} = \{P_1(1-P_1) + P_2(1-P_2)\} (Z/E)^2$$

Were,

P_1 and P_2 are the proportions of successes in each comparison group. The values of P_1 and P_2 that maximize the sample size are

$$P_1 - P_2 = 0.5.$$

n – Sample size

$$Z = 1.96 \text{ (for 80\% power).}$$

E is the desired margin of error (4%).

$$\Sigma \text{ – Standard deviation} = 2.82.$$

Hence, n = 107

This study involved 237 consented healthy children as subjects (117 males and 120 females respectively).

Sampling technique: This is a retrospective cross-sectional, stratified randomization method study.

Inclusion criteria[15]

- Apophyses were completely fused to the vertebral bodies.
- No degenerative changes affecting the length or heights of any element.
- Right handed and non-athletic (i.e., right hand is the dominant hand).

Exclusion criteria [15]

- Pathologies that affected stature (kyphosis of the spine, extensive degeneration of the vertebral bodies, etc.).
- Any apparent hand, limb.
- Left handed persons.
- Metabolic and/or developmental disorders.
- Poorly defined wrist creases.
- Presence of any diseases and/or injuries that may affect stature and hand morphology.

Informed consent

Subjects were provided with the information sheet and requested to sign a consent formalong their parents (in case of minor), prior to conducting the measurement.

The nature and underlying principle of the study were explained to the subjects followed by obtaining written informed consent in vernacular language.

None of the subjects participating in the study was coerced in any way or rewarded for their involvement. Their right to withdraw- if so desired at any stage of the study was also stated clearly to them. To ensure the confidentiality of the data, the crude data as well as responses from the questionnaire were destroyed upon completion of this research.

Research Strategy

Stadiometer calibrated in centimeters, weighing scale, digital sliding caliper (300 mm), Gloves, Permanent markers, Anthropometric proforma containing the participants' demographic data.

Stature measurement

Following the protocol prescribed by ***Gordon et al.***[16] the living height (stature) of each subject was measured using a Portable Stadiometer Seca 213.

A stadiometer is a piece of medical equipment used for measuring human height. It is usually constructed out of a ruler and a sliding horizontal headpiece which is adjusted to rest on the top of the head.

Stature is the person's natural height in an upright position.

The subject was instructed to stand on the board of a standard stadiometer with both feet in close contact with each other, trunk braced along the vertical board, and head oriented in ear–eye plane by keeping the lateral palpebral commissure and the tip of auricle of the pinna in a horizontal plane parallel to the feet. The measurement was taken millimeters by bringing the horizontal sliding bar to the vertex.

The vertex is defined as the highest point on the skull when the head is held in the Frankfort plane.

Somatometric measurements (in mm) of Hand.

In each subject,[9] hand anthropometric measurements were recorded on each hand using avernier caliper stainless steel Composites Digital Vernier Calliper with LED Screen 6 inch) and (whenever required) a measuring tape.

A vernier calliper is defined as A measuring device that is used for the measurement of linear dimensions. It is also used for the measurement of diameters of round objects with the help of the measuring jaws.[17-18]

The anthropometric measurements were followed by the study of Moorthy and Yin (2016).[19]

Table 5, Fig. 1 depicts Definition of hand measurements.[20]

Hand anthropometric measurements in millimeter (hand length, hand breadth, palm length, thumb length, index finger length, middle finger length, ring finger length, and little finger length) were measured by using a digital slide caliper in accordance with the conventional technique.

To take the hand measurements, the subject was placed their hands on a flat horizontal surface in an abducted position of the thumb and in the extended position of the other fingers.

Each measurement was repeated thrice, and the mean value was recorded to minimize inter-observer errors.

Intra-observer error was determined to be within accepted standards for all measurements (R > 0.9; r TEM < 5%).

Hand Index

The length and width of the right hand of the children were taken after their height and weight were measured. The results were recorded as mm. The results were calculated according to the formula and classified according to standard Krogman Index. (Table 3-4)[19]

$$\text{Hand Index} = \frac{Hand\ with \times 100}{Hand\ length}$$

The palmar index, also known as the hand index, is described as the ratio between the hand breadth and the hand length multiplied by 100.

Data Processing and Statistical Analysis[20]

The obtained data were computed and analyzed with SPSS 21.0 software. After the calculation of descriptive statistics, sex specific and bilateral differences of hand measurements were evaluated using a paired sample t-test.

RESULTS AND DISCUSSIONS

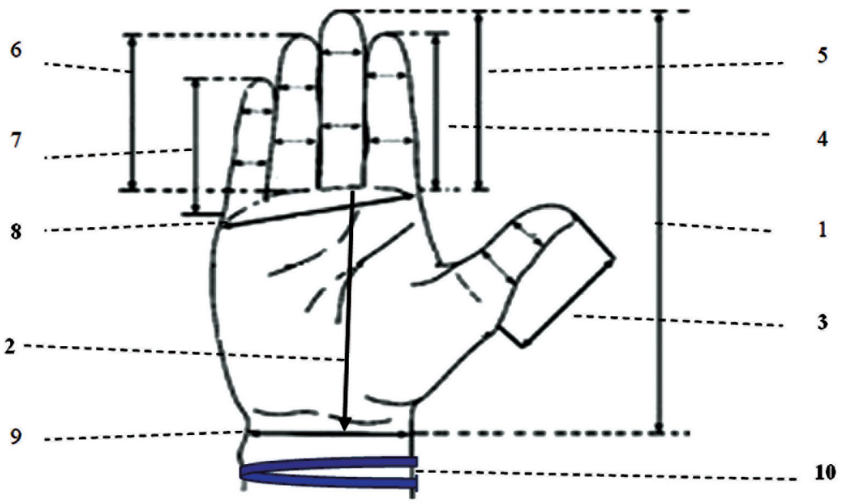
Identification is the determination of individuality of a person based on certain physical characteristics i.e., exact fixation of the personality.[21]

The estimation of sex is considered as one of the important parameters in the identification of a person. This fact has been utilized by many forensic scientists in the estimation of gender using body parts or skeletal remains.[22]

The descriptive statistics for age weight stature and, BMI in both males and females are shown in table 1, 2.

In this cross-sectional descriptive study, an attempt was made to estimate of a person by hand length, hand breadth and length of middle finger of both sides. Males and females aged between 16 to 20 years, were included.

The results of present study were comparable with the previous studies conducted by Abdul-*Malek et al.*[23], *Jasuja*[24] and Krishan and Sharma[25] all of them have observed that the mean stature



Note

1. Palm Length
2. Hand length
3. Thumb Length
4. Index Length
5. Middle Finger Length
6. Ring Finger Length
7. Little Finger Length
8. Hand Breadth
9. Wrist Width
10. Hand Circumference

was greater in males than females.

The mean stature found by different authors in India in different regions or states is slightly different and this can be explained by the different genetic constitution, environmental factors, and nutrition in different population groups.[26]

In L.L. Lloyd and T.M.C. John's, (1967) research on mean age of 20.44±3.89 years 117 male subjects which was in in par with the present study.[27]

There were statistical differences between males and females as regards age where p<0.0001

The mean male stature measured was 169.7 ± 5.2 and the mean female stature was 155.6 ± 13.9. A statistically significant difference was found between males and females as regard stature where p<0.0001

Table. 4 shows the distribution of Hand index among the participants' right hands was found to be higher in men and their difference was found to be statistically highly significant difference between the groups, though numerically, mesocheri predominate in most cases?

Table. 5 shows the analysis of variance (ANOVA) of the hand dimensions and Hand Index. There was significant difference between the right and left hand length and breadth in both genders. The male participants had higher hand dimensions than the female participants where p< 0.0001 for all measurements.

The overall means of hand length was 179.0mm (186.2 mm for males and 161.9mm for females).

In addition, the average of hand breadth (four fingers) was 82.2 mm (87.5 mm for males and 76.9 mm for females).

The measurement results of hand in the current study were close to the anthropometric measurements of ***M.J. Wang et al.***[28], but with the study done by Tarsem et al.[29] was not in favor of the present study.

Means ***L.W et al.*** they found that dominant right hand's length value is higher than their left hands' which was in par with the present study.[30]

In the current study, the result of hand breadth (four fingers) was consistent with the findings which suggested that approximately 95% of participants were below 100 mm which was in par with the study done by ***V. Putz-Anderson***.[31]

Our study is in accordance with the study conducted by ***Ishak et al.,***[32] in which they reported that bilateral variation was statistically significant for hand breadth only.

Limitations

- The difference in the hand dimensions

Table 1: Social-demographic variables of respondents

Individual scenario			
Variables	**Respondents**	**ANOVA (Inference)**	
		Frequency (n)	**Response rate (%)**
Total number of respondents		237/240	98.75
Gender	Male	117	50.00
	Female	120	51.28
Age group	16–20 years	19.02 ± 2.00	

Data Source: Field work, 2022

Table 2: Descriptive and inferential statistics of participants' pooled stature.

Individual scenario					
Variables	**Respondents**		**ANOVA (Inference)**		
	Gender	**Range**	**Mean ± SD Comparisons**	**Z Score Comparison**	**Inferential Statistics**
Stature (cm)	Male	162 to 176.5	169.7 ± 5.2	-9.9	p< 0.0001 HS*
	Female	152 to 161	155.6 ± 13.9	-2.4	p=0.0111 SS*
Weight (Kg)	Male	53 to 79.8	65.8 ± 7.9	6.4	p< 0.0001 HS*
	Female	49 to 72.6	60.8 ± 6.7	8.7	p< 0.0001 HS*

BMI (kg/m^2)	Male	16.7-37.6	24.2 ± 1.1	84.2	p< 0.0001 HS*
	Female	16.3-68.4	22.05 ± 1.0	97.9	HS*

BMI formula:

Weight in pounds = 5 x BMI + (BMI divided by 5) x (Height in inches minus 60)
Weight in kilograms = 2.2 x BMI + (3.5 x BMI) x (Height in meters minus 1.5)

Citation: Mudasir Ahmad Khan & Sunanda Raina. Anthropometric Measurement of Hand Length, Hand Breadth and Length of Middle Finger and Their Correlation with Stature in J & K Population Sch J App Med Sci2020; 8(9): 1985-1993.

Data Source: Fieldwork, 2022.

Note: Significance level p< 0.0001, *Significant; HS: Highly significant.

Table. 3 Anthropometric Dimensions Hand Index

Hand Index (HI). International Descriptions Standart Krogman Index Hand types based on Hand index	
Hand shape	Hand index (Range) %
Hyperdolichocheri	≤40.9
Dolichocheri	41.0-43.9
Mesocheri	44.0-46.9
Brachycheri	47.0-49.9
Hyperbrachycheiri	≥ 50.0
Hand Index=Hand width/Hand length x 100 (Standart Krogman Index)	

Citation: Nuriye Kübra Bayraktar, Esin Özşahin. Anthropometric measurement of the hand. East J Med 2018; 23 (4):298-301

Table 4: Descriptive and inferential statistics of Hand phenotypes

Individual scenario(n=237)											
Variable's	**Responses**								**ANOVA (Inference)**		
	Male (n=117)				**Female (n=120)**						
	Hand				**Hand**						
Hand phenotypes	**Right n (%)**	**Right Hand Index (f)%**	**Left n (%)**	**Left Hand Index (f)%**	**Right n (%)**	**Right Hand Index (f)%**	**Left n (%)**	**Left Hand Index (f)%**	**Total (n = 474)**	**χ2 Test**	**Inferential Statistics (p value)**
Hyperdolichocheri ≤ 40.9	15 (12.8)	40.3	15 (12.8)	40	13 (10.8)	37.3	12 (10)	38.3	55 (11.6)		p< 0.0001 HS*
Dolichocheri 41.0-43.9	24 (20.5)	43.5	22 (18.8)	42.2	21 (17.5)	41.09	32 (22.6)	41	99 (20.8)		p< 0.0001 HS*
Mesocheri 44.0-46.9	33 (28.2)	46.2	31 (26.4)	45.1	36 (30)	44.4	31 (25.8)	43.5	131 (27.6)	26.4 df=4	p< 0.0001 HS*
Brachycheri 47.0-49.9	22 (18.8)	49.1	21 (17.9)	48	33 (27.5)	47.6	26 (21.6)	47.5	102 (21.5)		p< 0.0001 HS*
Hyperbrachycheiri ≥ 50.0	23 (19.6)	53.6	28 (23.9)	50.5	17 (14.1)	50.6	19 (15.8)	49	87 (18.3)		p< 0.0001 HS*

Citation: Nuriye Kübra Bayraktar, Esin Özşahin. Anthropometric measurement of the hand. East J Med 2018; 23 (4):298-301.
Data Source: Fieldwork, 2022.
Note: Significance level p< 0.0001, *Significant; HS: Highly significant.

Table 5: Definition of hand and handprint measurements

Hand dimensions and designated labeling	Definition
Palm length (PL)	The distance from the mid-point of the distal transverse crease of the wrist to the proximal flexion crease of the middle finger.
Hand length (HL)	The distance from the middle of inter stylion to the tip of middle finger.
Thumb Length (TL)	The distance from the tip of the thumb to the border crease with the palm.
index Finger Length (IFL)	The distance from the tip of the index finger to the border crease with the palm.
Middle Finger Length (MFL)	The distance from the tip of the middle finger to the border crease with the palm.
Ring Finger Length (RFL)	The distance from the tip of the ring finger to the border crease with the palm.
Little Finger Length (LFL)	The distance from the tip of the little finger to the border crease with the palm.
Hand breadth (HB)	The distance between the most lateral point on the head of the 2ndmetacarpal to the most medial point on the head of the5th metacarpal.
Wrist width (WW)	The distance between the radial styloid process and ulnar styloid process.
Hand circumference (HC)	Wrist circumference was measured around the wrist using a non-elastic tape measure.

Citation: Jee SC, Yun MH. Estimation of stature from diversified hand anthropometric dimensions from Korean population. J Forensic Leg Med. 2015; 35:9–14.

between both genders may be explained to the late occurrence of maturity in males who have up to two more years of physical development compared to their female counter parts.

- This hand dimensions differences could stem from geographical and population variations. Population variations are reported in anthropologically related studies and could be considered in further studies.
- Other factors reported to influence body dimensions include locomotor pattern, lifestyle, and ability expenditure.
- The major limitation of this study is sample size.
- The models achieved in this study were based on adult sample and are not applicable for juveniles.

CONCLUSION

The study found smaller hand dimensions in females as compared to males as well as a statistically significant relationship between right hand dimensions and gender estimation. This finding can be applied in medicolegal contexts.

Recommended

It is recommended that further studies should take into consideration the handedness of the participants.

Conflict of interest & source of funding

The author declares no exceptional financial support for this research work from the funding agency, and there is no conflict of interest nor bias among the authors.

Ethical disclosures

- Protection of human and animal subjects: The authors declare that no experiments were performed on humans or animals for this study.
- Confidentiality of data: The authors declare that no patient data appear in this article.
- Right to privacy and informed consent: The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author owns this document.

Table 6: Descriptive and inferential statistics in Stature estimation of hand dimensions

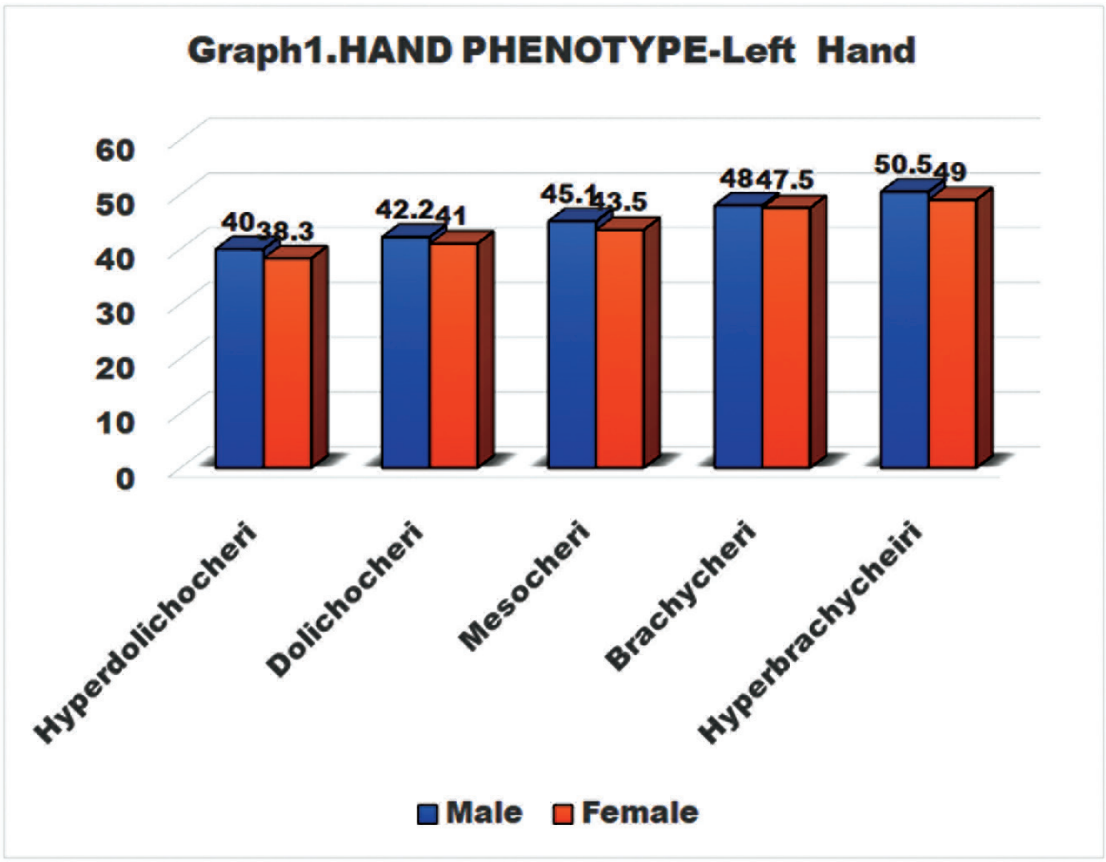
Individual scenario								
Variables (mm)	ANOVA (Inference) Male				ANOVA (Inference) Female			
	Dominant Hand		Z Score	Inferential	Dominant Hand		Z Score	Inferential
	Right hand	Left hand	Comparison	Statistics	Right hand	Left hand	Comparison	Statistics
	Mean ± SD Comparisons	Mean ± SD Comparisons		(p value)	Mean ± SD Comparisons	Mean ± SD Comparisons		(p value)
Palm Length	108.05 ± 3.9	107.82 ± 0.54	51.7 df=0.3	p< 0.0001 HS*	99.3 ± 3.1	98.9 ± 3.2	42.1 df=1.4	p< 0.0001 HS*
Hand Length	187.5 ± 3.5	185.01 ± 1.4	16.16 df=2.9	p< 0.0001 HS*	172.6 ± 6.5	171.2 ± 6.0	10.95 df=	p< 0.0001 HS*
Thumb Length	61.1 ± 5.4	60.0 ± 0.2	41.41 df=0.4	p< 0.0001 HS*	57.8 ± 1.8	56.02 ± 1.4	83.2 df=1.6	p< 0.0001 HS*
Index Length	69.4 ± 0.6	68.8 ± 0.4	289.14 df=0.9	p< 0.0001 HS*	65.3 ± 3.6	63.0 ± 6.03	35.67 df=1.3	p< 0.0001 HS*
Middle Finger Length	73.3 ± 0.8	75.7 ± 0.3	179.6 df=0.2	p< 0.0001 HS*	71.4 ± 0.5	69.6 ± 1.07	137.3 df=1.5	p< 0.0001 HS*
Ring Finger Length	71.08 ± 2.0	70.08 ± 0.4	104.08 df=1	p< 0.0001 HS*	66.7 ± 2.0	65.3 ± 1.1	80.5 df=0.4	p< 0.0001 HS*
Little Finger Length	65.3 ± 0.7	64.4 ± 0.6	228.6 df=0.5	p< 0.0001 HS*	60.0 ± 0.5	59.8 ± 0.4	400.2 df=0.2	p< 0.0001 HS*
Hand Breadth	88.2 ± 1.2	86.8 ± 0.4	127.1 df=1.3	p< 0.0001 HS*	77.4 ± 2.4	76.4 ± 1.08	86.01 df=1	p< 0.0001 HS*
Wrist Width	187.5 ± 5.4	185.3 ± 4.7	9.4 df=1.7	p< 0.0001 HS*	179.7 ±2.4	177.6 ± 0.4	28.6 df=1.1	p< 0.0001 HS*
Hand Circumference	217.9 ± 1.07	216.9 ± 0.2	20.2 df=1.5	p< 0.0001 HS*	176.02 ± 0.6	174.6 ± 0.7	71.3 df=1.6	p< 0.0001 HS*

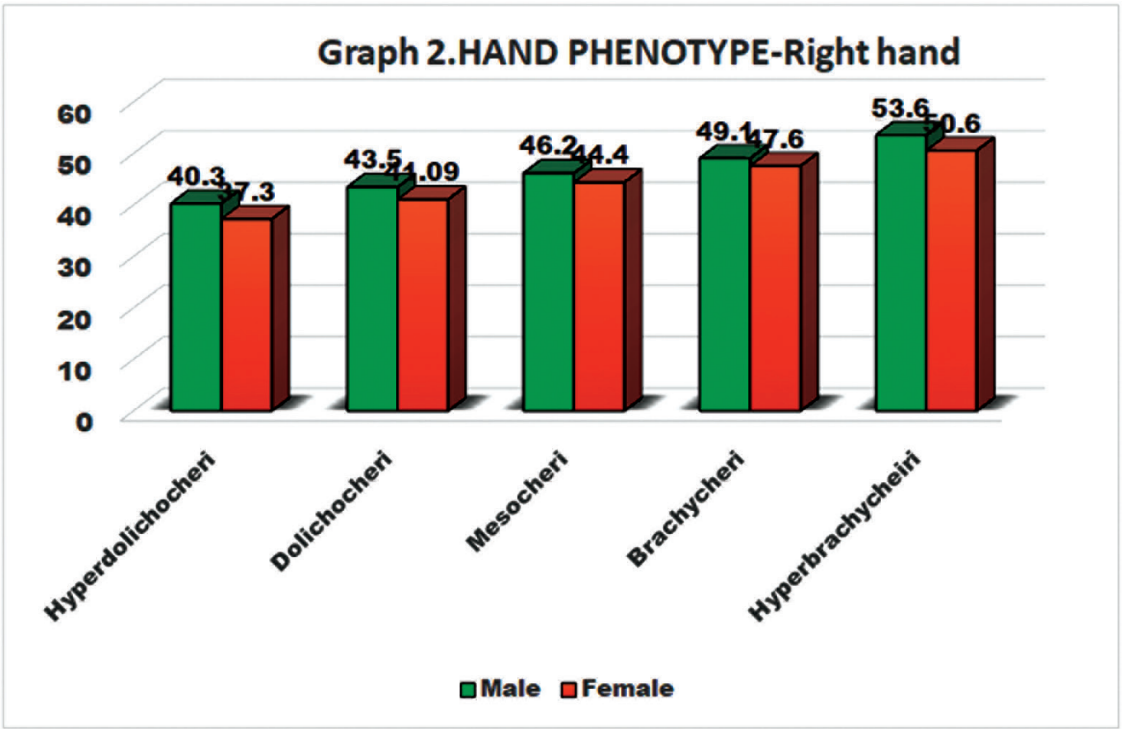
Citations: Ubulu L U, Babatunde L B, Ebukhaile, Racheal O, Adunfe O O, Ibeabuchi N M. Predictive Modelling of Stature from percutaneous Anthropometric Hand Dimensions of

Adolescent Nigerian School Children. J Forensic Sci & Criminal Inves. 2020; 14(5): 555897.

Data Source: Fieldwork, 2021

Note: Significance level p< 0.0001, *Significant; HS: Highly significant





ACKNOWLEDGEMENT

All the authors express sincere gratitude to all respondents whose honest attention, help, support, and study participants lead the Research project to a worthful outcome.

REFERENCES

1. Ibegbu AO, David ET, Hamman WO, Umana UE, Musa SA. Association of hand length with height in Nigerian school children. J Biol Life Sci 2013; 4:83-94.
2. M, Molla MBA, Noman SNA Stature estimation from handanthropometric measurements in Bangladeshi population. J Forensic LegMed 2019; 65:86-91.
3. Asadujjaman M, Rashid MHO, Rana MS, Hossain MM Stature estimationfrom footprint measurements in Bangladeshi adults. Forensic Sci Res 2020; b:1-8.
4. Zhang K, Chang YF, Fan F, Deng ZH. Estimation of stature from radiologic anthropometry of the lumbar vertebral dimensions in Chinese. Leg Med. 2015; 17:483-488.
5. Colmenares GG, Medina CS, Baez LC. Estimation of stature by cephalometric facialdimensions inskeletonized bodies: study from a sample modern Colombians skeletal remains. Forensic Sci Int 2016; 258 101.e1-e6.
6. Shrestha R, Shrestha PK, Wasti H, Kadel T, Kanchan T, Krishan K. Carniometricanalysis for estimation of stature in Nepalese population-a study on an autopsy sample. Forensic Sci Int. 2015; 248 187.1-e7.
7. Tang J, Chen R, Lai X. Stature estimation from hand dimensions in a Han population of Southern China. J Forensic Sci 2012; 57(6):1541-1544.
8. Reel S, Rouse S, Vernon W, Doherty P. Estimation of stature from static and dynamic footprint. Forensic Sci Int. 2012; 219(1-3) 283e1-e5.
9. Jee SC, Yun MH. Estimation of stature from diversified hand anthropometric dimensions from Korean population. J. Forensic Leg. Med. 2015; 35:9-14.
10. Paulis MG. Estimation of stature from handprint dimensions in Egyptian populationJ. Forensic Leg. Med. 2015; 34:55-61.
11. Rastogi P, Nagesh KR, Yoganarasimha K. Estimation of stature from hand dimensions of north and south Indians. Leg Med. 2008; 10(4):185-189.
12. Zulkifly N-R, Wahab RA, Layang E, Ismail D, Desa WNSM, Hisham S, Mahat NA Estimation of stature from hand and handprint measurements in Iban population in Sarawak, Malaysia, and its applications in forensic investigation. J Forensic Legal Med 2018; 53:35-45.
13. Sajjad Rostamzadeh, MahnazSaremi, Shahram Vosoughi, Bruce Bradtmiller, Leila Janani.Ali Asghar Farshad and Fereshteh Taheri. Analysis of hand-forearm anthropometric components in assessing handgrip and pinch strengths of school-aged children and adolescents: a partial least squares (PLS) approach. BMC Pediatrics 2021; 21:39-44.
14. Van Belle G. Statistical Rules of Thumb. 1st ed. New York,NY: Wiley Interscience. 2002. 248 -52.
15. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Stat Med. 1998; 17:101-10.
16. Gordon C, Chumlea W, Roche A. Stature, recumbent length, and weight. In: LohmanT, Roche A, Martorell R, eds. Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics Books; 1991:3-8.
17. Maryna Kornieieva1, Azza H. Elelemi. Estimation of Stature from Hand Measurements and Handprints in a Sample of Saudi Population Arab Journal of Forensic Sciences & Forensic Medicine 2016; Volume 1 Issue (3), 289-298.
18. Weiner, J.S., Lourie, J.A. (Ed.).1988, Practical Human Biology. Academic Press. London.
19. Moorthy TN, Yin TY () Estimation of stature from handprint anthropometry of Malaysian Chinese for forensic investigation. Indones J Leg Forensic Sci 2016; 6:1-5.
20. Ibeachu PC, Abu EC, Didia BC. Antropometric Sexual Dimorphism of Hand Length, Breath, and Hand Indices of University of Port-Harcout Students. Asian journal of medical Sciences 2011; 3: 146-150.
21. Md Asadujjama, Md. Babor Ali Molla, Sk. Nahid Al Noman Stature estimation from hand anthropometric measurements in Bangladeshi population. Journal of Forensic and Legal Medicine 2019; 65: 86-91.
22. Ulijaszek S, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Brit J Nutr 1999; 82: 165-177.
23. 23=Abdul-Malek AK, Ahmed AM, EL-Sharkawi SA and EL-Hamid NA. Prediction of stature from hand measurements. Forensic Science International 1990; 46: 181-187.
24. Jasuja OP and Singh G. Estimation of stature from hand and phalange length. Journal of Indian Academy of Forensic Medicine. 2004; 26(3): 100- 106.
25. Krishan K and Sharma A. Estimation of stature from dimensions of hand and feet in a North Indian population. Journal of Forensic Legal Medicine 2007; 14(6): 327-332.
26. Lloyd, L.L, John, T.M.C. Notes on Anthropometric Technique: Anthropometric Measurements-Right and Left Sides. American Journal of Physical Anthropology, 1967; 26: 367-370.
27. Krishan K, Kanchan T, Sharma A. Multiplication factor versus regression analysis in stature estimation from hand and foot dimensions. Journal of forensic and legal medicine. 2012;19(4):211-4.
28. M.J. Wang, M.Y. Wang, and Y.C. Lin, The

Anthropometric Database Manual of Taiwan (Hsinchu: Ergonomics Society of Taiwan, 2002).

29. K. Tarsem, S. Vishram, M.K. Mattoo, S.G. Sunil, Effect of hand preference on hand length, handbreadth and shape indices and its role in sexual dimorphism: a study in 300 Kashmiri Pandits, IOSR J. Dental Med. Sci 2015;14 (3) :10-16.
30. Means L.W., Walters, R.E.,1982, Note Sex, Handedness and Asymmetry of Hand and Foot Length. Neuropsychologia2015; 20(6): 715-719.
31. V. Putz-Anderson, Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limb (Taylor and Francis, London, England, 1988).
32. Ishak NI, Hemy N and Franklin D. Estimation of stature from hand and handprint dimensions in a western Australian population. Forensic Science International 2012; 216(1-3): 199e1-7.