

## REGRESSION ANALYSIS TO DETERMINE STATURE FROM HAND ANTHROPOMETRY AMONG ILOCANO POPULATION IN PHILIPPINES FOR PERSON IDENTIFICATION

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### ABSTRACT

Stature determination aids the person identification during forensic investigation. The human hand research is the current topic of interest among forensic scientist, forensic medicine experts and anthropologists. Based on sample size analysis, the study involved consented 60 males and 60 females, age ranged from 18 to 55 years old. Stature and hand lengths measurements were made with Stadiometer and Vernier Calipers for analysis. From each participant, ten hand length measurements, five from left and five from right hands were taken. The five length measurements in left hand are the inter-distance between the distal transverse crease of the wrist (LH) and tip of thumb (T), index finger (I), middle finger (M), ring finger (R) & little finger (L), as abbreviated LHT, LHI, LHM, LHR and LHL. Similarly, the right hand lengths indicated as RHT, RHI, RHM, RHR, and RHL. The data were statistically analyzed by using SPSS software, version 23 and column chart. The information about age, gender, name, and place of origin of the participants was coded for easy reference. This study finally developed regression equations to determine stature from hand anthropometry among Ilocano population in Philippines for person identification

**Keywords:** *Forensic Science, Stature, Hand Anthropometry, Ilocanos, Philippines*

### INTRODUCTION

Human hand research is a hot topic among forensic scientists, forensic medicine experts and anthropologists [1]. Fatality identification is a pivotal problem in forensic investigation [2]. Stature prediction from highly decomposing bodies and dismembered body parts is one of the biggest issues during forensic investigation [3],[4].

Stature, age, sex, and ancestry helps in narrowing down the pool of the possible victims and provide useful clues in person identification [5], [6], [7].

Wildlife forensic experts are also working for identification of animals [8] through physical evidence left by the animals such as impressions, hair, tissue and blood

stain etc. [9]. Researchers have established the existence of relationship between stature and human body parts like hand, finger, foot, trunk, and bones, hence the stature can be predicted from hand anthropometry [10]. Globally researchers are showing interest in stature determination from hand [3] and handprint [11] anthropometry based on populations and ethnics in forensic perspective. Literature review shows the non-availability of standards relating stature and hand anthropometry among Ilocano population in Philippines. Hence, this investigation developed population specific regression formulae to determine stature from hand anthropometry of the study population for forensic application.

## RESEARCH METHODS

### Materials and Methods

Based on sample size calculation, the study recruited 60 males and 60 females of adult Ilocanos, an indigenous ethnic group living in Philippines. These subjects have consented their participation in this study and MSU ethical committee had approved this research to proceed. The age range of the participant is from 18 to 55 years since stature at 18 years, accepted as adult in human beings [10]. The stature of the participants was measured with a portable Stadiometer and hand lengths with Vernier calipers and recorded the data. From each hand, measured five hand length measurements with a total of 10-hand length per subject, along with stature and recorded the data.

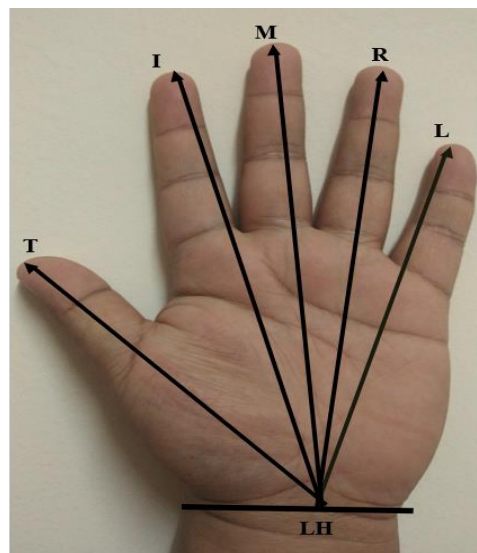


Figure 1. Landmarks and various hand length measurements

The five length measurements in the left hand are the inter-distance between the distal transverse crease of the left wrist (LH) and tip of 1. Thumb (T), 2. Index finger (I), 3. Middle finger (M), 4. Ring finger (R) and 5. Little finger (L), abbreviated as LHT, LHI, LHM, LHR and LH (Fig 1). Similarly, the right hand lengths, abbreviated as RHT, RHI, RHM, RHR, and RHL. The data were statistically analyzed by using SPSS software, version 23 and developed regression formulae for stature prediction. Bar graphs pictorially presented the gender and hand length variations and presented the results in tables. The participants' information, such as age, gender, name, and place of origin, as coded with sample ID for anonymity.

## RESULTS and DISCUSSION

### Results

Table 1 presents the stature and related information such as sample size (N), minimum (min) and maximum (max) stature of the subjects and standard deviation (SD).

**Table 1.** Stature of known and unknown gender among Ilocano population in Philippines.

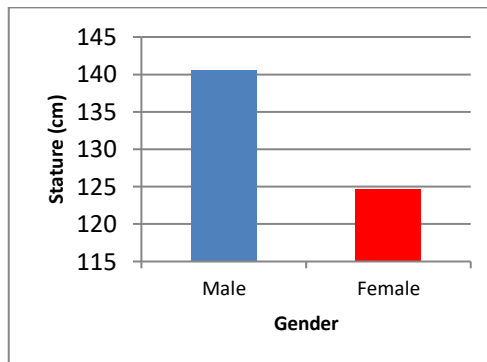
Variable	N	Min	Max	Mean	SD
Male	60	126	151	140.57	6.21
Female	60	114	135	124.75	5.12
Unknown gender	120	114	151	132.66	9.76

N- Sample size; Min – Minimum; Max- Maximum; SD-Standard deviation

The result in Table 1 shows that the stature of male ranged from 126 cm to 151 cm with a mean value of 140.57 cm while female stature ranged from 114 cm to 135 cm (mean 124.75 cm). The mean value for unknown gender (pooled male and female sample) is 132.66 cm. Pooled sample is the combination of male and female subject became unknown gender, as found in real crime scenarios.

Figure 2 shows the male-female stature variation among the study population.

**Figure 2.** Bar graph showing the gender variation in stature



Tables 2-4 present the right and left hand lengths among male, female and unknown gender of Ilocanos in Philippines.

**Table 2.** Hand lengths (in cm) among male Ilocano population in Philippines (N=60)

Length	Min	Max	Mean	SD
LHT	11.88	14.67	13.11	0.69
LHI	16.16	19.98	17.80	0.84
LHM	16.95	20.73	18.54	0.83
LHR	15.92	19.97	17.37	0.87
LHL	13.26	17.06	15.02	0.76
RHT	12.22	14.61	13.24	0.61
RHI	16.50	19.97	17.73	0.68
RHM	17.02	20.20	18.40	0.71
RHR	16.09	19.54	17.45	0.74
RHL	13.68	17.25	15.05	0.68

Ten hand length measurements taken with ten fingers from each subject. Table 2 shows the various hand lengths of male Ilocanos and the mean middle hand length (18.54 cm) is the longest while thumb hand length (13.11 cm) is the shortest in both hands of male.

**Table 3.** Hand lengths (in cm) among female Ilocano population in Philippines (N=60)

Length	Min	Max	Mean	SD
LHT	11.07	13.39	11.94	0.45
LHI	15.33	17.83	16.25	0.54
LHM	15.79	18.80	16.95	0.62
LHR	14.61	17.68	15.95	0.55
LHL	12.68	15.39	13.74	0.49
RHT	11.02	13.07	11.90	0.46
RHI	14.93	17.46	16.14	0.59
RHM	15.56	18.19	16.87	0.63
RHR	14.64	17.27	15.96	0.57
RHL	12.98	15.31	13.70	0.51

**Table 4.** Hand lengths (in cm) among unknown Ilocano population in Philippines (N=60)

Length	Min	Max	Mean	SD
LHT	11.07	14.67	12.52	0.83
LHI	15.33	19.98	17.03	1.05
LHM	15.79	20.73	17.75	1.08
LHR	14.61	19.97	16.66	1.02
LHL	12.68	17.06	14.38	0.90
RHT	11.02	14.61	12.57	0.86
RHI	14.93	19.97	16.93	1.02
RHM	15.56	20.20	17.63	1.02
RHR	14.64	19.54	16.71	0.99
RHL	12.98	17.25	14.38	0.91

**Table 5.** Linear regression formulae to determine stature from combined left and right hand lengths among male Ilocano population in Philippines (N=60)

Regression formulae	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SEE
S = 48.124 + 7.016HT	0.69	0.48	0.469	±4.53
S = 42.364 + 5.529HI	0.67	0.44	0.433	±4.68
S = 31.183 + 5.922HM	0.71	0.50	0.489	±4.44
S = 51.486 + 5.116HR	0.64	0.40	0.393	±4.84
S = 58.743 + 5.442HL	0.61	0.37	0.36	±4.97

p value <0.001

**Table 6.** Linear regression formulae to determine stature from combined left and right hand lengths among female Ilocano population in Philippines (N=60)

Regression formulae	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SEE
S = 52.293 + 6.078HT	0.51	0.26	0.243	±4.46
S = 44.944 + 4.927HI	0.53	0.28	0.263	±4.40
S = 50.637 + 4.383HM	0.52	0.27	0.261	±4.40
S = 50.836 + 4.633HR	0.49	0.24	0.226	±4.51
S = 43.710 + 5.907HL	0.55	0.30	0.285	±4.33

p value <0.001

**Table 7.** Linear regression formulae to determine stature from combined left and right hand lengths among unknown gender Ilocano population in Philippines (N=60)

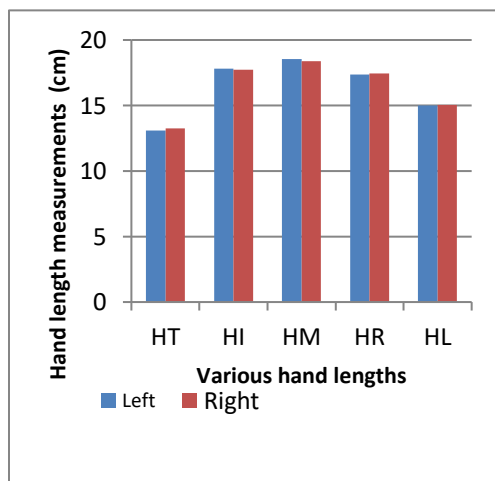
Regression formulae	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SEE
S = 10.186HT + 4.845	0.86	0.73	0.731	±5.06
S = 8.162HI - 5.935	0.85	0.73	0.726	±5.11
S = 8.071HM - 10.125	0.86	0.73	0.731	±5.06
S = 8.199HR - 4.117	0.83	0.69	0.685	±5.48
S = 9.158HL + 0.982	0.83	0.69	0.690	±5.43

p value <0.001

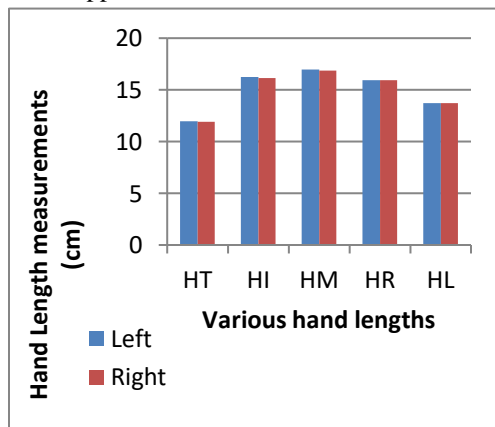
The table 3 presents the various hand length measurements in female Ilocanos. Here again the middle hand length is longer than other four hand lengths in both sides. The mean hand lengths of both male and female

subjects as illustrated in the form of bar graphs (Fig 3 and Fig 4). The mean left hand length and right hand are not similar, thus reflected the bilateral asymmetry.

**Figure 3.** Bar graph showing various hand length measurements among male Ilocanos in Philippines.



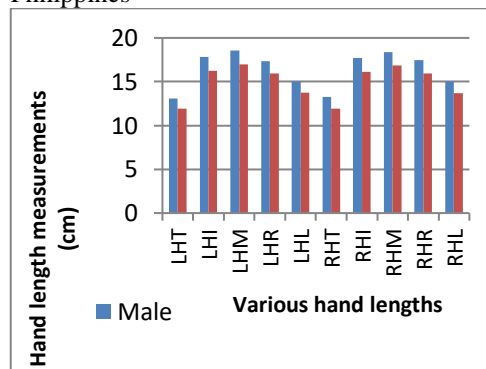
**Figure 4.** Bar graph showing various hand length measurements among female Ilocanos in Philippines.



The male hand lengths are longer than female hand lengths, showing the general male and female difference. The bilateral hand lengths

of male and female as presented in figure 5. The left hand length and right hand length show bilateral asymmetry but not significant in this population.

**Figure 5.** Bar graph showing bilateral hand length measurements among Ilocanos in Philippines



The result of unknown gender (Table 4) shows that the middle hand length is the longest in both sides but not similar. The standard deviation (SD) in unknown gender is slightly higher than male and females. Because of the non-existence of significant bilateral asymmetry among left and right hand lengths of this population, the study combined the left and right hand lengths, as unified and developed regression equations to determine stature for forensic application, irrespective of left or right hands found in crime scene.

Tables 5-7 show the linear regression formulae to determine stature (S) from various hand lengths among males, females and unknown gender. The correlation coefficient (R) values are statistically significant and higher correlation exists in unknown gender (0.804-0.847) than males

(0.545-0.676) and females (0.447-0.529). The coefficient of determination ( $R^2$ ), the predictive accuracy, is found to be higher in unknown gender and statistically significant ( $<0.001$ ).

### Discussion

The Ilocanos, also called as Ilokanos, or Iloko ethnic is the third largest group in Philippines, mostly residing within Ilocos region in the northwestern seaboard of Luzon, Philippines. Ilocanos, known for their hardworking, appreciative, simple and determined lifestyle. Most of them speak Ilocano, which is part of the northern Philippines subgroup of Austronesian family language. As a second language, they also speak Tagalog and English, most Ilocanos are Roman Catholics [12]. The age range of the study population is 18-55, considered adult since it was shown that people attained adult at 18 years old [13]. The result of the study showed that the mean stature of male is 140.57 cm while female is 124.75 cm. On the contrary, the stature of Thailand population (male: 171.50 cm and female 159.63 cm) and middle hand lengths (Male R:18.18 cm, L :18.13; Female R:14.90, L: 14.80) are different from Ilocano population [14].

Similarly, in Sri Lankan population study of stature determination, the stature of male is 170.14 cm with hand length, 19.01 cm and female stature is 157.55 cm with hand length, 17.62 cm [15]. Researchers have conducted autopsy-based study on stature estimation from hand lengths, involving dead bodies,

received for autopsy examination against living persons in India. The mean stature of the male deceased was 163.54 cm with mean hand length of 18.60 cm while female deceased stature was 155.69 cm with mean hand length of 16.39 cm. The study revealed that the male right hand is larger than left hand whereas in females left hand is slightly larger than right. For stature estimation from hand lengths, many researchers have used only one hand length, the longest hand length, i.e. hand length with middle finger [10], [14], [16], [17].

However, the present study used five-hand length measurements from left and five from right side for stature determination. The incidents of mass disaster, industrial accidents, and major bomb blasting are frequent and the dismembered human body parts in the crime scenes are the primary challenge to the investigators for person identity. The present study developed five linear regression formulae separately for male, female and unknown gender. A total of 15 equations were developed so that the presence of partial dismember hand parts with unknown gender become a valuable clue for stature determination, leading to person identification. It is cumbersome to face this challenge if only one regression equation developed for stature determination for a population. Another advantage of this research is the development of regression equations to determine stature from pooled sample or unknown gender. In real crime scenarios, in many incidences, it is difficult to find out the

gender of the dismembered and decomposed hands and hence the unknown gender equations developed in this study would find use to determine stature of the dismembered hand parts to solve the mystery.

### CONCLUSION

The study concluded with the development of fifteen population specific regression formulae to determine stature from hand anthropometry among Ilocanos in Philippines. The study result would be useful even in the presence of partial or portion of hand pieces found in the crime scenes. Researchers are encouraged to develop standards for stature determination on various populations for crime scene application.

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