

Formulae Development to Determine Living Body Weight from Hand Anthropometry among Tagalog People in the Philippines

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Abstract:

Physical evidence, called objective material evidence, can bridge the crime and criminals. Stature, gender, and body weight determination play a role in establishing the biological profile of the unknown in forensic investigation. Ethnicity or population should be considered when conducting anthropological research. This study is an international collaborative research, with sample collection in the Philippines and data analysis in Malaysia. The present study examines the relationship between body weight and hand anthropometry among Tagalog people in the Philippines. Volunteers with hand-related disorders and deformities were excluded from the study. The study recruited 180 male and 180 female Tagalogs and recorded the body weight and five hand length measurements from each hand. The collected data were analyzed statistically, and formulae were developed for body weight determination from hand anthropometry in the study population.

Keywords: Forensic Science, Body weight, Hand anthropometry, Tagalog, Philippines.

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Introduction

Forensic investigators are roaming the crime scenes to locate physical evidence, the only magic wand to solve crimes scientifically. Physical evidence, also called real material evidence, can bridge the crime and criminals. Physical evidence is not only the impression evidence like fingerprints, footprints, toe prints, hair, paint flakes, etc. but also the human body parts like the hand, foot, head, arm and bones. Impression evidence is mainly found in burglary, sexual assault and homicide crime scenes, while human body parts and bones are found in mass disaster incidents like manmade and natural calamities. This physical evidence in the crime scenes may present in the form of fingerprint (Nataraja, 2021), footprint (Nataraja, 2021), handprint (Nataraja and Tee, 2016), hair (Nataraja and Jessica, 2015), charred document, firearms (Mohammad *et al.*, 2016), fire residue (Nataraja, 2021) and many others.

The impression evidence left by the criminals is used to develop regression formulae to determine basic characteristics viz. stature (Nataraja *et al.*, 2014), body weight (Nataraja *et al.*, 2021), and gender (Nataraja and Devina, 2021) as the initial step of investigation for personnel identification. Body weight and body height are the basic characteristics used to describe another person. As a part of the biological profile, body mass can aid personal identification (Zuzana *et al.*, 2018). The literature review shows limited studies on body weight determination from the physical evidence. Hence, the present study aims to determine Tagalog people's body weight in the Philippines by hand anthropometry.

Methodology

The corresponding author, Prof. Nataraja Moorthy (TN), designed the research and also visited the Philippines to supervise the sample collection. Mr. Lao Dinglasa Ivan Nikkimor, an MSU Forensic Science student of Filipino origin, collected the samples in the Philippines. Management and Science University (MSU) Ethic Committee approved this research. The data was examined at MSU, Shah Alam, Selangor, Malaysia, under the supervision of the corresponding author.

The study recruited 360 consented adult Tagalog people, born and living in the Philippines with 180 males and 180 females. People with hand-related injuries or deformities were excluded from this study. The subject's living body weight (kg) was taken using a SECA 803 digital body weighing scale, and five hand length measurements were recorded using

vernier callipers. Hand length (cm) is the direct length measurement from the mid-point of the distal transverse crease of the wrist joint (H) to the most anterior projection of the skin of all fingers (T: Thumb, I: Index, M: Middle, R: Ring, L: Little), as shown in Fig. 1.

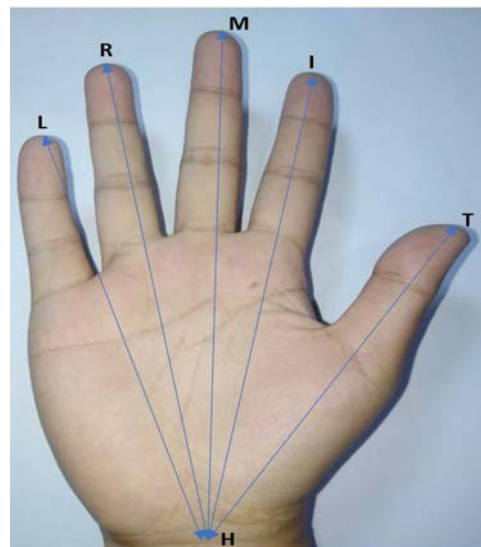


Figure No. 1: Landmarks and hand length measurements

The measured data were examined statistically using SPSS software version 23, and linear regression formulae were developed to determine body weight from hand anthropometry among Tagalog people. The findings were presented in the form of tables and figures.

Result

The descriptive statistics of living body weight for males and females of Tagalog are shown in Table 1. The mean body weight of the male subjects (65.61 kg) was higher than that of the female subjects (55.31 kg). The standard deviation (SD) is lower in females (8.64) than in males (12.69).

Table No. 1: Descriptive statistics of body weight of Tagalos in the Philippines

Gender	Range (in kg)	Mean (in kg)	Standard Deviation
Male	41.60 – 115.30	65.61	12.69
Female	41.90 – 79.30	55.31	8.64

Table 2 shows various hand length measurements of male Tagalog people in the Philippines, and the mean

middle hand lengths (HM) are longer in both the left (18.22 cm) and right (18.10 cm) hands, while the thumb hand length is the shortest on the left side (12.93 cm) and right (12.78 cm) side. The standard deviation (SD) values are low on both sides (0.77-1.04) and reflect better accuracy. The left and right sides are not the same but not statistically significant.

Table No. 2: Various hand-length measurements of male Tagalogs in the Philippines

Lengths	Left hand			Right hand		
	Range	Mean	SD	Range	Mean	SD
HT	11.05 - 14.90	12.93	0.79	11.42-14.86	12.78	0.77
HI	15.00 - 19.89	17.25	0.98	14.95-19.22	17.30	0.95
HM	16.17 - 21.01	18.22	1.01	15.46-21.28	18.10	1.04
HR	15.03 - 20.52	17.28	0.99	14.77-19.64	17.02	0.90
HL	13.20 - 17.53	14.93	0.90	12.81-16.79	14.59	0.87

HT: hand length with thumb; HI: hand length with index finger; HM: hand length with middle finger; HR: hand length with ring finger; HL: hand length with little finger; SD: Standard Deviation

Table 3 presents various hand-length measurements of female Tagalog people in the Philippines. As in males, the mean middle hand lengths (HM) are longer in both the left (16.76 cm) and right (16.70 cm) hands, while the thumb hand is the shortest on the left side (11.72 cm) and right (12.02 cm) side. The standard deviation (SD) values are low on both sides (0.57-0.84), reflecting better accuracy in the measured values. The left and right sides are not the same, but not statistically significant.

Table No. 3: Various hand-length measurements of female Tagalogs in the Philippines

Lengths	Left hand			Right hand		
	Range	Mean	SD	Range	Mean	SD
HT	10.06-13.66	11.72	0.57	10.05-13.52	12.02	0.66
HI	14.16-17.94	15.92	0.79	13.24-17.96	15.96	0.83
HM	14.70-18.91	16.76	0.84	14.58-18.58	16.70	0.80
HR	14.20-17.82	15.81	0.77	13.39-17.96	15.67	0.83
HL	11.12-15.57	13.55	0.81	11.15-17.52	13.35	0.84

HT: hand length with thumb; HI: hand length with index finger; HM: hand length with middle finger; HR: hand length with ring finger; HL: hand length with little finger; SD: Standard Deviation

The statistical analysis shows that the standard deviation values are very low on the left and right sides (0.57-0.84). As in males, females' left-hand and right-hand lengths show minor differences in length measurements and are not statistically significant. Hence, the right- and left-hand lengths were integrated as only 'hand lengths, without mentioning the sides for males and females to overcome certain limitations for identification (Prabhu and Poornima, 2015).

Table 4 presents the integrated hand lengths in male and female Tagalogs. Here again, the middle hand lengths of males (18.16 cm) and females (16.73 cm) are longer, while thumb hand lengths are shorter in males (13.10 cm) and females (11.87 cm). All five hand lengths of males are longer than females and are statistically significant. The standard deviation values of females are smaller (0.57-0.79) than males (0.73-0.95).

Table No. 4: Integrated left- and right-hand length measurements of male and female Tagalogs in the Philippines

Lengths	Male			Female		
	Range	Mean	SD	Range	Mean	SD
HT	11.59 - 14.78	13.10	0.73	10.06 - 13.49	11.87	0.57
HI	15.11 - 19.49	17.28	0.92	13.99 - 17.63	15.94	0.78
HM	15.93 - 20.98	18.16	0.95	14.77 - 18.68	16.73	0.79
HR	15.16 - 20.08	17.15	0.91	13.80 - 17.89	15.74	0.76
HL	13.08 - 16.92	14.76	0.83	11.29 - 16.25	13.45	0.78

HT: hand length with thumb; HI: hand length with the index finger; HM: hand length with the middle finger; HR: hand length with the ring finger; HL: hand length with the little finger; SD: Standard Deviation

Table 5 presents the regression formulae to determine body weight from integrated hand lengths for males and females Tagalog people in the Philippines. The correlation between body weight and hand length is positive and statistically significant for body weight prediction. The correlation coefficient (R) values in males are higher (0.33-0.38) in all hand lengths than in females (0.24-0.30) hand lengths. R² is the coefficient of determination for body weight prediction, and the predictive accuracy is statistically significant. The standard error of estimate (SEE) values are higher in males (11.71-11.99) than in females (8.26-8.41) of the Tagalog people in the Philippines.

Table No. 5: Linear regression formulae to determine body weight from the integrated left- and right-hand length of male and female Tagalogs in the Philippines

Male				Female			
Formulae	R	R ²	SEE	Formulae	R	R ²	SEE
W = 6.673HT - 21.822	0.38	0.15	±11.75	W = 11.917 + 3.655HT	0.24	0.06	±8.41
W = 5.095HI - 22.424	0.37	0.14	±11.82	W = 9.086 + 2.900HI	0.26	0.07	±8.37
W = 5.212HM - 29.026	0.39	0.15	±11.71	W = 9.324 + 2.749HM	0.25	0.06	±8.39
W = 5.390HR - 26.819	0.39	0.15	±11.74	W = 8.365 + 2.982HR	0.26	0.07	±8.36
W = 5.065HL - 9.169	0.33	0.11	±11.99	W = 10.558 + 3.326HL	0.30	0.09	±8.26

Discussion

The crime scene is a treasure of information with visible and invisible physical evidence found at the scenes (Nataraja Moorthy, 2020). Only knowledgeable crime scene investigators with the presence of mind alone can identify the evidence and solve the mystery under crime scene reconstruction (Nataraja *et al.*, 2021; Nataraja, 2022). Tagalogs are the second highest population in the Philippines, and many speak the Tagalog language (Nataraja, 2021). The deceased is the most valuable piece of potential evidence at any death scene (Vinod and Sarthak, 2017). The examination of a death scene, in particular, a highly decomposed dead body and dismembered body parts, the crime scene visit by experts from Forensic Science and Forensic Medicine provides more information to the police officers at the crime scene itself (Nataraja, 2023). In this research, the mean body weight of males and females is 65.61 kg and 55.31 kg. Literature review shows that the mean body weight of East Malaysia populations like Iban

population with males: 55.6 kg, females: 52.3 kg (Nataraja and Hairunnisa, 2016), Melanau population with males: 58.7 kg, females: 49.4kg (Nataraja and Hairunnisa, 2016), Bidayuh population with males: 63.9 kg, females: 54.6 kg (Nataraja and Hairunnisa, 2017), and Slovak population with males: 78.27kg, females: 58.16 kg (Zuzana *et al.*, 2018) are different from the body weight of present study population, thus reflecting the ethnic variation. Many researchers have used only one hand length with the middle finger for stature and body weight determination. This study used all hand lengths so that the presence of partial hands or with only one hand length is sufficient for body weight determination. In the present study, the middle hand length of males is 18.22 cm on the left side and 18.10 cm on the right side. In the Minang population in Indonesia, the middle hand length of males is 17.40 cm on the left side and 16.89 cm on the right side (Nataraja *et al.*, 2021). The Bangladeshi population study reported that the middle hand lengths of males on the left and right sides were 18.51 and 18.48 cm (Asadujjaman *et al.*, 2019), while hand lengths on Turkey population of males on the left and right sides

were 19.01 cm and 17.74 cm (Ahmet *et al.*, 2020). Hence, the body weight and hand length measurements of the present study population differ from those of other populations, thus reflecting ethnic variation.

Conclusion

The research concluded by developing regression formulae to determine living body weight from hand anthropometry among the Tagalog population in the Philippines. The finding applies to the Tagalog population only and is unsuitable for other populations.

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