NC1001: Estimation of stature from hand measurements in Thais

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Abstract

Personal identification of an unknown individual is one of the main objectives of forensic investigations. The estimation of stature from human remains is particularly important in establishing positive personal identification. The estimated stature can be used to narrow down the pool of potential matching identities in the missing persons reports. To date, regression equations for estimation of stature from hand measurements are not yet available for the Thai population. Therefore, the present study aims to investigate the relationship between stature and hand measurements in Thais and derive regression equations for estimation of stature from hand measurements for the Thai population.

Stature, hand length, hand width, and palm length were taken from 100 randomly selected Thai students (50 males and 50 females) from Faculty of Science, Mahidol University. The study sample ranged from 18 to 26 years of age. Correlation and regression analyses were then performed on the measurement data. All the hand measurements of both sexes exhibit positive and statistically significant correlation coefficients with stature ($r = 0.349$-0.736 $p < 0.05$). The standard error of the estimate of the regression equations ranges from ±3.295 cm to ±4.878 cm. Hand length is the best measurement for estimating the stature of an unknown individual.

Keywords: estimation of stature, hand, Thais

1. Introduction

Personal identification of an unknown individual is one of the main objectives of forensic investigations (Kanchan, Menezes, et al., 2008). With increasing frequency of murders, accidents, or mass disasters, it is common to find dismembered human remains at crime scenes, and estimating stature from these remains is particularly important in establishing positive personal identification. In mass disaster and assault cases, where the victim's body is dismembered to conceal his or her identity, identification of the remains is vital for further investigations (Kanchan, Kumar, & Menezes, 2008). The estimated stature can be used to narrow down the pool of potential matching identities in the missing persons reports.

By performing regression analysis on the data of stature and hand measurements, we may derive regression equations which can be used to estimate stature from hand measurements. Due to differences in genetic and environmental factors such as diet, nutrition, climate, and lifestyle, the body proportion of one population may be different from that of another (Mendonça, 2000). As a result, the equations for one population may not be equally applicable in another, and, therefore, different regression equations should be derived for each population to provide the most accurate results.

Previous research in various populations has shown that stature can be accurately estimated from hand measurements: e.g., Indians, SEE ±4.03-5.06 cm (Jasuja & Singh, 2004), SEE ±4.26-4.63 cm (Sunil, Dikshit, & Aggrawal, 2005); North Indians, SEE ±3.16-5.60 cm (Krishan & Sharma, 2007), SEE ±4.24-5.97 cm (Rastogi, Nagesh, & Yoganarasimha, 2008); South Indians, SEE ±3.76-5.73 cm (Rastogi et al., 2008); Mauritians, SEE ±4.163-4.956 cm (Agnihotri, Agnihotri, Jeebun, & Googoolye, 2008); Egyptians, SEE ±4.54-5.48 cm (Habib & Kamal, 2010); and Western Australians, SEE ±4.74-6.53 cm (Ishak, Hemy, & Franklin, 2012). To date, regression equations for estimation of stature from hand measurements are not yet available for the Thai population.

2. Objective

The present study aims to investigate the relationship between stature and hand measurements in Thais and derive regression equations for estimation of stature from hand measurements for the Thai population.

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3. Materials and Methods

3.1 Subjects

The study sample consisted of 100 randomly selected Thai students (50 males and 50 females) from Faculty of Science, Mahidol University. The subjects ranged between 18 and 26 years of age. The mean age of males was 21.2 years (range 18-26) and for females, it was 20.5 years (range 18-26). Most of the subjects were from the Central Region of Thailand. Only healthy individuals without any significant diseases or deformities of the hand, leg, foot, or back were recruited for the study.

The subjects were given a participant information sheet and were required to sign an informed consent form before participating in the study. They were also asked to fill in a questionnaire containing demographic (e.g. sex, age, and nationality) and general (e.g. handedness and congenital diseases) questions. Stature and hand measurements were then taken by the examiner.

3.2 Stature

Stature was measured using a stadiometer. Each subject was asked to stand bare-footed on the flat platform of the stadiometer, with the heels of the feet placed together and touching the base of the vertical backboard. The head, scapulae, back, and buttocks were positioned in contact with the vertical backboard. Each subject was then asked to maintain an upright position, with the head positioned in the Frankfort Horizontal Plane, as the horizontal sliding bar was lowered to the vertex of the head. Stature was recorded in centimeters to the nearest millimeter (Gordon, Chumlea, & Roche, 1991).

3.3 Hand measurements

Hand measurements, as defined in Table 1, were taken from each hand of the subject using a sliding caliper. Hand length and palm length were measured when the subjects placed their hands supine on a flat horizontal surface with the fingers extended and adducted. Hand width was measured when the subjects placed their hands prone on a flat horizontal surface, with the thumb abducted and other fingers extended and adducted. All the hand measurements were recorded in centimeters to the nearest 0.5 millimeter (Rastogi et al., 2008).

Table 1 Definition of the hand measurements used in the present study

Measurement	Definition
Hand length (HL)	Distance between the mid-point of the distal transverse wrist crease to the most anterior projection of the skin of the middle finger (Rastogi et al., 2008)
Hand width (HW)	Distance between the most lateral point on the head of the 2nd metacarpal to the most medial point on the head of the 5th metacarpal (Agnihotri et al., 2008)
Palm length (PL)	Distance between the mid-point of the distal transverse wrist crease to the proximal flexion crease of the middle finger (Kanchan & Rastogi, 2009)

3.4 Statistical analysis

All the statistical analysis was performed using SPSS for Windows version 18.0. Descriptive statistics for stature and hand measurements was calculated for both sexes. Bilateral asymmetry in the measurement data of each sex was evaluated using paired samples t-tests. The correlation between stature and hand measurements was assessed by Pearson's correlation coefficient (r) analysis.

Simple linear and backward multiple regression analyses were performed to derive regression equations for estimation of stature from hand measurements. The accuracy of stature estimation of each regression equation was assessed by the coefficient of determination (R^2) and the standard error of the estimate (SEE). The significance level of the present study was set at 0.05.

4. Results

4.1 Descriptive statistics

The descriptive statistics for stature and hand measurements in males and females is shown in Table 2. It is observed that the mean values of all the measurements are higher in males than in females.

Table 2 Descriptive statistics for stature and hand measurements in males and females

Measurement (in cm)	Male (n = 50)				Female (n = 50)			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Stature	163.40	182.80	171.580	4.412	149.70	170.50	159.632	5.279
Hand length								
Right	16.60	20.80	18.181	0.870	14.90	18.50	16.679	0.864
Left	16.50	21.00	18.130	0.799	14.80	18.90	16.599	0.919
Hand width								
Right	7.45	9.40	8.169	0.449	6.30	8.30	7.131	0.455
Left	7.25	9.40	7.984	0.476	6.10	8.20	6.992	0.457
Palm length								
Right	9.70	12.10	10.677	0.518	8.80	11.40	9.796	0.503
Left	9.40	12.50	10.645	0.550	8.60	11.30	9.678	0.551

4.2 Bilateral asymmetry

Bilateral asymmetry in hand measurements of males and females is shown in Table 3, respectively. For males, only the hand width exhibits statistically significant bilateral asymmetry ($p < 0.05$), and the mean value of hand width is significantly higher on the right side than on the left side. For females, all the hand measurements exhibit statistically significant bilateral asymmetry ($p < 0.05$), and the mean values of hand length, hand width, and palm length are significantly higher on the right side than on the left side.

Table 3 Bilateral asymmetry in hand measurements of males and females

Measurement (in cm)	Male (n = 50)				Female (n = 50)			
	MD (right-left)	SD	t	p	MD (right-left)	SD	t	p
Hand length	0.051	0.218	1.653	0.105	0.080	0.210	2.688	0.010
Hand width	0.185	0.193	6.776	0.000	0.139	0.168	5.843	0.000
Palm length	0.032	0.181	1.251	0.217	0.118	0.228	3.658	0.001

4.3 Pearson's correlation coefficients

The Pearson's correlation coefficients between stature and hand measurements for males and females are shown in Table 4. All the hand measurements of both sexes exhibit positive and statistically significant correlation coefficients with stature (p-value < 0.05). The correlation coefficients between stature and hand measurements range from 0.349 to 0.674 for males and from 0.404 to 0.736 for females. For males, the highest correlation coefficient is exhibited by right hand length ($r = 0.674$) and the lowest by right hand width ($r = 0.349$). For females, the highest correlation coefficient is exhibited by right hand length ($r = 0.736$) and the lowest by left hand width ($r = 0.404$).

Table 4 Pearson's correlation coefficients between stature and hand measurements for males and females

Measurement (in cm)	Male (n = 50)		Female (n = 50)	
	r	p	r	p
Hand length				
Right	0.674**	0.000	0.736**	0.000
Left	0.667**	0.000	0.716**	0.000

*Significant at p-value < 0.05
**Significant at p-value < 0.01

Table 4 Pearson's correlation coefficients between stature and hand measurements for males and Females (cont.)

Measurement (in cm)		Male (n = 50)		Female (n = 50)	
		r	p	r	p
Hand width					
	Right	0.349*	0.013	0.412**	0.003
	Left	0.439**	0.001	0.404**	0.004
Palm length					
	Right	0.570**	0.000	0.706**	0.000
	Left	0.568**	0.000	0.648**	0.000

*Significant at p-value < 0.05
**Significant at p-value < 0.01

4.4 Simple linear regression equations

Simple linear regression equations for each hand measurement for males and females are shown in Table 5. The standard error of the estimate ranges from ±3.295 cm to 4.177 cm for males and from ±3.609 cm to 4.878 cm for females. For males, the equation for right hand length shows the lowest standard error of the estimate (SEE ±3.295 cm) while that for right hand width shows the highest standard error of the estimate (SEE ±4.177 cm). For females, the equation for right hand length shows the lowest standard error of the estimate (SEE ±3.609 cm) while that for left hand width shows the highest standard error of the estimate (SEE ±4.878 cm).

4.5 Multiple regression equations

Multiple regression equations for multiple hand measurements on each side for males and females are shown in Table 6. The standard error of the estimate ranges from ±3.297 cm to ±3.328 cm for males and from ±3.514 cm to ±3.680 cm for females. For males, the equation for hand length and hand width on the left side shows the lowest standard error of the estimate (SEE ±3.297 cm) while that for hand length and hand width on the right side shows the highest standard error of the estimate (SEE ±3.328 cm). For females, the equation for hand length and palm length on the right side shows the lowest standard error of the estimate (SEE ±3.514 cm) while that for hand length and palm length on the left side shows the highest standard error of the estimate (SEE ±3.680 cm).

Table 5 Simple linear regression equations for estimation of stature from hand measurements for males and females

Male (n = 50)			Female (n = 50)		
Equation*	R^2	SEE	Equation*	R^2	SEE
Right			Right		
S = 109.465 + 3.416 HL	0.454	3.295	S = 84.587 + 4.499 HL	0.542	3.609
S = 143.510 + 3.436 HW	0.122	4.177	S = 125.614 + 4.770 HW	0.169	4.861
S = 119.788 + 4.851 PL	0.325	3.664	S = 86.951 + 7.419 PL	0.499	3.775
Left			Left		
S = 104.819 + 3.682 HL	0.445	3.321	S = 91.318 + 4.116 HL	0.513	3.722
S = 139.111 + 4.066 HW	0.193	4.005	S = 126.995 + 4.668 HW	0.164	4.878
S = 123.103 + 4.554 PL	0.323	3.668	S = 99.596 + 6.203 PL	0.419	4.064

*S: Stature (in cm)

Table 6 Multiple regression equations for estimation of stature from multiple hand measurements for males and females

Male (n = 50)			Female (n = 50)		
Equation*	R^2	SEE	Equation*	R^2	SEE
Right			Right		
S = 109.465 + 3.343 HL + 0.293 HW	0.454	3.328	S = 78.453 + 2.925 HL + 3.306 PL	0.575	3.514
Left			Left		
S = 100.643 + 3.269 HL + 1.462 HW	0.464	3.297	S = 87.061 + 3.090 HL + 2.200 PL	0.534	3.680

*S: Stature (in cm)

Discussion

Anthropometry is a useful tool in the field of forensic science; it is a well-established forensic technique that uses specific body proportions and features to determine age, race, sex, and even stature. Stature is one of the most important and useful anthropometric parameters that define the physical identity of an individual, and knowing one's stature can significantly help establish his or her personal identity. Simple and accurate mathematical equations for estimating the stature of an unknown individual from hand measurements are particularly useful in cases of missing persons where only dismembered human remains are recovered from the crime scene. The present study is one of the first studies to provide such equations for the Thai population.

In terms of bilateral asymmetry, the mean values of all the hand measurements as shown in Table 2 are expectedly higher on the right side than on the left side as most of the subjects were right-handed. However, for males, only the bilateral asymmetry in hand width is statistically significant ($p < 0.05$) according to Table 3. On the other hand, for females, bilateral asymmetry in all the hand measurements, including hand length, hand width, and palm length are statistically significant ($p < 0.05$). The significance of bilateral asymmetry suggests the use of the dominant hand for a more accurate estimation of stature.

In examining the correlation between stature and hand measurements, among the three hand measurements used in the present study, namely hand length, hand width, and palm length, hand length is found to exhibit the highest correlation coefficients with stature in both sexes. Such findings have also been observed in North Indians (Krishan & Sharma, 2007), South Indians (Rastogi et al., 2008), and Western Australians (Ishak et al., 2012). Hence, hand length is the best estimator of stature while palm length, which exhibits the lowest correlation coefficients with stature, is the worst estimator of stature.

In assessing the accuracy of the simple linear regression equations, the coefficient of determination (R^2) and the standard error of the estimate (SEE) are used. In the present study, the coefficient of determination is highest and the standard error of the estimate is lowest when hand length is used (R^2 = 0.454-0.575; SEE ±3.295-3.609 cm). As expected, previous studies have also shown that hand length is the most accurate measurement for stature estimation: e.g. Krishan and Sharma (2007), Rastogi et al. (2008), Habib and Kamal (2010), and Ishak et al. (2012).

In regards to the multiple regression equations, for males, none is more accurate than the simple linear equations using only hand length. On the other hand, for females, the multiple regression equation using hand length, hand width, and palm length on the right side is more accurate than the simple linear equations using only hand length; however, the difference is only as small as SEE ±0.095 cm. Thus, hand length would be the best measurement for stature estimation for both sexes.

Conclusion

To conclude, the present study has investigated the relationship between stature and hand measurements in Thais and derived regression equations for estimation of stature from hand measurements for the Thai population.

Firstly, all the hand measurements of both sexes exhibit positive and statistically significant correlation coefficients with stature (r = 0.349-0.736, $p < 0.05$). The highest correlation coefficient with stature is exhibited by hand length in both males (r = 0.667-0.674) and females (r = 0.716-0.736).

Secondly, the regression equations show a standard error of the estimate ranging from ±3.295 cm to ±4.878 cm. Simple linear regression equations using hand length provide the lowest standard error of the estimate for both males (SEE±3.295-3.321 cm) and females (SEE±3.609-3.722 cm), making it the best measurement for stature estimation.

Limitations and Suggestions

As most of the study subjects were Thais originating from the Central Region of Thailand between 18 and 26 years of age, further studies in other age groups and populations are required to confirm whether the regression equations derived in the present study are equally applicable elsewhere.

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