Malays. Appl. Biol. (2016) 45(2): 57–62

DETERMINATION OF STATURE FROM FINGERPRINTS IN MALAYSIAN MALAYS BY REGRESSION ANALYSIS

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Accepted 24 October 2016, Published online 21 December 2016

ABSTRACT

Determination of human stature is an important parameter in person identification. Fingerprints form a valuable physical evidence in crime investigation. The pressure of fingers produced impression on the objects and thus producing fingerprint impression that can be used for person identification. The fingerprints provide useful clue towards narrowing the pool of potentially matching identities. No criminal history record is created for non-offenders and first-time offenders who are out of police view and it is cumbersome to identify them through fingerprint records and hence investigators search for suspects. If the height of the offender is known through fingerprint, it is easy to narrow down the suspects. The arrest is the event that triggers the creation of a criminal history record for a particular case. Literature review shows that very limited studies were conducted in estimating stature from fingerprints and currently there are no population specific standards to determine stature from fingerprints in a Malaysian Malay population. Hence the present study is aimed to derive population specific regression equations to determine the stature in this population.

Key words: Forensic science, stature, fingerprint, Malaysian Malays

INTRODUCTION

Person identity, not only the dead but also the living individual is one of the significant aspects of forensic investigation. Determination of living human stature is an important parameter in person identification in cases like murder, robbery, house breakings, and bomb blasting incidents based on the physical evidence found in the crime scene. Human stature determination is possible using the measurements of different body parts (Ozaslan *et al.,* 2013; Zverev, 2003; Sanli *et al*., 2005; Nataraja Moorthy *et al.,* 2014b). Researchers have been conducting studies on stature determination from hand (Krishan & Abihilasha, 2007a; Nataraja Moorthy *et al.,* 2014c; Jianpin *et al.,* 2012; Nur *et al.,* 2012), handprint (Nur *et al.,* 2012; Melad, 2015), foot (Agnihotri *et al*., 2007; Jaydip & Ghosh, 2008), footprint (Nataraja Moorthy *et al.,* 2014b; Hairunnisa & Nataraja, 2015) and foot outline (Nataraja Moorthy *et al.,* 2014b). Among various modalities in biometrics, such as fingerprints, face, iris, etc., fingerprints are the most widely used and have the longest history in real world law enforcement applications (O'Gorman, 1999). Fingerprint recognition is one of most popular and accuracy Biometric technologies (Le & Ha, 2010). Touching, grasping and manipulating objects are fundamental ways in which humans interact with the surrounding environment. The hands have suitably equipped contact surfaces for protective, sensory and friction functions (Miroslav & Králík, 2007). The recovered fingerprints in the crime scenes are compared through Automated Fingerprint Identification System to fix and identify the offenders (Kaoru, 2005). But when the crime is committed by first offender, it is cumbersome to use the identification system since the fingerprints are not at all recorded and found in the database. The forensic investigator should necessarily go for suspects and to obtain fingerprints for comparison analysis. The height of the persons will provide

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useful information in narrowing down the suspects by the way of inclusion or exclusion and ease the investigation process. Literature review shows that no study on population specific standards for estimating stature from fingerprints was conducted in a Malaysian Malay population. Hence it is aimed to derive population specific regression equations to determine stature from fingerprints of this population. These equations would afford a means of determining stature in crime investigation involving mostly latent (crime scene) fingerprints.

MATERIALS AND METHODS

Sampling area

The study subjects consist of 200 adults Malaysian Malays (100 males and 100 females) and the subjects were from colleges, universities and the general public in Malaysia. Malays are an ethnic group who predominantly inhabit the Malay Peninsula, the east coast of Sumatra and the coast of Borneo and who speak a Malayo-Polynesian language, which is a member of the Austronesian family of languages (Hatin *et al.,* 2011). The participants were confirmed to be descendants from three generations of Malays to ensure that no genetic variation within races disrupted the results as characteristics of fingerprints can be affected not only by the environment but also by the genetic makeup. The age of the participants is ranged from 18 to 40 years. Informed consent and ethical approval were obtained following the standard procedure. Subjects with any apparent hand-related disease, orthopedic deformity or injury were excluded from the study.

Methodology

Stature was measured without head and footwear using a portable body meter measuring device (SECA model 208) following the standard procedure (Nataraja Moorthy *et al.,* 2011, 2014a,b). Considering the diurnal variation, the height of the individual was taken in the evening at a fixed time. The diurnal change in height of a person was indicated as early as 1726 and the shortening in stature during daytime was reported and confirmed by the researchers (Krishan & Vij, 2007b). The cleaned hand was placed on a fingerprint inked plate with mild pressure and then impressed on an A4 size white paper. The thumb was in abducted position and other fingers in extended position (Tang *et al.,* 2012).

The land marks and measurement of fingerprints on the right hand print are depicted in Figure 1. A total of ten anthropometric measurements, five lengths in a left handprint and five lengths in right handprints were taken and recorded. It is the straight distance between the most forwarding projecting points on the tip of the fingerprints (T, I, M, R and L) to the distal digital crease mark (A).

Fingerprint length measurements in right handprint

I. AT – length, measurement taken from anterior point of thumb fingerprint to the distal digital crease
II. AI – length, measurement taken from anterior point of index fingerprint to the distal digital crease
III. AM – length, measurement taken from anterior point of middle fingerprint to the distal digital crease
IV. AR – length, measurement taken from anterior point of ring fingerprint to the distal digital crease
V. AL – length, measurement taken from anterior point of little fingerprint to the distal digital crease

Both left and right hand fingerprint lengths were measurements by using a 250 mm digital sliding caliper (Mitutoyo CD67-S20PS). All fingerprints and participants' information were coded with sample ID for anonymity.

STATISTICAL ANALYSIS

The data were analyzed using PASW Statistics version 22 (Predictive Analytic Software). Karl Pearson's correlation coefficient (R) between various

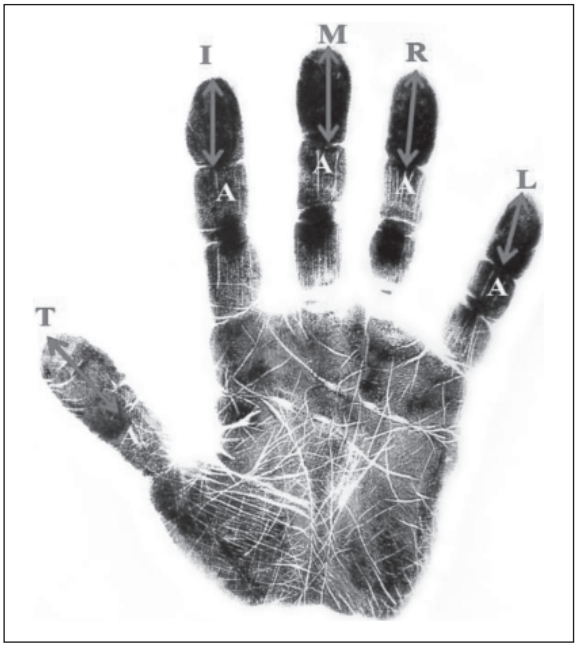

Fig. 1. Land marks and measurements of fingerprints on the right hand print.

fingerprint lengths and stature was obtained. The linear regression analysis method was employed for stature determination from various finger print length measurements since stature estimation from fingerprint length is accurate and reliable with regression analysis.

RESULTS

Table 1 presents the descriptive statistics of stature measurements in males and females of Malaysian Malays. In males, the stature ranges from 157.0 to 184.0 cm (mean 168.71 cm) and in females the stature ranges from 142.0 to 168.0 cm (mean 156.31 cm). The result showed that the mean stature is found to be significantly higher in males than females. The standard deviation (SD) is comparatively lower in males (5.929) than females (6.011). Tables 2–4 present the descriptive statistics of finger print lengths of males, females and pooled samples. The pooled sample shows the combination of male and females measurements. In real crime scenarios, it is cumbersome to identify the gender of the fingerprints. When the gender of the crime scene is fingerprint is unknown, the pooled sample measurements and regression equations may be used to determine stature. Regarding fingerprint length measurements, the mean length of male finger prints is found to be longer than the female finger prints, showing the gender difference. The mean length of thumb fingerprint is found to be longer than other fingerprint lengths both in right and left hands in both genders. The mean left finger print length of the female is slightly longer than the right finger print length. On the contrary, the male mean right fingerprint is slightly longer than the left side. Thus these findings show the existence of bilateral asymmetry in both genders but statistically not significant. The standard deviations values are also low in fingerprint length measurements.

Table 1. Descriptive statistics of stature in males and females of adult Malaysian Malays

Sex	N	Min (cm)	Max (cm)	Mean (cm)	SD
Male	100	157.00	184.00	168.71	5.929
Female	100	142.00	168.00	156.31	6.011

Min: minimum; Max: maximum; SD: standard deviation; N: sample size.

Table 2. Descriptive statistics of fingerprint lengths (cm) in males of adult Malaysian Malays (N=100)

Variable	Right Hand				Left Hand			
	Min	Max	Mean	SD	Min	Max	Mean	SD
AT	2.00	3.50	2.880	0.322	2.00	3.60	2.842	0.299
AI	1.90	3.00	2.220	0.204	1.90	3.00	2.255	0.227
AM	1.90	3.00	2.321	0.247	2.00	3.00	2.347	0.205
AR	1.90	3.00	2.293	0.210	1.90	2.90	2.315	0.201
AL	1.70	2.90	2.122	0.186	1.70	3.10	2.132	0.209

Min: minimum; Max: maximum; SD: standard deviation; N: sample size.

Table 3. Descriptive statistics of fingerprint lengths (cm) in females of adult Malaysian Malays (N=100)

Variable	Right Hand				Left Hand			
	Min	Max	Mean	SD	Min	Max	Mean	SD
AT	1.90	3.60	2.445	0.270	2.00	3.00	2.465	0.241
AI	1.50	2.70	2.002	0.199	1.50	2.40	1.970	0.149
AM	1.50	2.50	2.106	0.178	1.70	2.50	2.074	0.157
AR	1.50	2.60	2.056	0.164	1.60	2.50	2.070	0.173
AL	1.50	2.60	1.930	0.176	1.50	2.20	1.896	0.160

Min: minimum; Max: maximum; SD: standard deviation; N: sample size.

Table 4. Descriptive statistics of fingerprint lengths (cm) in pooled sample of adult Malaysian Malays (N=200)

Variable	Right Hand				Left Hand			
	Min	Max	Mean	SD	Min	Max	Mean	SD
AT	1.90	3.60	2.663	0.368	2.00	3.60	2.653	0.330
AI	1.50	3.00	2.111	0.229	1.50	3.00	2.112	0.239
AM	1.50	3.00	2.214	0.240	1.70	3.00	2.210	0.228
AR	1.50	3.00	2.175	0.222	1.60	2.90	2.193	0.224
AL	1.50	2.90	2.026	0.205	1.50	3.10	2.014	0.220

Min: minimum; Max: maximum; SD: standard deviation; N: sample size.

Table 5–7 show the various linear regression equations derived to determine stature from various fingerprint lengths in both hands and genders. If the gender of the fingerprint is unknown, the regression equations derived for pooled sample as shown in Table 7 may be used to determine the stature. The correlation between stature and fingerprint lengths are shown as Karl Pearson's correlation coefficient (R). The R values are found to be comparatively higher in males (0.272-0.479) when compared with females (0.010-0.293). The coefficient of determination (R^2), the predictive accuracy, is found to be higher in males than females and all measurements are found to be positive and statistically significant (<0.05) for stature determination. The derived linear regression equations to estimate stature from finger print lengths in both males and females show reliability and accuracy since the standard error of estimate (SEE) values are found to be low.

Table 5. Linear regression equations for stature determination through various fingerprint length measurements in adult male Malaysian Malays (N=100)

Side	Variable	R	R^2	Regression equation	SEE
LEFT	AT	0.383	0.147	S=147.106 + 7.614AT	5.503
	AI	0.341	0.117	S=148.642 + 8.913AI	5.601
	AM	0.479	0.230	S=136.243 + 13.846AM	5.230
	AR	0.272	0.074	S=150.112 + 8.047AR	5.734
	AL	0.306	0.093	S=150.244 + 8.676AL	5.673
RIGHT	AT	0.283	0.080	S=153.754 + 5.204AT	5.716
	AI	0.340	0.115	S=146.822 + 9.873AI	5.604
	AM	0.459	0.211	S=143.126 + 11.036AM	5.293
	AR	0.469	0.220	S=138.379 + 13.241AR	5.263
	AL	0.410	0.168	S=140.957 + 13.094AL	5.435

R: correlation coefficient; $R^{2:}$ coefficient of determination; SEE: standard error of estimation; p-value < 0.05.

Table 6. Linear regression equations for stature determination through various fingerprint length measurements in adult female Malaysian Malays (N=100)

Side	Variable	R	R^2	Regression equation	SEE
LEFT	AT	0.010	0.000	S=146.541 + 3.989AT	5.716
	AI	0.166	0.027	S=144.358 + 6.099AI	5.958
	AM	0.119	0.014	S=146.499 + 4.761AM	5.998
	AR	0.225	0.051	S=137.332 + 9.198AR	5.886
	AL	0.293	0.086	S=147.440 + 4.711AL	5.776
RIGHT	AT	0.010	0.000	S=156.929 + 4.396 AT	5.716
	AI	0.166	0.027	S=146.359 + 5.002AI	5.958
	AM	0.119	0.014	S=147.895 + 4.026AM	5.998
	AR	0.225	0.051	S=139.408 + 8.251AR	5.886
	AL	0.293	0.086	S=137.079 + 9.997AL	5.776

R: correlation coefficient; $R^{2:}$ coefficient of determination; SEE: standard error of estimation; p-value < 0.05.

Table 7. Linear regression equations for stature determination through various fingerprint length measurements in pooled samples of Malaysian Malays (N=100)

Side	Variable	R	R^2	Regression equation	SEE
LEFT	AT	0.572	0.327	S=123.023 + 14.900AT	7.068
	AI	0.575	0.331	S=118.883 + 20.674AI	7.050
	AM	0.611	0.373	S=111.590 + 23.057AM	6.822
	AR	0.551	0.304	S=116.122 + 21.179AR	7.191
	AL	0.519	0.269	S=121.745 + 20.264AL	7.367
RIGHT	AT	0.510	0.260	S=130.843 + 11.911AT	7.414
	AI	0.499	0.249	S=123.017 + 18.731AI	7.471
	AM	0.516	0.267	S=121.641 + 18.485AM	7.380
	AR	0.595	0.354	S=112.534 + 23.004AR	6.926
	AL	0.555	0.308	S=115.321 + 23.315AL	7.171

R: correlation coefficient; R^2: coefficient of determination; SEE: standard error of estimation; p-value < 0.05.

DISCUSSION

For person's identity, fingerprint system is widely used throughout the world (Davide *et al.,* 2003). The investigation shows that mean height of a male is found to be larger than females, showing the existance of a statistically significant gender difference in Malaysian Malays. This may be attributed general male-female differences and natural size in both genders. Similar results were observed by the previous researchers in their studies (Krishan & Vij, 2007b; Nataraja Moorthy *et al.,* 2011; Sonali & Ashish, 2012; Hairunnisa & Nataraja, 2013, 2015). Similarly the mean fingerprint length measurements in males are found to be larger than females both in both sides. The age range of the subject in this research is appropriate since stature at 18 years is accepted as adult since average length of the adult's foot and hand is attained by the age of 16 years in males and 14 years in females (Krishan & Vij, 2007b; Nataraja Moorthy *et al.,* 2014a). The result of the study indicated that the correlation coefficient (R) between stature and fingerprint length measurements is higher in pooled sample compared to male and female. The standard error of estimate (SEE) is a measure of the accuracy of predictions and are presented in tables. The derived regression equations from fingerprint length measurements for stature determination in both males and females show reliability and accuracy since the SEE values were found to be low. The coefficient of determination (R^2), the predictive accuracy, is found to be higher in the pooled sample when compared with males and females and all measurements are found to be positive and statistically significant (<0.05) for stature determination.

CONCLUSION

The results of this investigation provided regression equations for stature determination from finger prints in Malaysian Malays. The presence of a single fingerprint (either latent or stained print) in crime scenes is sufficient to estimate during the investigation process. The regression equations derived from the pooled sample can be used to determine stature when the sex of the finger print's owner remains unknown, as in real crime scenarios.It is improper to utilize these regression equations for stature determination to any other population either in Malaysia or any other parts of the world.

ACKNOWLEDGEMENTS

The authors are thankful to all participants who took part in this strenuous study. Thanks are due to Management and Science University for encouraging research and publication.

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