A Study of Anthropometric Measurement of Hand Length and Their Correlation with Stature of University Students

Fatin Syahida Anuar*, Gargi Soni

International Medical School, Management and Science University, University Drive, Off Persiaran Olahraga, 40100, Shah Alam, Selangor.

**Bachelor in Medical Science, Management and Science University; Email: fatinsyahidaanuar@gmail.com*

ABSTRACT: Stature is one of main parameters widely used in forensic fields as personal identification. As time passes by, the frequency of mass disasters are also increased, hence, this aspect is very important for forensic anthropologist to determine the identification of the victims. Previous studies done before proved that there are correlation between hand length and stature. This study investigates the correlation of anthropometric measurement of hand length and stature in three main races in Malaysia which are Malay, Chinese and Indian. The hand length and stature of 259 university students from those three different races were measured according to standard anthropometric measurement. The correlation coefficients between stature and hand length was positive and statistically significant ($p<0.05$). It was observed that males are significantly taller than females in all three races. Males hand length is significantly higher than females in all three races. Indian have the largest stature and hand length among the three races. Generally, Chinese are shorter in hand length and stature than Malay and Indian. However, the Chinese females have higher values of hand length and stature compared to Malay females. Linear regression derived for both sexes for all three races and the difference between true and estimated stature were significant. This study supports that variations present in genders and also races, thus formulae derived one race and both genders may not applicable to other races and gender. In brief, this study contributes to the standard anthropometric values in estimating the stature for three major races in Malaysia.

Keywords: Stature, hand length, anthropometric measurements, regression equations

Introduction

In forensic field, personal identification is one of the crucial tasks to be done as one of important parameter in the investigations. Apart from age, sex and ethnicity, stature has also been widely used as it gained importance to help identify victims of mass or natural disasters such as bomb explosions, earthquake, flood, tsunami vehicle accidents such as airplane crash or car accidents Krishan et al. [1]. Body dimensions have been used to estimate the stature in the absence of complete human body as the relationship between human features and the stature has been established by many studies. Some of the body parts include foot length, metatarsals, tibia, femur, upper arm length, ribcages, facial or skull, and last but not least, hand and phalanges. Anthropologists, forensic experts, anatomists and medical scientists used the anthropometry technique to estimate the stature of a person from remain skeletal parts of the body since long time ago. However, stature varies with races as Dewangan et al. [2] stated that stature formation formulae differ from one race to another in which in their study they found that there were significant differences in hand dimensions between regions in India. Kar et al. [3] and Okunribido [4] found that there were significant difference in anthropometry measurement existed between different nationalities. In the past studies, it was examined that the stature formation estimation were different between one race to another. Hence, the current study is to study the relationship between the hand length and the stature of three main races in Malaysia.

Material and Method

This is a cross sectional study where 259 subjects were university students aged between 18-25 years from different races including Malays, Indian and Chinese. The subjects were explained about the methods used to take the hand length and the stature upon consent to participate in this study. Measurements were taken as follows:

i. ***Hand length:*** The subjects placed their hands supine on a flat horizontal surface with fingers extended and adducted. The hand length of each students were taken using Vernier calipers, from the middle of the distal wrist crease to the distal end of

most projecting point of the hand that is tip of the middle finger [5].

ii. ***Stature:*** The stature of each student was taken using a stadiometer. The student stood barefooted on it with both feet close together and hands were kept close at each side in upright standing position. Head, buttock and back were in contact with the vertical surface as the head was positioned forward with the Frankfurt lane. The headpiece of the stadiometer was kept firmly over the vertex to compress the hair as the height was later measured [6].

The participants with medical history such as deformities (scoliosis, kyphosis, lordosis, contracture or missing legs) were excluded. This age group was selected because the normal growth development becomes static. Left handed students were also excluded to keep the uniformity as the effect of hand dominance on hand measurements has been established. The hand length and stature measurement were measured by the same person to avoid inter-observer bias [7].

Results

The samples were made up of 122 male and 137 female university students. The data collected were divided and analysed according to the gender and the races of the respondents. The mean of the stature and hand length for male and female subjects is shown in Table 1.

Table 1: Mean of stature and hand length for male and female subjects

Gender of respondents	N	Hand length (cm) ± SD	Stature (cm) ± SEM	p-value
Male	122	18.47 ± 1.03	174.30 ± 6.64	0.001
Female	137	16.54 ± 0.98	157.70 ± 5.97	0.001

Independent sample t-test indicated that the differences between the hand length of males and females were statistically significant ($p<0.05$). Table 2 shows the relationship between hand length and stature in male and female subjects upon a Pearson correlation test. There was a positive correlation between hand length and stature which was statistically significant ($p<0.05$) in both male and female subjects. The highest correlation was observed in females ($r = 0.70$). The R^2 also indicated that females subjects have the highest correlation compared to male.

Table 2: Correlation between hand length and stature in males and females

Gender of respondents	Male	Female	p-value
Correlation (r)	0.69	0.70	< 0.001
R^2	0.48	0.49	< 0.001

Table 3 shows the linear regression equation formulated to estimate stature from hand length of both genders. Regression analysis of the measurement was performed separately for male and female since statistically significant different were observed between these two genders. Note that the equations consist of standard error of estimate (SEE) to estimate the deviations of the predicted stature from the measured stature.

Table 3: Linear regression equations for hand length studied in male and female subjects

Variables	Male	Female
N	122	137
Mean stature ± SEM	174.30 ± 0.60	157.70 ± 0.51
Mean hand length ± SEM	18.47 ± 0.09	16.54 ± 0.08
Correlation coefficient	0.69	0.70
Regression coefficient	4.43	5.86
Value of constant	92.43	61.99
Regression equation ± SEE	92.43 + (4.43 × hand length) ± 4.84	87.10 + (4.27 × hand length) ± 3.14

Table 4 shows the extent of reliability of these regression equations derived, by comparing the measured stature and the estimated stature. In both male and female subjects, it was observed that the estimated and actual measured stature were all very close. Paired t-test was performed to determine whether the estimated and measured stature have any statistically significant difference. The result shows that there was statistically significant different between the estimated and measured stature ($p<0.05$).

Table 4: The comparison of predicted stature and measured stature in male and female subjects

Gender	Prediction formula	Measured stature ± SEM	Estimated stature ± SEM	Significant (two-tailed)
Male	Stature = 92.43 + (4.43 × hand length) ± 4.84	174.30 ± 0.60	174.25 ± 0.54	< 0.001
Female	Stature = 87.10 + (4.27 × hand length) ± 3.14	157.70 ± 0.51	157.73 ± 0.46	< 0.001

Comparison for stature estimation between Malay, Chinese and Indian irrespective of gender is shown in Table 5. Indian has the largest stature and hand length among the three races. The difference was significant in Malay when compared to Chinese ($p<0.05$) as well as when Chinese compared to Indian ($p<0.05$).

Table 5: Comparison of stature (cm), hand length (cm) and linear regression equations for stature estimation of Malay, Chinese and Indian

Variables	Malay	Chinese	Indian
N	102	53	104
Mean height ± SEM	163.62 ± 1.02	162.06 ± 0.98	169.15 ± 1.07
Mean hand length ± SEM	17.20 ± 0.14	17.08 ± 0.14	17.88 ± 0.14
Correlation coefficient	0.86	0.82	0.83
Regression coefficient	6.45	5.86	6.14
Value of constant	52.58	61.99	59.23
Regression equation ± SEE	52.58 + 6.45(hand length) ± 5.15	61.99 + 5.86(hand length) ± 4.12	59.23 + 6.14(hand length) ±6.12

The mean values of stature, hand length and the linear regression equation derived for both genders of Malay, Chinese and Indian are shown in Tables 6-8, respectively. The averaged values in males of all three races were higher than their opposite gender. It was also observed that both stature and hand length were significantly larger in male compared to females in all three races ($p<0.05$).

Table 6: Comparison of stature (cm), hand length (cm) and linear regression equation for stature estimation in Malay by gender

Variables	Males	Females
N	46	56
Mean height ± SEM	172.76 ± 0.84	156.11 ± 0.86
Mean hand length ± SEM	18.28 ± 0.12	16.32 ± 0.15
Correlation coefficient	0.63	0.76
Regression coefficient	4.34	4.47
Value of constant	93.34	83.21
Regression equation ± SEE	93.34+4.34(hand length) ± 4.51	83.21+4.47(hand length) ± 4.23

Table 7: Comparison of stature (cm), hand length (cm) and linear regression equation for stature estimation in Chinese by gender

Variables	Males	Females
N	22	31
Mean height ± SEM	168.36 ± 0.84	157.58 ± 1.05
Mean hand length ± SEM	17.91 ± 0.13	16.48 ± 0.14
Correlation coefficient	0.65	0.64
Regression coefficient	2.62	4.89
Value of constant	121.36	77.07
Regression equation ± SEE	121.36+2.62(hand length) ± 1.96	77.07+4.89(hand length) ± 4.61

Table 8: Comparison of stature (cm), hand length (cm) and linear regression equation for stature estimation in Indian by gender

Variables	Males	Females
N	54	50
Mean height ± SEM	178.04 ± 0.85	159.56 ± 0.70
Mean hand length ± SEM	18.86 ± 0.16	16.83 ± 0.13
Correlation coefficient	0.65	0.59
Regression coefficient	3.44	3.25
Value of constant	113.10	104.82
Regression equation ± SEE	113.10+3.44(hand length) ± 4.85	104.82+3.25(hand length) ± 4.03

Table 9 shows the comparison of stature, hand length and linear regression equations derived for estimating the stature of males in Malay, Chinese and Indian. Indian males had the largest stature and hand length among the three races while Malay had the larger stature compared to Chinese. In short, Chinese had the shortest stature and hand length compared to the other two races. There was no significant difference in hand length when compared between Malay-Chinese males and Chinese-Indian males ($p>0.05$) and a significant difference was observed when compared between Malay and Indian males. Meanwhile, the difference in stature was significant when compared between each other ($p<0.05$).

Table 9: Comparison of stature (cm), hand length (cm) and linear regression equations for stature estimation of male subjects in Malay, Chinese and Indian

Variables	Malay	Chinese	Indian
N	46	22	54
Mean height ± SEM	172.76 ± 0.84	168.36 ± 0.84	178.04 ± 0.85
Mean hand length ± SEM	18.28 ± 0.12	17.91 ± 0.13	18.86 ± 0.16
Correlation coefficient	0.63	0.65	0.65
Regression coefficient	4.34	2.62	3.44
Regression equation ± SEE	93.34+4.34(hand length) ± 4.51	121.36+2.62 (hand length) ± 1.96	113.10+3.44(hand length) ± 4.85

Table 10 shows the comparison of stature, hand length and linear regression equation derived for estimating stature of females in Malay, Chinese and Indian. Indian females had the largest stature and hand length of all the three races, while Chinese females had the larger stature compared to Malay females. It was observed that there was no significant difference in hand length between Malay-Chinese females and Chinese-Indian females. A significant difference was observed when compared between Malay and Indian females hand length and no significant difference in stature when compared between Malay-Chinese females and Chinese-Indian females ($p>0.05$). However, there was a significant difference in stature when compared between Malay and Indian females ($p<0.05$).

Table 11 shows the comparison between true (measured) stature and estimated stature from the hand length measurement of all three races. There was a significant difference between the true stature and estimated stature ($p<0.05$).

Table 10: Comparison of stature (cm), hand length (cm) and linear regression e quations for stature estimation of female subjects in Malay, Chinese and Indian

Variables	Malay	Chinese	Indian
N	56	31	50
Mean height ± SEM	156.11 ± 0.86	157.58 ± 1.05	159.56 ± 0.70
Mean hand length ± SEM	16.32 ± 0.15	16.48 ± 0.14	16.83 ± 0.13
Correlation coefficient	0.76	0.64	0.59
Regression coefficient	4.47	4.89	3.25
Regression equation ± SEE	83.21+4.47(hand length) ± 4.23	77.07+4.89(hand length) ± 4.61	104.82+3.25(hand length) ± 4.03

Table 11: Comparison of true stature and estimated stature of the three races

Races	Gender	True stature ± SEM	Estimated stature ± SEM	p-value
Malay	Both	163.62 ± 1.02	163.52 ± 0.91	< 0.001
	Male	172.76 ± 0.84	172.75 ± 0.77	< 0.001
	Female	156.11 ± 0.86	156.16 ± 0.76	< 0.001
Chinese	Both	162.06 ± 0.98	162.07 ± 0.87	< 0.001
	Male	168.36 ± 0.84	168.28 ± 0.46	< 0.001
	Female	157.58 ± 1.05	157.16 ± 0.76	< 0.001
Indian	Both	169.15 ± 1.07	169.01 ± 0.95	< 0.001
	Male	178.04 ± 0.85	177.98 ± 0.84	< 0.001
	Female	159.56 ± 0.70	159.52 ± 0.66	< 0.001

Discussion

Stature is widely used by anthropologist to determine the personal identification of an individual. In light of many mass disaster events frequently increased by years, many studies had been conducted to estimate the stature from various parts of the body. The objective of this study was to determine the correlation between the anthropometric measurement of hand length and the stature as well as whether the races become a variable in influencing the estimation. On top of that, the study was conducted to achieve the stature estimation standards specifically for the Malaysian population composed of various races mainly Malay, Chinese and Indian.

The study has also shown there was a positive correlation between stature and anthropometric measurement of the hand length in males and females subjects. Previous studies also gave the same results as observed in the current study. For example, the study done by Geetha et al. [8] showed that there was statistically significant positive correlation with stature and hand length measurement. This study shows that the difference in values of correlation coefficients of males and females was remarkable.

The results of the present study were in agreement with many other studies where males were significantly bigger than females in stature. Males are genetically bigger or taller than females as indicated by Rastogi et al. [9]. The skeletal growth of males and females vary and the maturity of the bones was observed to be mature earlier in females [10].

The present study shows Indian males have the largest hand length and stature among the three races and Malay have the larger stature compared to Chinese. In short, Chinese had the shortest hand length and stature compared to the other two races. There was no significant difference in hand length when compared between Malay-Chinese males and Chinese-Indian males and a significant difference was observed when compared between Malay and Indian males.

The difference in stature was significant when compared between each other. Indian females have the largest stature and hand length of all the three races. Meanwhile Chinese females had the larger stature compared to Malay females. It was observed that there was no significant difference in hand length between Malay-Chinese females and Chinese-Indian females. A significant difference was observed when compared between Malay and Indian females hand length. There was no significant difference in stature when compared between Malay-Chinese females and Chinese-Indian females. However, it was observed that there was a significant difference in stature when compared between Malay and Indian females.

Previous studies had shown that hand dimensions specifically hand length measurement vary in different races [11-13] and also usually sexually dimorphic [14-15]. These variations may be caused by genetic and environmental factors [16-17]. As a result, the estimation formulae derived for one race and gender could not be applied for other type of race and gender for the stature estimation but only to the population where the data has been collected.

The current study was the first to be conducted in Malaysia on determining the stature estimation standard anthropometric values between three main races in Malaysia. Thus, it would be useful in anthropology fields as well as forensic investigations precisely for Malaysia. Anthropometric techniques have been used widely for stature estimation [18] which is very crucial especially in events such as mass or natural disasters in identifying the victim as stature is one of the important criteria in personal identification [1]. Stature estimation from the hand length measurement in this field could be a great help as it can predict the actual height or stature of an individual with physical or congenital deformities such as scoliosis and kyphosis or contracture and missing legs due to injury [19].

Conclusion

The study provides anthropometric data and formulae for estimation of stature in three major races in Malaysia which could be used as comparison for future studies that may be conducted. However, the estimation formulae need to be authenticated by forensic experts for it to serve as a tool in the estimation of stature. This study revealed that variations were present not only between genders but also among races. Hence, the formulae derived for one race and both genders might not be applicable to other races and gender. Therefore, this research provides useful anthropometric values for stature estimation based on anthropometric measurement of hand length for three main races; Malay, Chinese and Indian.

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