ORIGINAL ARTICLE

THE ESTIMATION OF DIFFERENT BODY DIMENSIONS FROM STATURE IN BANGLADESHI MALE POPULATION

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ABSTRACT

The prime concern of forensic anthropometry is to identify the individuals by analyzing the disintegrated human body parts. The aim of this study was to investigate the correlation between different human body measurements, and to estimate different body dimensions from stature. The study was carried out on 348 male volunteer participants; aged 19 to 25 years. Fourteen anthropometric parameters had been measured to conduct this study. After analyzing the data, it was found that there was a meaningful relation between the stature and other body dimensions ($p< 0.001$). Correlation coefficient (r) values of anthropometric data with stature were ranged from +0.22 to +0.83. The standard errors of estimation (SSE) values were varied from ±0.310 cm to ±3.899 cm. Regression equations derived in this paper can be used to estimate various body parts from stature for Bangladeshi male population. Finally, this study concluded that stature is a useful tool to estimate different human body dimensions. Consequently, this is such a novel study for the forensic department to identify persons in case of murders, accidents, natural disasters or war casualties.

Keywords: *Forensic anthropometry, Body dimensions estimation, Stature*

INTRODUCTION

The word anthropometry comes from two Greek words *anthropos* (man) and *metron* (measure), which means human body measurement (Bridger, 1995). Assessment of different human body parts from stature is an area of interest in the field of forensic science and medicine, anatomy, and human factors engineering. In forensic research, anthropometry or human body measurement has been extensively used to identify the criminals and victims of accidents, natural disasters, terrorist attacks or war casualties (Menezes et al., 2011; Kharoshah et al., 1011; Jee and Yun, 2015). Stature or a person's natural height is one of the most important parameter to determine physical characteristics. In recent studies of forensic science, stature estimation has been carried out from different body dimensions like hands (Zaher et al., 2011; Pal et al., 2016), handprints (Krishan et al., 2015), feet (Hemy et al., 2013), footprints (Kanchan et al., 2013; Moorthy et al., 2014), radials and ulnas (Torimitsu et al., 2014) etc. To estimate the relationship between body dimensions, stature is the major predictor of the other body parts (Oyewloe et al., 2010). Therefore, estimation of different body parts from stature is also important in the field of forensic science and human factors engineering.

Regression analysis is extensively used to estimate correlation between anthropometric parameters (Oyewloe et al., 2010; Sahni et al., 2010; Shi-zhu and Ping, 2012; Ahram and Karwowski, 2012; Ahmed, 2013; Shrestha et al., 2015). A study on 480 students in Nigeria had shown that, popletial height can be predicted from stature by regression analysis as there is a strong positive correlation between them (Osmaila et al., 2012).

Nevertheless, all human body dimensions can not be estimated from stature (Cavder, 2013). In Turkey, a study on 29 human body measurements showed that, among them 17 body measurements may be estimated from stature (Cavder, 2013). In Iran, Balande et al., (2016) had conducted a study to design workstations for working with microscopes based on regression analysis and showed that standing eye height, sitting eye height, and sitting horizontal range of accessibility had a significant correlation with stature. Nuruzzaman and Asadujjaman (2012); and Islam et al., (2013) had conducted a study to determine the hospital bed dimensions based on patients' anthropometric data. It was shown that, bed length, bed width, bed height and bed stand height were related to stature, elbow span, popliteal height and vertical grip reach (standing) respectively. Therefore, linear regression analysis was used to estimate anthropometric parameters from stature for the design of the hospital bed.

The measurement of human body varies widely among nations and within nations (Tunay and Melemez, 2008). Therefore, regression equations and correlation coefficients between anthropometric measurements vary by regions. The aim of this study was to investigate the correlation between different human body measurements, and to derive specific regression equations to determine the anthropometric parameters from stature for Bangladeshi male people.

The outline of the paper is as follows. Section 2 describes materials and methods. Section 3 describes the result and findings of this research. Section 4 concludes the paper with limitations and future work.

MATERIALS AND METHODS

Participants

In this study, participants that included 348 male Bangladeshi were of age ranging from 19 to 25 years. All of the data gathered in this study were collected from three different Universities of Bangladesh: Rajshahi University of Engineering & Technology, Rajshahi University, and Varendra University.

Measurements

A total of 14 anthropometric measurements was obtained from each participant. To measure the body dimension of the participants, a standard measuring steel tape and steel ruler were used. All the participants included in this study were healthy with no physical disabilities. The following anthropometric measurements were taken from each participant to conduct this study (Table 1).

Table 1. Anthropometric dimensions and their description

Anthropometric Dimensions	Description
Stature (S)	The vertical distance from floor to top of the head, when standing.
Standing elbow height (SEH)	The vertical distance from the floor to the lowest point of the right elbow, when standing.
Forward elbow reach (FER)	The distance from the back of the right elbow to the tip of the middle finger, with the elbow flexed at 90°.
Sitting height (SH)	The vertical distance from the sitting surface to the top of the head, when sitting.
Sitting shoulder height (SSH)	The vertical distance from the sitting surface to the tip (acromion) of the shoulder, when sitting.
Subscapular height (SUH)	The vertical distance from the lowest point (inferior angle) of the scapula to the subject's seated surface.
Popliteal height (PH)	Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps femoris muscle inserts into the lower leg.
Knee height (KH)	The vertical distance from the sitting surface to the right knee cap, when sitting with knees flexed at 90°.
Buttock-knee depth (BKD)	The horizontal distance from the back of the buttocks to the back of right knee, when sitting with the knees flexed at 90°.
Buttock calf-length (BCL)	The horizontal distance from the back of the buttocks to the calf, when sitting with the knees flexed at 90°.
Buttock-popliteal length (BPL)	The horizontal distance from the back of the buttocks to the right knee just below the thigh, when sitting with the knees flexed at 90°.
Thigh thickness (TT)	Vertical distance from the seat surface to the top of the uncompressed soft tissue of the thigh as its thickest point, generally where it meets the abdomen.
Elbow height (sitting) (EHS)	The vertical distance from the sitting surface to the lowest point of the right elbow, when sitting.
Hip width (HW)	The maximal horizontal breath across the hips or thighs, whatever is greater, sitting position.

Data Analysis

The statistical mean, standard deviation, range and coefficient of correlation were calculated using Microsoft Office Excel 2013. To estimate different human body dimensions from stature, linear regression analysis was also used.

RESULTS

The summary of statistical analysis, including statistical mean, standard deviation, and range of different body dimensions have been shown in Table 2. The mean values of stature, standing elbow height, forward elbow reach, sitting height, sitting shoulder height, subscapular height, popliteal height, knee height, buttock-knee depth, buttock-calf length, buttock-popliteal length, thigh thickness, elbow height (sitting) and hip width were 168.0 cm, 106.3 cm, 44.7 cm, 86.6 cm, 58.9 cm, 45.8 cm, 44.1 cm, 53.5 cm, 56.2 cm, 48.8 cm, 47.4 cm, 13.8 cm, 21.4 cm and 32.1 cm respectively.

Table 2. Summary of measured body dimensions (cm)

Anthropometric Parameter	Male	
	Mean ± SD	Range
Stature	168.0 ± 6.1	188.0 — 152.4
Standing elbow height	106.3 ± 4.6	123.2 — 91.9
Forward elbow reach	44.7 ± 2.2	51.3 — 39.6
Sitting height	86.6 ± 3.7	99.1 — 76.2
Sitting shoulder height	58.9 ± 3.4	72.0 — 49.0
Subscapular height	45.8 ± 4.2	64.0 — 36.8
Popliteal height	44.1 ± 2.8	64.0 — 35.6
Knee height	53.5 ± 3.0	67.5 — 42.7
Buttock-knee depth	56.2 ± 3.4	67.6 — 45.7
Buttock-calf length	44.8 ± 3.8	58.9 — 35.0
Buttock-popliteal length	47.4 ± 3.2	57.4 — 39.9
Thigh thickness	13.8 ± 2.5	34.3 — 9.0
Elbow height (sitting)	21.4 ± 3.6	47.2 — 14.7
Hip width	32.1 ± 3.4	46.0 — 25.4

Anthropometric parameters are correlated to each other (Osmaila et al., 2012; Oyewole et al., 2010; Sahni et al., 2010; Shi-zhu & Ping, 2012; Ahram & Karwowski, 2012; Ahmed, 2013; Shrestha et al. 2015). Table 3 shows the correlation coefficient matrix for different body dimensions. Among different anthropometric parameters, the correlation coefficient was varied from -0.01 to +0.83. The values of the coefficient of correlation between stature and others anthropometric parameters were between +0.22 and +0.83. Coefficient of correlation was higher between stature and sitting elbow height. It was also seen that, negative correlation existed between buttock calf length with thigh thickness; buttock calf length with elbow height (sitting), and others parameter were positively correlated. This is reasonable, because when thigh thickness is more, then it reduces buttock calf depth.

Table 3. Correlation coefficient matrix

Sl. No	Anthrpometric Parameters	S	SEH	FER	SH	SSH	SUH	PH	KH	BKD	BCL	BPL	TT	SEH	HW
1	S	1.00													
2	SEH	0.83	1.00												
3	FER	0.64	0.61	1.00											
4	SH	0.65	0.57	0.45	1.00										
5	SSH	0.49	0.55	0.35	0.68	1.00									
6	SUH	0.35	0.30	0.18	0.33	0.30	1.00								
7	PH	0.52	0.44	0.28	0.30	0.40	0.11	1.00							
8	KH	0.59	0.60	0.50	0.47	0.50	0.14	0.51	1.00						
9	BKD	0.63	0.59	0.56	0.38	0.27	0.20	0.35	0.56	1.00					
10	BCL	0.49	0.48	0.44	0.22	0.25	0.14	0.24	0.39	0.69	1.00				
11	BPL	0.56	0.50	0.50	0.27	0.20	0.22	0.40	0.41	0.70	0.61	1.00			
12	TT	0.30	0.24	0.16	0.29	0.28	0.20	0.31	0.41	0.22	-0.01	0.24	1.00		
13	EHS	0.22	0.19	0.04	0.40	0.40	0.28	0.22	0.18	0.03	-0.08	0.07	0.43	1.00	
14	HW	0.33	0.22	0.15	0.21	0.19	0.29	0.32	0.25	0.24	0.04	0.28	0.45	0.27	1.00

Table 4 represents linear regression equations to estimate different human body measurements from stature. Table 4 also exhibits determination coefficient (R^2), standard error of estimation (SEE), and *p*-value. In this study, the value of the coefficient of determinations (R^2) varied from 0.049 to 0.683.

Table 4. Linear regression equations for the estimation of different body measurements (in cm) from stature

Equations	R^2	SEE	*p*-value
Standing elbow height = 1.616 + 0.625 (Stature)	0.683	2.575	0.000*
Forward elbow reach = 5.656 + 0.232 (Stature)	0.414	1.677	0.000*
Sitting height = 20.27 + 0.395 (Stature)	0.425	2.782	0.000*
Sitting shoulder height = 12.104 + 0.278 (Stature)	0.242	2.989	0.000*
Subscapular height = 5.44 + 0.240 (Stature)	0.122	3.899	0.000*
Popliteal height = 3.907 + 0.24 (Stature)	0.270	2.390	0.000*
Knee height = 3.754 + 0.296 (Stature)	0.346	2.469	0.000*
Buttock-knee depth = -3.874 + 0.358 (Stature)	0.403	2.639	0.000*
Buttock-calf length = - 6.632 + 0.306 (Stature)	0.243	3.275	0.000*
Buttock-popliteal length = - 1.8 + 0.293 (Stature)	0.312	0.310	0.000*
Thigh thickness = - 6.927 + 0.123 (Stature)	0.093	2.340	0.000*
Elbow height (sitting) = - 0.89 + 0.133 (Stature)	0.049	3.523	0.000*
Hip width = 0.667 + 0.187 (Stature)	0.111	3.221	0.000*

*Significant ($p<0.001$)

It is known that, perfect estimation is practically impossible from the regression analysis. Therefore, the standard error of estimation (SEE) is needed to predict the deviation of estimated body measurements from the actual value. A low value of SEE means greater reliability in the estimated body dimension. If SSE is zero, then there exists perfect correlation which means no variation of the regression line. The SSE showed a lower value while estimates various body measurements from stature. In our study, the SSE values were found to be in between 0.310 to 3.899.

The present data showed that stature was statistically significant with all parameters ($p<0.001$). It means that the estimation of different body dimensions was reliable with the help of stature dimension. Finally, the present research would be very helpful for forensic anthropometry and human factors engineering research in Bangladesh.

CONCLUSION

The present study finally concludes that stature is a very useful tool to estimate different human body dimensions. The linear regression formula derived in this study can be used not only for forensic pathologists, but also for anatomist, anthropologists, product designers and human factor engineers. The present research might have some limitations. This study considered only the male population; therefore, further research is needed in the female population to compare the findings with the male population. This research was done on subjects aged ranging 19 to 25 years. Although adult is considered at the age of 18, therefore, this result may not be useful for all adult groups as stature is decreased after a sudden period in both sexes with the increase of age (Klepinger, 2006). In the future, this research can be continued to investigate relevant regression equations to estimate other anthropometric parameters from stature for other age groups to compare it with different regional data of the Bangladeshi people, and with other country populations.

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COMPETING INTERESTS

There is no conflict of interest.

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