

Stature estimation from the hand dimensions in the Eastern Saudi Arabian adult male population

Mohammed Madadin, Ritesh G. Menezes

Department of Pathology, College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Abstract. *Background and aim:* Anthropometry is widely used in preliminary forensic investigations involving the identification of unknown dismembered body parts. Stature estimation is an important indicator of forensic identification considered during such initial investigations. Different populations have different body sizes and proportions that affect the forensic anthropometric estimation of stature. Hence, the need for population-specific databases and analyses. The present study was conducted with the objective of estimating stature from the hand dimensions in the Eastern Saudi Arabian adult male population. *Methods:* The present study included 200 Eastern Saudi Arabian males aged from 20 to 56 years. Stature and hand dimensions of hand length, palm length, and hand breadth were measured as per standard anthropometric procedures. Linear and multiple regression equations were derived to estimate stature from the aforementioned hand dimensions. *Results:* Correlation coefficients between stature and the aforementioned hand dimensions were found to be statistically significant. The hand length and palm length showed higher correlation coefficients than the hand breadth. Single variable linear regression and multi-variable linear regression equations were derived to estimate stature from the hand dimensions. Higher correlation coefficients were obtained for multi-variable linear regression than single variable linear regressions. *Conclusions:* In conclusion, hand dimensions can be used as a reliable predictor to estimate stature in the Eastern Saudi Arabian adult male population. (www.actabiomedica.it)

Key words: forensic anthropology, hand anthropometry, hand dimensions, stature estimation, regression equation, Saudi Arabia

Introduction

Anthropometry is widely used in preliminary forensic investigations involving the identification of unknown dismembered body parts. Stature is one of the important indicators of forensic identification considered during such initial investigations (1–4). Different populations have different body sizes and proportions that affect the forensic anthropometric estimation of stature (5, 6). Hence, the need for population-specific databases and analyses.

Previously published research on forensic anthropometry of the hand has been focused on different

populations worldwide. These studies have demonstrated that stature can be estimated from various hand dimensions. Ishak et al. assessed the significance of using anthropometric hand measurements for the estimation of stature in a Western Australian adult population (7). The hand length and breadth were evaluated for stature estimation in an adult Sudanese population by Ahmed (8). Various researchers have assessed the significance of utilizing different anthropometric hand measurements for stature estimation in adult Indian populations (9, 10). Similar studies are also conducted on the Chinese, Egyptian, Korean and Slovak populations (11–14).

Saudi Arabia is a vast country that occupies most of the Arabian Peninsula in the Middle East. Although much literature on stature estimation exists internationally, there is a lack of research on stature estimation from body dimensions conducted in Eastern Saudi Arabia. Further, such population-specific anthropometric studies on hand dimensions in the Eastern Province of Saudi Arabia are yet to be published. The objective of the present study was to estimate stature from hand dimensions estimation in the Eastern Saudi Arabian adult male population.

Materials and methods

Ethical approval to undertake this research was obtained from the Institutional Review Board (IRB) of Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia (IRB-2014-01-014). The subjects included in the present study were 200 adult males of

Saudi origin residing in the Eastern Province of Saudi Arabia, aged 20 years and above. This study was conducted in the Dammam region (Dammam, Dhahran, and Khobar) of the Eastern Province of Saudi Arabia. Stature and hand dimensions of hand length, palm length, and hand breadth were measured as per standard anthropometric procedures.

Stature was measured as the vertical distance from the floor with the feet of the subject on the flat, horizontal floor to the vertex on the top of the head with the head of the subject held in the Frankfurt horizontal plane. The length of the right hand was measured as the linear distance from the mid-point of the distal transverse flexion crease of the right wrist to the distal-most point corresponding to the tip of the right middle finger (Figure 1).

The length of the right palm was measured as the linear distance from the mid-point of the distal transverse flexion crease of the right wrist to the mid-point of the proximal-most flexion crease at the base of the right middle finger (Figure 2).

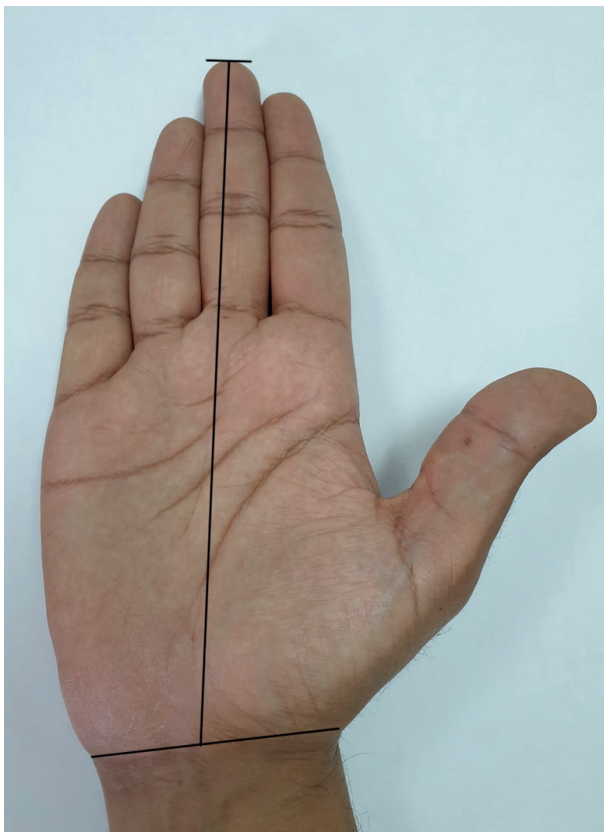


Figure 1. Illustration of the measurement of hand length.

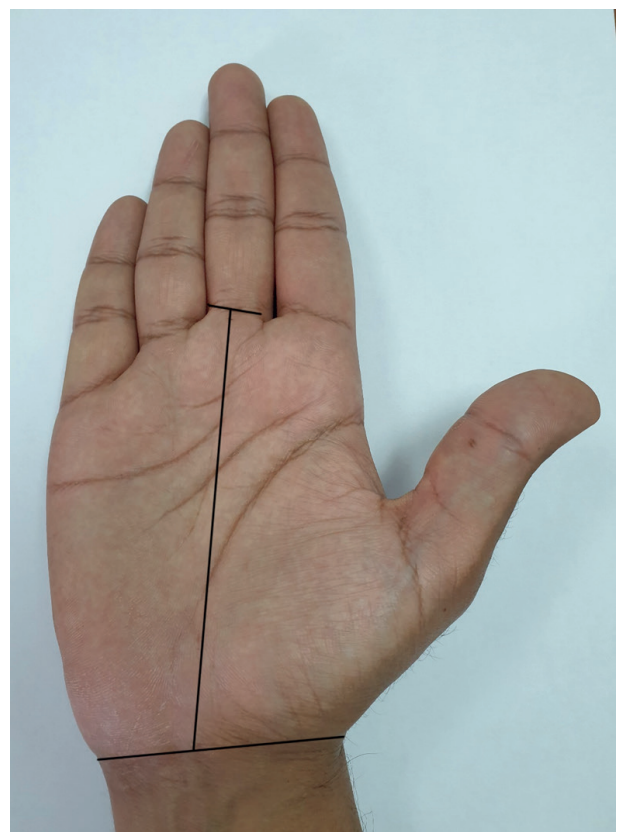


Figure 2. Illustration of the measurement of palm length.

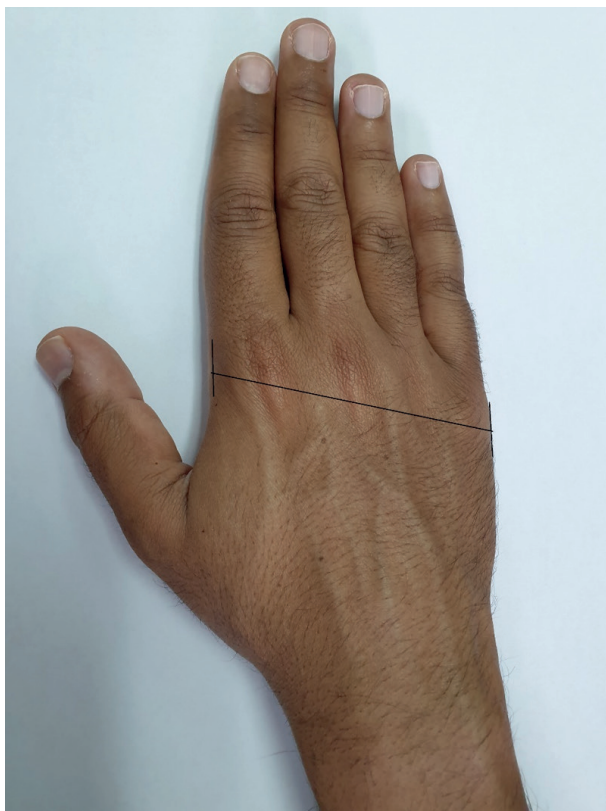


Figure 3. Illustration of the measurement of hand breadth.

The breadth of the right hand was measured as the linear distance between the outer-most point at the head of the second right metacarpal and the inner-most point at the head of the fifth right metacarpal (Figure 3).

The measurements described above for the right hand were similarly measured on the left hand. The hand length and palm length were measured by placing the hand on a flat-surfaced horizontal table in a supine position with the palm faced upward. The hand breadth was measured with the hand placed in a prone position with the palm faced downward. A vernier caliper was used to measure the various hand dimensions in millimeters (mm) and a portable stadiometer (seca 217 mobile stadiometer, Seca Ltd., Hamburg, Germany) was used to measure the stature in centimeters (cm). The stature in cm was then converted to mm by multiplying by 10. Statistical analysis was performed using IBM SPSS Statistics.

Results

The mean (\pm SD) age of the study sample was 26.88 (\pm 7.03) years. The age of the individuals included in the present study ranged from 20 to 56 years. Stature ranged from 1550 to 1865 mm with a mean (\pm SD) of 1703.71 (\pm 60.12) mm. Descriptive statistics for the hand dimensions are summarized in Table 1. No significant inter-observer and intra-observer variations ($p > 0.05$) were found in the measurements of stature and the hand dimensions.

Correlation coefficients of stature with the hand dimensions and regression equations for stature estimation from the hand dimensions are summarized in Table 2. Correlation coefficient resultants in the present study were statistically significant. Stature showed the highest correlation with hand length (0.633 and 0.643), followed by palm length (0.613 and 0.627). However, the correlation between stature and hand breadth was the lowest (0.390 and 0.387). When all the three hand dimensions were simultaneously considered, the correlation of stature increased marginally (0.642 and 0.651) when compared to the correlation of stature with hand length alone.

Discussion

The present study was conducted with the primary objective of estimating stature from the hand dimensions in the Eastern Saudi Arabian adult male population. This anthropometric study is the first in forensic anthropology to be conducted in the Eastern Province of Saudi Arabia. In addition to finding a correlation between stature and hand dimensions, linear and multiple regression models for estimation of stature from hand dimensions were derived.

Table 3 outlines the comparisons of the sample size, age, and stature observations in the present study with those reported for other populations (7–14). In the present study, stature ranged from 155 cm to 186.5 cm with a mean of 170.37 cm. This range is on the lower side when compared to other Arab populations, where the average stature was 175.11 cm and 174.61 cm in the Sudanese and Egyptian populations, respectively (8, 12). Variations in the average stature are an

Table 1. Descriptive statistics for hand dimensions (in mm)

Parameters (mm)	Left hand (n=200)			Right hand (n=200)			T	P
	Min	Max	Mean±SD	Min	Max	Mean±SD		
HL	166.38	199.99	185.03±8.30	164.61	199.98	184.35±8.36	0.817	0.414
PL	93.62	120.40	107.32±5.16	93.36	119.41	106.80±5.20	1.004	0.316
HB	71.75	97.05	82.89±4.40	72.96	95.75	84.41±4.36	-3.486	0.001

Note: HL (hand length), PL (palm length), PB (hand breadth)

Table 2. Regression equations for stature estimation (in mm) from hand dimensions (in mm)

Parameter	Left hand			Right hand		
	Equation	R	SE	Equation	R	SE
HL	$S = 4.584(\text{HL}) + 855.468$	0.633	46.67	$S = 4.622(\text{HL}) + 851.702$	0.643	46.16
PL	$S = 7.151(\text{PL}) + 936.284$	0.613	47.60	$S = 7.250(\text{PL}) + 929.433$	0.627	46.94
HB	$S = 5.338(\text{HB}) + 1261.302$	0.390	55.49	$S = 5.342(\text{HB}) + 1252.778$	0.387	55.57
HL, PL, HB	$S = 2.821(\text{HL}) + 2.813(\text{PL}) + 0.642(\text{HB}) + 826.534$	0.642	46.42	$S = 2.948(\text{HL}) + 2.866(\text{PL}) + 0.165(\text{HB}) + 840.152$	0.651	45.98

Note: HL (hand length), PL (palm length), HB (hand breadth)

Table 3. Comparisons of sample size, age, and stature observations of the present study on the Eastern Saudi Arabian adult male population with those reported for other adult male populations

Population	Sample size (n)	Age (years) (Range)	Age (Mean [SD]) [#]	Stature (cm) ^{**} (Range)	Stature (Mean [SD]) [#]
Western Australian (7)	91	19-68	38.2 [*]	162.4-200.5	178.5 [7.05]
Sudanese (8)	100	25-30	27.64 [1.7]	161-192.1	175.11 [6.22]
South Indian (9)	110	20-30	*	149-192	171.95 [7.05]
North Indian (9)	120	20-30	*	156-189	171.6 [6.62]
North Indian (10)	123	17-20	*	147.6-183.6	168.24 [6.5]
Han population of Southern China (11)	145	20-25	*	160-186.3	170.49 [4.82]
Egyptian (12)	82	18-25	*	*	174.61 [7.34]
South Korean (13)	2750	*	41.6 [*]	148-192.8	170.69 [6.4]
Slovak (14)	120	18-24	*	164.5-198.7	179.5 [6.46]
Eastern Saudi Arabian (Present study)	200	20-56	26.88 [7.03]	155-186.5	170.37 [6.01]

Note: [#]SD – Standard deviation; *Information not provided; ^{**}1 cm = 10 mm

indication that people in different populations attain different heights that can be attributed to genetics and environmental factors (15).

Table 4 outlines the comparisons of the findings related to hand dimensions in the present study with those reported in other studies in different populations (7–14).

In the present study, stature showed the highest correlation coefficient with hand length and the

lowest correlation coefficient with hand breadth. Similar findings were also observed in the Australian, Sudanese, Indian, Chinese, Egyptian, Korean and Slovak populations (7–14). However, the hand breadth was not considered for stature estimation in the Egyptian study (12). The correlation coefficient of stature with palm length was close to that of stature with hand length in the present study. However, the

Table 4. Comparisons of the findings related to hand dimensions of the present study on the Eastern Saudi Arabian adult male population with those reported for other adult male populations

Population	Left hand			Right hand		
	Hand length	Palm length	Hand breadth	Hand length	Palm length	Hand breadth
	Range {cm} (Mean[SD#])			Range {cm} (Mean[SD#])		
Western Australian (7)	* (19.56[0.92])	* (11.22[0.51])	* (9.04[0.49])	* (19.54[0.93])	* (11.21[0.51])	* (9.10[0.48])
Sudanese (8)	16.8-21.8 (19.16[1.12])	Not measured	6.6-8.9 (7.91[0.54])	Not measured	Not measured	Not measured
South Indian (9)	17.0-22.6 (18.81[0.96])	Not measured	7.2-9.6 (8.03[0.39])	17.0-21.3 (18.82[0.95])	Not measured	7.3-9.6 (8.11[0.39])
North Indian (9)	16.5-20.7 (18.87[0.91])	Not measured	7.0-8.9 (7.96[0.38])	16.5-20.7 (18.89[0.91])	Not measured	7.2-8.9 (8.05[0.37])
North Indian (10)	15.9-20.8 (18.21[0.91])	Not measured	7.1-9.8 (8.09[0.43])	16.0-20.9 (18.24[0.9])	Not measured	7.3-9.6 (8.23[0.39])
Han population of Southern China (11)	15.8-21.6 (18.36[0.87])	Not measured	6.0-11.4 (8.33[0.91])	15.9-21.6 (18.37[0.88])	Not measured	6.0-11.3 (8.34[0.93])
Egyptian (12)	* (19.36[0.86])	Not measured	Not measured	* (19.29[0.84])	Not measured	Not measured
South Korean (13)	Not measured	Not measured	Not measured	16.0-21.2 (18.42[0.80])	Not measured	7.2-9.9 (8.37[0.40])
Slovak (14)	16.7-22.0 (18.73[0.92])	Not measured	7.4-9.8 (8.51-0.45)	16.6-22.0 (18.7[0.89])	Not measured	7.3-9.6 (8.48[0.42])
Eastern Saudi Arabian (Present study)	16.63-19.99 (18.5[0.83])	9.36-12.04 (10.73[0.51])	7.17-9.70 (8.28[0.44])	16.46-19.99 (18.43[0.83])	9.33-11.94 (10.68[0.52])	7.29-9.57 (8.44[0.43])

Note: #SD – Standard deviation; *Information not provided; ¹1 cm = 10 mm

palm length was not considered for stature estimation in the other studies except for the Australian study (7). Stature showed a better correlation coefficient with palm length in the Western Australian population than that in the present Eastern Saudi Arabia population. The correlation coefficient of stature with hand breadth reported in the present study is higher than that reported in the Sudanese, Chinese, Korean and Slovak populations (8, 11, 13, 14). The least correlation coefficient of stature with hand breadth was reported in the Korean study (13). Nevertheless, a higher correlation coefficient of stature with hand breadth was observed in the Australian and Indian populations when compared to the present Eastern Saudi Arabian population. Similar to the other studies (7–14), the present study also indicates a more accurate stature estimation from the hand length than the hand breadth. Moreover, similar to other populations, higher correlation coefficients were obtained for multiple regressions than linear regressions in our study too. Bilateral hand dimensions were studied in

the present study and other studies except for the Sudanese and Korean studies. Population-specific usage of regression equations or formulae is further emphasized because of different correlation coefficients observed in different populations.

The primary implication of the findings of the present study is related to the provision of new standards for stature estimation from hand dimensions in the Eastern Saudi Arabian adult male population. The present study addresses the related lacunae in the literature by providing regression equations for stature estimation from isolated hands that may be subjected to forensic examination. Establishing the identity of a deceased individual is one of the key objectives of forensic investigations (16). In mass disasters, victim identification is of paramount importance (17). It is not uncommon for fleshed dismembered or mutilated body parts to be subjected to a medico-legal examination. In such instances, estimation of stature from fleshed dismembered body parts using anthropometric measurements is an important initial step in investigations.

The present study is not without any limitations. The sample size of 200 could be considered a limitation of the present study. Nevertheless, similar population-based studies are conducted on even smaller sample sizes (7–12, 14). We recommend that future similar studies should be conducted on larger samples. A further limitation is that the regression equations or formulae derived in the present study were not cross-validated on another sample of the same population. Besides, the regression equations derived in the present study are based on adults and are not applicable for stature estimation from juvenile remains. We recommend additional similar studies to be conducted on children of different age groups and adolescents. The findings presented in this article are related to the male population in Eastern Saudi Arabia and therefore it is important to additionally report similar findings in the female population. The hand dimensions measured in the present study do not reflect dry bone measurements related to the hand. Therefore, the regression equations for stature estimation derived in the present study cannot be applied for stature estimation from skeletal remains. Future research in this area should also focus on stature estimation from bones either by considering direct measurements or indirectly with the aid of radiology.

Conclusion

In conclusion, the observations and interpretations of the present study indicate that hand dimensions can be used as a reliable predictor to estimate stature in the Eastern Saudi Arabian adult male population. This study has forensic implications considering the preliminary investigation of identifying unknown dismembered or mutilated body segments such as the hands. Such investigations are based on population-specific studies and therefore the present study creates a database of anthropometric measurements of the hand in the Eastern Saudi Arabian adult male population. Stature estimation is one of the important indicators of identification during such initial stages of the forensic investigation involving unknown body segments like the hands. The observations and results of the present study will certainly benefit the law enforcement and crime detection agencies in Saudi Arabia.

Acknowledgements: We express our sincere thanks to the Dean-ship of Scientific Research at Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia for providing a grant to conduct this research.

Conflict of Interest: Each author declares that he has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. Rastogi P, Kanchan T, Menezes RG, Yoganarasimha K. Middle finger length: a predictor of stature in the Indian population. *Med Sci Law* 2009; 49: 123–6.
2. Menezes RG, Nagesh KR, Monteiro FN, et al. Estimation of stature from the length of the sternum in South Indian females. *J Forensic Leg Med* 2011; 18: 242–5.
3. Kanchan T, Krishan K, Sharma A, Menezes RG. A study of correlation of hand and foot dimensions for personal identification in mass disasters. *Forensic Sci Int* 2010; 199: 112.e1–6.
4. Asadujjaman M, Al Noman SN, Molla MB. Stature estimation from foot anthropometric measurements in Bangladeshi population. *Ir J Med Sci* 2020; 189: 365–72.
5. Sjøvold T. Stature estimation from the skeleton. In: Payne-James J. *Encyclopedia of Forensic and Legal Medicine*. Amsterdam: Elsevier; 2005. p. 100–5.
6. Krishan K, Kanchan T, Menezes RG, Ghosh A. Forensic anthropology case work: essential methodological considerations in stature estimation. *J Forensic Nurs* 2012; 8: 45–50.
7. Ishak N, Hemy N, Franklin D. Estimation of stature from hand and handprint dimensions in a Western Australian population. *Forensic Sci Int* 2012; 216: 199.e1–7.
8. Ahmed AA. Estimation of stature from the upper limb measurements of Sudanese adults. *Forensic Sci Int* 2013; 228: 178.e1–7.
9. Rastogi P, Nagesh KR, Yoganarasimha K. Estimation of stature from hand dimensions of North and South Indians. *Leg Med (Tokyo)* 2008; 10: 185–9.
10. Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a North Indian population. *J Forensic Leg Med* 2007; 14: 327–32.
11. Tang J, Chen R, Lai X. Stature estimation from hand dimensions in a Han population of Southern China. *J Forensic Sci* 2012; 57: 1541–4.
12. Habib SR, Kamal NN. Stature estimation from hand and phalanges lengths of Egyptians. *J Forensic Leg Med* 2010; 17: 156–60.
13. Kim W, Kim YM, Yun MH. Estimation of stature from hand and foot dimensions in a Korean population. *J Forensic Leg Med* 2018; 55: 87–92.
14. Uhrova P, Benus R, Masnicova S, et al. Estimation of stature using hand and foot dimensions in Slovak adults. *Leg Med (Tokyo)* 2015; 17: 92–7.

15. Bentham J, Di Cesare M, Stevens GA, et al. A century of trends in adult human height. *Elife* 2016; 5: e13410.
16. Madadin M, Siddique N, Waris A, et al. Research trends in forensic anthropology: a bibliometric analysis. *J Forensic Leg Med* 2022; 86: 102305.
17. Menezes RG, Shetty BS, Rastogi P, et al. The Mangalore air crash of 22 May 2010: practical problems related to identification of the dead in a populous developing country. *Med Leg J* 2012; 80: 151-4.

Correspondence

Received: 19 September 2021

Accepted: 14 October 2021

Prof. Ritesh G. Menezes, MD, DNB, MNAMS

Forensic Medicine Division

Department of Pathology

College of Medicine

Imam Abdulrahman Bin Faisal University

Dammam, 34212 Saudi Arabia

E-mail: mangalore971@yahoo.co.in; rgmenezes@iau.edu.sa

Phone: +966508160375

ORCID: 0000-0002-2135-4161