

Determination of Stature from Fingerprint Anthropometry among Malaysian Indians for Crime Scene Application

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ABSTRACT

KEYWORDS

*Forensic Science,
Forensic Anthropology,
Stature,
Fingerprint,
Malaysian Indians.*

Forensic crime scene investigators depend on physical evidence found at the crime scene to solve the mystery. Impression evidence found at crime scenes is in either latent or visible forms. Fingerprints and footprints are evidence left unintentionally by the perpetrators during their crime operations. There are instances wherein smudged fingerprints and handprints are found at the scenes without ridge characters and considered unfit for comparison. In this situation, the fingerprint anthropometric technique is used to determine stature, followed by identification considering the ethnicity. Hence, the present study aimed to predict stature from fingerprint anthropometry among Malaysian Indians with ages ranging from 20 to 50 years old. The study recruited consented 200 subjects and collected fingerprints and stature measurements. The data were analyzed statistically, and developed regression formulae to determine stature from fingerprint measurements. The mean stature of males and females was 171.43 and 159.39 cm, respectively. The mean fingerprint lengths of males ranged from 2.16 to 2.94 cm, while females ranged from 1.92 to 2.62 cm. In conclusion, the study developed a biological profile for stature determination from fingerprint anthropometry among Malaysian Indians.

Introduction

Forensic science starts from a crime scene, and this science is not intended to establish the guilt or innocence of individuals. Instead, it creates relationships between collectable and observable physical clues found at crime scenes, which are correspondingly used to relate to suspects or deduce the events in the crime scenes

(Jayaprakash, 2023). Pal Kirk stated that only the intelligent crime scene investigator can recognize observable evidence, interpret it appropriately and connect the evidence and perpetrator (Kirk, 1974). Physical evidence is a silent witness found at the crime scenes, and different kinds of physical evidence, including impression evidence, can tell about the crime scene. The impression evidence includes footprints (Nataraja et al., 2014) and fingerprints (Nataraja and Nuranis, 2016) left unintentionally by the crime operators, which help crime investigators to fix the offenders. Fingerprints afford an infallible means of personal identification since the fingerprint is unique because of its ridge characteristics, and no two persons have the same fingerprint, including identical twins (Mark and Philemon, 2022). The corresponding author (herein as TN), also a former Government Forensic Crime Scene Investigator in India, learned to lift the latent fingerprints in crime scenes and studied the ridge characteristics, sometimes even after enhancement

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for individual identification. Enhancement technique is used even in charred document analysis (Nataraja and Keethaambigai, 2016).

During crime scene investigation, particularly in burglary and housebreaking cases, TN noticed the smudged fingerprints without ridge characteristics. They could not compare them with suspects and considered them unfit for analysis, thus losing the chance of identification through fingerprints (Nataraja and Povaneswari, 2018). Offenders tend to wear gloves to avoid leaving fingerprints during the offence. Still, complete glove impressions of finger impressions with well-demarcated phalangeal creases can unconsciously be left on the surfaces of objects when touching, holding, pushing or pulling (Fisher and Fisher, 2012; Melad, 2019). Also, currently, researchers are showing interest in determining stature (Nataraja et al., 2014), body weight (Nataraja et al., 2021) and gender (Nataraja et al., 2019) through fingerprint and footprint anthropometry, even in the absence of ridge characteristics, thus easing the investigation process (Nataraja et al., 2022a).

Alphonse Bertillon, a French Police Officer and Biometric researcher in the 1890s, first introduced the anthropometric technique. Thus, fingerprint length measurements of the offenders can be achieved even without ridges and proceed with the scientific investigation. This study investigates the relationship between stature and fingerprint length among Malaysian Indians.

Materials and Methods

The participants are Indians born and living in Malaysia and most Malaysian Indians living in Peninsular Malaysia who migrated from India during the British era in the early 19th century. This research was approved by the University Research Ethics Committee (FYP-FHLS-DHS-2022-0128). Considering the sample size calculation, 200 Malaysian Indians were chosen for this research, including 100 males and 100 females. The subjects' ages ranged from 20 to 50 years, and the participants with hand-related injuries and deformities were excluded.

The participants were advised to clean their hands with a hand wash solution and remove headwear and footwear. Using a portable stadiometer, the height measurements (in cm) were made from the subjects and recorded. In a clean glass plate of 30 x 30 cm size placed on a table, fingerprint ink was uniformly smeared using a fingerprint roller and the left hand of a subject was advised to place on the inked plate with mild pressure. The inked hand was then advised to lift slowly and place on an A4 size white paper placed at the side of the glass plate, and thus the handprint was transferred with fingerprints.

The procedure was repeated with the right hand and continued for all other participants. The fingerprint length is the straight distance between the 1st crease (A) and the anterior (distal) tip of each fingerprint (T, I, M, R, L), as shown in figure (1).

The fingerprint length measurements were taken from each handprint, AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length and AL: Little fingerprint length. Five fingerprint length measurements were made from each hand, with ten measurements from each subject.

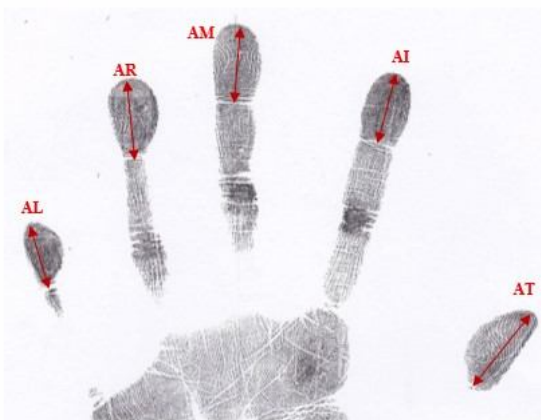


Fig. (1) Landmarks on left fingerprint length measurements in a handprint of a Malaysian Indian. AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length, and AL: Little fingerprint length.

Statistical analysis

SPSS statistical software (version 28.0.1) and Microsoft Excel 13 were used to analyse the data. Descriptive statistics such as mean and standard deviation were calculated. An analysis of covariance using the general linear model (GLM) was conducted to test whether sex has an effect on the stature and fingerprint anthropometry. A simple linear regression model was used to estimate the stature from fingerprint anthropometry. Pearson correlation coefficient (R) was used for establishing the relationship between stature and fingerprint anthropometry. The R -value indicates the strength and direction of the relationship between the stature and fingerprint anthropometry. The coefficient of determination (R^2), standard error of estimation (SEE),

and p values were also used to describe the stature prediction from fingerprint measurements from regression equations. R^2 interprets the proportion of the stature variance estimated from the fingerprint anthropometry.

Results

The stature measurements showing the minimum, maximum and mean values were presented in table (1). The height of males ranged from 159 to 182 cm with a mean value of 171.43 cm, while the females' height ranged from 138 to 175 cm with a mean value of 159.39 cm. The mean stature of males was found to be higher than that of females. The standard deviation (SD) value was comparatively lower in males (5.26) than in females (7.19).

Table (1): Descriptive statistics of stature in males and females of adult Malaysian Indians (n:200).

Sex	n	Min (cm)	Max (cm)	Mean (cm)	SD
Male	100	159.00	182.00	171.43	5.256
Female	100	138.00	175.00	159.39	7.191

Min: Minimum, Max: Maximum, SD: Standard Deviation, n: number.

The results in tables (2 and 3) show the various left and right fingerprint length measurements for both genders. Table (2) shows that males' mean left fingerprint lengths (range:2.16-2.94 cm) are longer than females (range:1.94 - 2.62 cm). Table (3) shows that males' mean right fingerprint lengths (range:2.16 -

2.94 cm) are longer than females (range: 1.92 - 2.62 cm), showing the natural gender variation.

Interestingly, the study shows the bilateral asymmetry in the fingerprints of both genders. This means the right-hand fingerprint lengths and left-hand fingerprints are not similar.

Table (2): Descriptive statistics of LEFT fingerprint lengths (cm) in males and females of Malaysian Indians (n: 200)

Variables	Males (n: 100)				Females (n: 100)			
	Min (cm)	Max (cm)	Mean (cm)	SD	Min (cm)	Max (cm)	Mean (cm)	SD
AT	2.50	3.50	2.94	0.25	2.00	3.30	2.62	0.25
AI	1.80	2.60	2.25	0.19	1.70	2.50	2.07	0.18
AM	2.00	3.00	2.42	0.25	1.90	2.50	2.16	0.17
AR	2.00	3.00	2.44	0.22	1.90	2.50	2.18	0.18
AL	1.90	2.70	2.16	0.19	1.60	2.30	1.94	0.17

AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length, AL: Little fingerprint length, Min: minimum, Max: maximum, SD: standard deviation, n: number.

Table (3): Descriptive statistics of RIGHT fingerprint lengths (cm) in males and females of Malaysian Indians (n: 200)

Variables	Males (n: 100)				Females (n: 100)			
	Min (cm)	Max (cm)	Mean (cm)	SD	Min (cm)	Max (cm)	Mean (cm)	SD
AT	2.50	3.50	2.94	0.25	2.00	3.30	2.62	0.25
AI	1.80	2.60	2.25	0.19	1.70	2.50	2.07	0.18
AM	1.90	3.00	2.43	0.24	1.80	2.70	2.19	0.19
AR	2.00	3.00	2.40	0.23	1.70	2.50	2.15	0.18
AL	1.80	2.70	2.16	0.21	1.60	2.30	1.92	0.18

AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length, AL: Little fingerprint length, Min: minimum; Max: maximum; SD: standard deviation; n: number.

Tables (4 and 5) present the bilateral linear regression equations to predict stature from fingerprint lengths among male and female Malaysian Indians. This study developed ten regression equations for males and ten for females to determine stature in the study population. A statistically significant correlation exists between stature and various

fingerprint lengths ($p < 0.05$). The coefficient of determination (R^2), the predictive accuracy, is found to be statistically significant and positive ($p < 0.05$) for stature determination. The standard error of estimate values is higher in females (6.53 - 7.18) than in males (5.04 - 5.27).

Table (4): Regression equations to determine stature from fingerprints anthropometry among male Malaysian Indians

FP length h	Right fingerprints				Left fingerprints			
	Regression equations	R ²	p	SEE	Regression equations	R ²	p	SEE
AT	S=170 + 0.48AT	0.001	> 0.05	5.28	S=163+ 2.90AT	0.028	>0.05	5.21
AI	S=153 + 8.4AI	0.091	< 0.05	5.04	S=165+ 2.97AI	0.016	>0.05	5.24
AM	S=166 + 2.28AM	0.011	>0.05	5.25	S=164+ 3.17AM	0.022	>0.05	5.22
AR	S=167 + 2.03AR	0.008	>0.05	5.26	S=149+ 9.3AR	0.148	<0.05	4.88
AL	S=168 + 1.74AL	0.005	>0.05	5.27	S=152+ 8.97AL	0.105	<0.05	4.99

FP: finger print, AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length, and AL: Little fingerprint length

Table (5): Regression equations to determine stature from fingerprints anthropometry among female Malaysian Indians

FP length	Right fingerprint				Left fingerprints			
	Regression equations	R ²	p	SEE	Regression equations	R ²	p	SEE
AT	S=146+5.0AT	0.030	>0.05	7.12	S=152+3.75AT	0.019	>0.05	7.16
AI	S=150+4.42AI	0.013	>0.05	7.18	S= 147+6.01AI	0.021	>0.05	7.15
AM	S=145+6.7AM	0.033	>0.05	7.11	S=129+14.22AM	0.113	<0.05	6.81
AR	S=142.8.0AR	0.042	<0.05	7.08	S=129+13.98AR	0.127	<0.05	6.75
AL	S=140+10.2AL	0.06	<0.05	6.99	S=125+17.77AL	0.183	<0.05	6.53

FP: finger print, AT: Thumb fingerprint length, AI: Index fingerprint length, AM: Middle fingerprint length, AR: Ring fingerprint length, and AL: Little fingerprint length.

Discussion

Malaysian Indians are descendants of those who migrated from India during the British Malaya era from the 19th to mid-20th centuries. Malaysian Indians have the third highest population (6.6%), following Chinese (22.9%) and Malays (69.7%) in Malaysia. Malaysia is a Southeast Asian country occupying parts of the Malay Peninsula and Malaysian Borneo Island as west and east Malaysia (Nataraja et al., 2018). The age of the subjects ranged between 20 and 50 years, i.e., adults, as indicated by the earlier researchers (Hairunnisa and Nataraja, 2013).

Fingerprints are the undeniable forensic evidence found primarily on burglary, robbery, homicide and sexual assault scenes. Based on my (corresponding author) crime scene visit and investigation experiences (Nataraja et al., 2022a; Nataraja et al., 2022b), instances wherein smudged fingerprints and impression within gloves were found on the objects at the scenes without any ridge characteristics. In these incidents, the investigating officers used to reject these prints, considering it unfit for comparison and thus, the investigation lost the chance of person identification. To avoid this handicap, the fingerprint anthropometric technique was used to determine stature followed by person identification considering ethnicity since anthropological profiling may vary among different populations.

Anthropological researchers have shown that a person's height and body parts are closely related. The stature varies based on the population since ethnicity plays a vital role in stature determination. Even within India, ethnic variation in height is reflected depending upon the states of origin, culture, environment and food habits since India is a multi-racial and multi-ethnic country (Khandpurkar and Radke, 2012; Garg and Chauhan, 2016; Ritesh et al., 2018; Prasa et al., 2019; Atul and Harsha, 2022).

In the present study, the mean height of males and females are 171.43 cm and 159.39 cm, respectively. In comparison, the mean stature of Bangladeshi males and females are 168.61 cm and 155.27 cm (Asadujjaman et al., 2019), relatively different from the present study population. The

Pakistan Punjabi population's mean height is 173.42 cm for males and 162.08 cm for females (Asgar et al., 2021). The mean height of the Minang population in Indonesia for males and females is 163.085 cm and 152.39 cm respectively (Haslinda and Nataraja, 2020), thus reflecting ethnicity effect on height.

Higher stature in males compared to females can be noticed in all previously mentioned studies. Similarly, fingerprint length is longer in males than in females. This may be attributed to both sexes' general male-female differences and natural size (Hairunnisa and Nataraja, 2013).

Interestingly, the present study shows bilateral asymmetry between the right- and left-hand fingerprint lengths of both genders. Bilateral asymmetry in different finger and handprint measurements was previously reported by Ishak et al. (2011) and Zulkifly et al. (2018).

The present results showed a statistically significant correlation between stature and fingerprint lengths. Ten regression equations were derived. Thus, every single print can be used to estimate stature with the standard error of estimate (SEE) values ranging between 6.53 and 7.18 in females and 5.04-5.27 in males. Many previous studies in different populations correlated hand and fingerprint measurements to stature e.g. Ahemad and Purkait (2011) in central Indian, Ishak et al. (2011) in Western Australian population, Paulis (2015) in Egyptians, Zulkifly et al. (2018) in Malaysians and Asadujjaman et al. (2021) in Bangladeshi populations.

Forensic science starts at the crime scene with the presence of physical evidence, and it is the only magic to solve the crime mystery. Paul Kirk commented that the offender cannot leave the place without leaving any evidence, and a keen crime scene examination is required to trace the same (Kirk, 1974).

Conclusion

The present study developed a population-specific forensic standard for stature determination from fingerprint anthropometry among Malaysian Indians. This study highlights that even a single fingerprint without ridge characteristics found at the crime scenes can be used to determine the stature from fingerprint anthropometry, followed by personal identification.

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Conflicts of interest

The authors declare no conflicts of interest.

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