REGRESSION ANALYSIS TO DETERMINE STATURE FROM FINGERPRINTS IN MALAYSIAN CHINESE FOR PERSON IDENTIFICATION

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ABSTRACT

Identification is a key element in any forensic investigation. Stature is an identifying characteristics which provides useful information to solve the crime. Fingerprint is a valuable physical evidence found in crime scenes like burglary, homicide, sexual assault and so on. The present study is aimed to estimate stature from fingerprint measurements in Malaysian Chinese for forensic investigation. The study involved 200 Malaysian Chinese participants (100 males and 100 females) age ranged from 18 to 58 years. Following the standard procedure, the height and handprint were collected from the consented participants. The distal phalange (tip) print was measured using a sliding calipers. The data obtained have been analysed using SPSS software version 22.0 and derived population specific regression equations to estimate stature from fingerprints in Malaysian Chinese. There is a strong positive correlation exists between stature and fingerprint length.

Keywords: Forensic Science, Identification, Stature, Finger print, Malaysian Chinese.

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Introduction

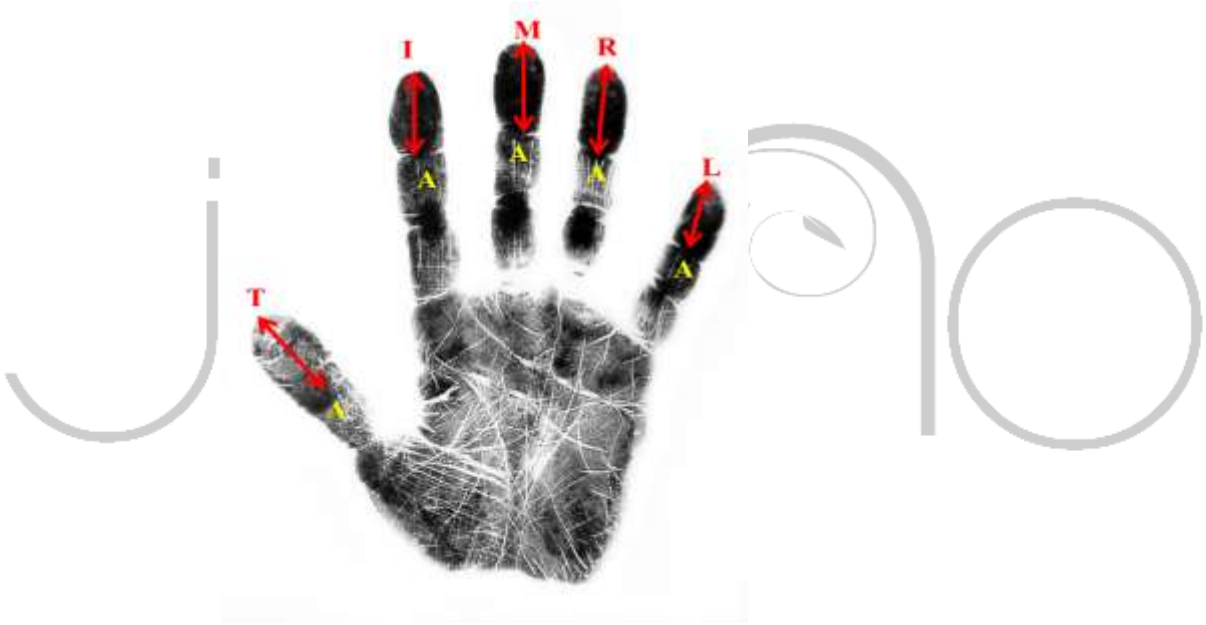
Stature may be determined using the measurements of different body parts (Ozaslan *et al.,* 2003; Zverev, 2003; Sanli *et al.,* 2005; Nataraja Moorthy & Nuranis, 2014; Hairunnisa & Nataraja Moorthy, 2013; Manisha *et al.,* 2008; Ryan & Bidmos, 2007; De Mendonca, 2000). Earlier, the anthropometry-based Bertillon system was invented by French anthropologist Alphonse Bertillon (1853-1914) for the purpose of human identification (Kennedy, 2000;) Fingerprints are permanent physiological features of human beings. It is well known that they are highly distinctive between individuals (Maltoni et al., 2003). Fingerprint forms an important biometric system used throughout the world. Fingerprint is a valuable physical evidence found in crime scenes like burglary, homicide, sexual assault and so on. The investigators or fingerprint experts used to mention crime scene finger prints as "chance finger prints", since the finger prints are left by chance by the perpetrators while committing crime. Stature is an identifying characteristics which provides useful information to solve the crime. Examination of foot (Jahar *et al.,* 2010), footprint (Nataraja Moorthy *et al*.,2014), hand (Sunil *et al.,* 2005), handprint (Melad, 2015), and fingers (Jaytip, 2014) help in estimation of an individual's stature because of the existence of a strong correlation between one's stature and hand, foot size (Nur-Intaniah *et al*., 2012). It is known fact that chance prints are available in most of the crime scenes wherein the tip portion of the impression are mostly found as "latent finger prints' in the indoor crime scenes which are then enhanced by various techniques like applying various fingerprint powders, glues and forensic lights. Fingers are constructed of ligaments (strong supportive tissue connecting bone to bone), tendons (attachment tissue from muscle to bone), and three phalanges (bones). The first bone, closest to the palm, is the proximal phalange; the second bone is the middle phalange; and the smallest and farthest from the hand is the distal phalange. The thumb does not have a middle phalange. Mostly the distal phalanges impression are found in abundant in crime scenes as latent finger prints. Literature review shows no study was conducted on stature determination from distal phalange print (hereafter called "fingerprint" as used by the investigators). It is an accepted fact that the most accurate biological profile is formulated using contemporary population specific standards (Nur-Intaniah, 2012). Hence the present study is aimed to determine stature from various fingerprint length measurements through regression analysis among Malaysian Chinese.

Materials and methods

The study subjects consist of 200 adult Malaysian Chinese (100 males and 100 females) and the subjects were from colleges, universities and general public in peninsular Malaysia. Chinese are largely descendants of immigrants who arrived between the fifteenth and the mid-twentieth centuries from various parts of China (Lee, 2000). The age of the

participants is ranged from 18 to 58 years. Informed consent and ethical approval were obtained following the standard procedure. Subjects with any apparent hand-related disease, orthopaedic deformity or injury were excluded from the study. Stature was measured without head and footwear using a portable body meter measuring device (SECA model 208) following the standard procedure (Nataraja Moorthy, 2013, 2014 a,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 (Whitehouse,1974; Krishan, 2007). 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).

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



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 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 fingerprint to the distal digital crease mark.

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

Results and discussion

Table 1 presents the descriptive statistics of stature measurements in males and females. In males, the stature ranges from 148.0 to 184.0 cm (mean 168.53 cm) and in females the stature ranges from 148.0 to 175.0 cm (mean 159.34 cm). The result showed that the mean stature is found to be significantly higher in males than females. The standard deviation (SD) for male is 7.32 while female is 6.67.

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

Gender	N	Min(cm)	Max (cm)	Mean (cm)	SD
Male	100	148.0	184.0	168.53	7.32
Female	100	148.0	175.0	159.34	6.67

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

Table 2 and 3 present the descriptive statistics of finger print lengths (length measurement taken from anterior point of fingerprint to the distal digital crease). The mean length of male finger prints are longer than the female finger prints showing the gender difference similar to stature. The mean length of thumb finger is found to be longer than other fingerprint lengths both in right and left hands in Malaysian male and female Chinese. The left finger print length is slightly longer than the right finger print length showing the bilateral asymmetry but statistically not significant. The standard deviations are comparatively lesser in left fingerprints than right

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

Variable	Left (cm)				Right (cm)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
AT	2	4.5	2.92	0.685	2.0	4.7	2.87	0.661
AI	2	3.3	2.39	0.379	2.0	3.5	2.39	0.405
AM	2	3.3	2.33	0.376	2.0	3.2	2.34	0.363

AR	2	3.3	2.37	0.389	2.0	3.5	2.38	0.404
AL	2	3.5	2.28	0.323	2.0	3.5	2.28	0.331

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

Table 3. Descriptive statistics of Fingerprint lengths in females of adult Malaysian Chinese (N=100).

Variable	Left (cm)				Right (cm)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
AT	2.0	3.9	2.85	0.451	2.0	3.7	2.76	0.465
AI	2.0	3.0	2.27	0.289	2.0	3.0	2.28	0.292
AM	2.0	3.0	2.25	0.269	2.0	3.0	2.28	0.276
AR	2.0	3.0	2.28	0.298	2.0	3.0	2.29	0.301
AL	2.0	2.8	2.15	0.228	2.0	2.8	2.14	0.226

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

Table 4 and 5 present the linear regression equations to estimate stature from various fingerprint length measurements on left and right hands of both genders. Karl Pearson's correlation coefficient (R) values are found to be higher in males (0.169-0.284) when compared with females (0.006-0.098). 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 estimation. The standard error of estimate (SEE) is a measure of accuracy of predictions. The derived linear regression equations to estimate stature from finger print lengths in both males and females show reliability and accuracy since the SEE values were found to be low.

Table 4. Linear regression equations for stature estimation through various fingerprint length measurements in adult male Malaysian Chinese (N=100)

Side	Variable	R	R^2	Regression equation	SEE
LEFT	AT	0.169	0.029	163.238 + 1.509 AT	7.251
	AI	0.184	0.034	160.018 + 1.637AI	7.231
	AM	0.284	0.081	155.648 + 1.611 AM	7.055
	AR	0.273	0.075	156.322 + 1.615 AR	7.077
	AL	0.206	0.043	157.881 + 1.626 AL	7.199
RIGHT	AT	0.148	0.022	163.810 + 1.655 AT	7.276
	AI	0.202	0.041	159.796 + 1.635 AI	7.205
	AM	0.258	0.066	156.396 + 1.616 AM	7.109
	AR	0.252	0.064	157.660 + 1.622 AR	7.119
	AL	0.195	0.038	158.708 + 1.630 AL	7.216

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

Table 5. Linear regression equations for stature estimation through various fingerprint length measurements in adult female Malaysian Chinese (N=100)

Side	Variable	R	R^2	Regression equation	SEE
LEFT	AT	0.049	0.002	161.411 + 1.607 AT	6.696
	AI	0.011	0.000	159.939 + 1.597AI	6.704
	AM	0.049	0.002	162.078 + 1.609AM	6.696
	AR	0.098	0.010	154.356 + 1.565AR	6.671
	AL	0.068	0.005	155.034 + 1.570AL	6.689
RIGHT	AT	0.013	0.000	160.604 + 1.600AT	6.702
	AI	0.024	0.001	162.405 + 1.610AI	6.693
	AM	0.056	0.003	158.641 + 1.589AM	6.703
	AR	0.014	0.000	159.706 + 1.595AR	6.704
	AL	0.006	0.000	159.706 + 1.595AL	6.704

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

Stature is found to be larger in males than females, showing the existence of a statistically
significant sex difference in Malaysian Chinese. This may be attributed to general male and female differences and natural size in both sexes and this finding is in accordance with the previous studies (Hairunnisa and Nataraja Moorthy, 2013; Nataraja Moorthy and Nuranis, 2014). The age range of the subject is considerably appropriate since the researchers have indicated that the male attained adult by the age of 16 years and female by the age of 14 years (Anderson *et al.,* 1956 and Blais *et al.,* 1956).

Conclusion

The results of this investigation provided regression equations for stature determination from finger prints in Malaysian Chinese. Even the presence of single finger print found in crime scenes is enough to estimate the stature for the purpose of inclusion and exclusion during the investigation process. It is erroneous to utilize these regression equations for stature determination to any other population either in Malaysia or any other parts of the world.

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Conflict of interest

The authors have no conflict of interest to declare.

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