Journal of Forensic and Legal Medicine 35 (2015) 9–14

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

# Estimation of stature from diversified hand anthropometric dimensions from Korean population

Soo-chan Jee, Myung Hwan Yun*

*Seoul National University, Republic of Korea*

ARTICLE INFO

*Article history:*
Received 5 March 2015
Received in revised form
21 May 2015
Accepted 20 June 2015
Available online 26 June 2015

*Keywords:*
Forensic anthropometry
Hand dimension
Stature estimation
Hand anthropometry

ABSTRACT

The anthropometric method has served as a useful tool in reducing the amount of time and effort in confirmation of identity. This study is based on a sample of 321 people (167 males and 154 females) from South Korea. Twenty-nine variables including lengths, breadths, thickness, and circumference of their hands and wrists were measured. The body dimension data were analyzed using descriptive statistics. To find the relationship between the various parts of the hand and height, Pearson correlation coefficients for the parts were compared. Further, the single regression and determination coefficient of a regression estimation equation ($R^2$) and standard error of estimate (S.E.E) were calculated to compare prediction reliability. Hand length was found to be the variable with the highest correlation to stature in both males ($r = 0.628$) and females ($r = 0.534$). For male subjects, hand length ($R^2 = 0.398$) and palm length ($R^2 = 0.358$) proved to be the greatest determining factors for the regression equation. For both males and females, an R-square value of 0.643 was obtained with an estimation error of ±5.719 cm by using the derived multiple regressions. In this study single and multiple regression equations were derived for accurate estimation of stature and hand length was found to be the most relevant predictor of stature.


## 1. Introduction

In forensic research, anthropometrics, which uses body parts to estimate the physical characteristics of an individual, has served as a useful tool in reducing the amount of time and effort in confirmation of identity.[1,2] For this reason, anthropometrics have been widely used for identifying the culprit in criminal cases, or for determining the identity of victims in large-scale natural disasters or terrorist attacks.[3,4] In identity verification, one of the most important biological profiles is the stature of an individual. Stature shows a great deviation among people, and thus, it plays an important role in reducing the number of suspects.[5]

When only a small part of a human body is found after a disaster or a scene of an incident, it is hard to predict stature by using the anatomical method, which reconstructs the entire body height with combing major body parts. In such a case, mathematical methods based on linear equations can be a reasonable solution. When applying a mathematical method, more diverse regression models that can predict the height of subjects will allow investigators to estimate their stature with a higher success rate and accuracy. Among the various body parts, the hand is frequently found in crime scenes or disaster spots. In addition, the human hand is a complex structure consisting of 27 bones and 15 joints and possesses many biological features that can be used for stature estimation. Thus, a number of previous studies used parts of the hand to estimate stature.[6]

For instance, Agnihotri used the hand lengths and breadths of 250 Mauritius students to predict their heights.[7] In the study, hand length was shown to be the most important predictor of stature, and the estimation accuracy was found to be higher in females ($R^2 = 0.564$) than in males ($R^2 = 0.353$). In the study by Habib on Egyptian subjects, the correlation between phalange lengths and stature was derermined.[8] Ahemad, on the basis of the hand and phalange lengths of 503 Indian male subjects, showed that hand length is the most important predictor of stature.[9] Akhlaghi derived a regression equation with high accuracy from the lengths of the upper limb and hand.[10] Krishan used various dimensions of the hands and feet of Indian subjects to estimate their stature.[11] Altayeb Abdalla used various dimensions of body parts constituting the upper limb of Sudanese subjects and showed that hand length is more predictable than hand breadth.[12] Uhrova used hands and foot lengths for stature estimation. In the study, no bilateral difference

* Corresponding author.
*E-mail addresses:* mhy@snu.ac.kr, mhy1128kr@gmail.com (M.H. Yun).

http://dx.doi.org/10.1016/j.jflm.2015.06.014
1752-928X/

in the right and left hands was shown, and the estimation based on hand length was reported to be more accurate in males ($R^2 = 0.40$) than in females ($R^2 = 0.34$).[13]

Previous studies used hand lengths and breadths or hand and foot lengths as a variable for deriving a regression equation for stature estimation. However, in some forensic investigation, it is impossible to measure hand length or breadth owing to some loss of damage to fingers. In such cases, it is not possible to predict height by using hand length or breadth. However, if prediction regression equations are available for different hand parts in addition to hand length and hand breadth, it will be possible to increase the success rate of stature estimation by using other regression models for diverse hand parts. Therefore in this study, phalange and finger lengths, as well as hand and wrist circumference and thicknesses were additionally used for stature estimation. In previous studies, it was reported that if the regression equations for one ethnic group are used for other races, prediction accuracy is lowered. Thus, it is urgent to derive regression formulas that can be applied to Korean people or ethnic groups similar to Koreans when a crime or an accident happens. Through this study, which to the best of our knowledge is the first attempt at stature estimation for Koreans, we aim to identify possible criteria that would be applicable in forensic practices for Koreans. Moreover, the results of this study may be utilized not only in forensic practices, but also in other fields such as therapy, sports, and clothing design.

## 2. Methods

### 2.1. Materials

In this study, data were obtained from the body measurements of Korean subjects collected by the National Agency for Technology and Standards Measurement, Republic of Korea. The total number of subjects was 321, comprising 167 males and 154 females. The mean age was 42.5 for males (minimum 20 and maximum 70) and 46.5 for females (minimum 20 and maximum 83). None of subjects had a history of any hand- or spine-related disease. All the subjects were of the Korean race and were born and grew up in Korea. This study was approved by the research ethics committee of Seoul National University (SNUIRB NO. E1505/001-002), and was therefore conducted according to the guidelines laid down in the Declaration of Helsinki. Written informed consent was obtained from all subjects.

### 2.2. Measurement

The measurements included a total of 29 variables, indicated in Table 1 and Fig. 1, some of which are lengths, breadths, thicknesses, and circumferences of fingers, phalanges, palms, and wrists. The measurements were carried out on the right hands of the subjects.[6,14,15] To reduce any measurement error, each investigator was asked to measure each dimension. For length, breadth, and thickness measurements, digital calipers were used; for circumference measurement, tape measures were used. All subjects were asked to remove their top clothes and sit down on a chair. They were then asked to place their hands stretched straight on a measurement unit for reference point marking, and the distance between the points were measured. For height measurement, an extensometer was used. The subjects placed one of their feet parallel on the extensometer and stood facing front; a single investigator then recorded their heights indicated by the extensometer. Before starting measurements, hand measurements were conducted on 12 subjects twice at different times and the measurement error was evaluated. Intra-observer error was measured by calculating the relative technical error of measurement (rTEM) and the coefficient of reliability (R); rTEM was less than 5%, and R was greater than 0.91. Further, intra observer error was considered to be within acceptable standards for all measurements.[16]

### 2.3. Statistical analysis

Average and standard deviations were calculated for each measured dimension by using SPSS 21. In order to identify the dimension differences between males and females, a t-test was conducted. To find the relationship between the various parts of the

**Table 1**
Definition of the hand measurement employed in this research with Refs. 6,14,15.

| Type | Hand dimension | Abbreviation | Definition |
|---|---|---|---|
| Length | Hand length | HL | The distance from the middle of inter stylion to the tip of middle finger |
| | Palm length | PL | The distance from the middle of inter stylion to the proximal flexion crease of the middle finger |
| | Thumb; index; middle; ring; little finger length | 1DL, 2DL, 3DL, 4DL, 5DL | The distance from the proximal flexion crease of the finger to the tip of the respected finger |
| | Thumb; index; middle; ring; little finger proximal phalange length | 1DT2L, 2DI3L, 3DM3L, 4DR3L, 5DL3L | The distance from the proximal interphalangeal joint crease to metacarpophalangeal joint crease of each finger |
| | Thumb; index; middle; ring; little finger middle phalange length | 2DI2L, 3DM2L, 4DR2L, 5DL2L | The distance from the distal interphalangeal joint crease to the proximal interphalangeal joint crease |
| | Index; middle; ring; little finger distal phalange length | 1DT1L, 2DI1L, 3DM1L, 4DR1L, 5DL1L | The distance from the most forwarding projecting point on the tip of each finger to distal interphalangeal joint crease of each finger |
| Breadth | Hand breadth | HB | The distance from the most lateral point on the head of the 2D metacarpal to the most medial point on the head of 5D metacarpal |
| | Maximum hand breadth | MHB | The distance from the most lateral point on the head of the 1D metacarpal to the most medial point on the head of 5D metacarpal with closing fingers |
| | Wrist breadth | WB | The distance from the most lateral point on the wrist to the most medial point of wrist |
| Circumference | Hand circumference | HC | The superficial distance around the edge of metacarpal |
| | Maximum hand circumference | MHC | The maximum superficial distance around the edge of the hand with closing fingers |
| | Wrist circumference | WC | The superficial distance around the edge of the wrist |
| Thickness | Hand thickness | HT | The distance from the back of the middle finger to the most medial point of palm |
| | Maximum hand thickness | MHT | The maximum distance from the back of the hand to the most projected point of abductor pollicis brevis |