Legal Medicine 17 (2015) 92–97

Contents lists available at ScienceDirect

Legal Medicine

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

Estimation of stature using hand and foot dimensions in Slovak adults

Petra Uhrová [a,*], Radoslav Beňuš [b], Soňa Masnicová [c], Zuzana Obertová [d], Daniela Kramárová [b], Klaudia Kyselicová [b], Michaela Dörnhöferová [b], Silvia Bodoriková [b], Eva Neščáková [b]

[a] Comenius University in Bratislava Science Park, Faculty of Natural Sciences, Mlynská dolina, 84215 Bratislava, Slovak Republic
[b] Department of Anthropology, Faculty of Natural Sciences, Comenius University, Mlynská dolina, 84215 Bratislava, Slovak Republic
[c] Department of Criminalistics and Forensic Sciences, Academy of Police Forces, Sklabinská 1, 83517 Bratislava, Slovak Republic
[d] Waikato Clinical School, University of Auckland, Hamilton, New Zealand

ARTICLE INFO

Article history:
Received 4 January 2014
Received in revised form 7 October 2014
Accepted 8 October 2014
Available online 22 October 2014

Keywords:
Stature
Anthropometry of hand
Anthropometry of foot
Linear regression equations

ABSTRACT

Hand and foot dimensions used for stature estimation help to formulate a biological profile in the process of personal identification. Morphological variability of hands and feet shows the importance of generating population-specific equations to estimate stature. The stature, hand length, hand breadth, foot length and foot breadth of 250 young Slovak males and females, aged 18–24 years, were measured according to standard anthropometric procedures. The data were statistically analyzed using independent *t*-test for sex and bilateral differences. Pearson correlation coefficient was used for assessing relationship between stature and hand/foot parameters, and subsequently linear regression analysis was used to estimate stature. The results revealed significant sex differences in hand and foot dimensions as well as in stature ($p < 0.05$). There was a positive and statistically significant correlation between stature and all measurements in both sexes ($p < 0.01$). The highest correlation coefficient was found for foot length in males ($r = 0.71$) as well as in females ($r = 0.63$). Regression equations were computed separately for each sex. The accuracy of stature prediction ranged from ±4.6 to ±6.1 cm. The results of this study indicate that hand and foot dimension can be used to estimate stature for Slovak for the purpose of forensic field. The regression equations can be of use for stature estimation particularly in cases of dismembered bodies.

1. Introduction

In forensic anthropology, determination of sex, age and stature is the foremost task for establishing the biological profile of an individual, which may consequently lead to a positive personal identification. In case of dismembered bodies, this task is more complicated so it is important to search for methods that can be used for estimating the above mentioned basic individual characteristics.

Human stature is an anatomical complex of linear dimensions, including skull, vertebral column, pelvis and lower extremities, so that it is assumed that significant associations exist between the total stature and these individual body parts [1–3]. A number of studies have presented the relation between stature, foot length and foot breadth among different human populations utilizing linear and multiple regression equations [4–8]. Foot measurements, such as foot navicular and malleol height were used for the first time in Zeybek's et al. to estimate stature and sex, and then in the study by Uhrová et al. to estimate stature [9–10]. Several studies have attempted to derive regression equations from measurements of footprints and foot outlines [11–13]. Although upper extremities are not part of this complex, previous research has shown that the dimensions of upper extremities are also associated with stature to some degree [14–15]. A number of studies on the relationship between hand measurements and stature to calculate population-specific regression equations have been reported [16–18]. It needs to be taken into the consideration that the equations derived from one population cannot be used for other populations as the body dimensions show ethnic variation due to hereditary and environmental conditions.

The aim of this study is to assess the relationship of hand and foot dimensions with stature, and to provide stature estimation equations for Slovak population. The results of our research have practical use in forensic field as well as in the field of sport and clinical anthropology.

2. Materials and methods

The present study was conducted in the Department of Anthropology at the Faculty of Natural Sciences, Comenius University in

* Corresponding author. Tel.: +421 2 602 96 567.
E-mail address: uhrova.p@gmail.com (P. Uhrová).

http://dx.doi.org/10.1016/j.legalmed.2014.10.005
1344-6223/

Slovakia. The study sample consisted of 250 students (120 males and 130 females) aged between 18 and 24 years from various regions of Slovakia. Because of the diurnal variation in stature, all subjects were measured approximately at the same time in the morning.

Hand length, hand breadth, foot length and foot breadth were taken on the left and right side on each individual. All these dimensions as well as stature were measured in centimeters to the nearest millimeter according to the standard anthropometric procedures. Stature and feet measurements were taken on barefoot subjects.

2.1. Landmarks

Inter-stylion – the middle point of the line connecting the point stylion radiale (the most distal point on the styloid process of radius) and stylion ulnare (the most distal point on the styloid process of ulna).

Acropodian – the most forward-projecting point on the head of the longest toe (first or second) with the subject standing erect.

Metacarpal-radiale – the most medially projected point on the head of the second metacarpal with the hand stretched.

Metacarpal-ulnare – the most laterally projected point on the head of the fifth metacarpal with the hand stretched.

Pternion – the most backward-projecting point on the heel with the subject standing upright with equal pressure on both feet.

Metatarsal-tibiale – the most medially projecting point on the head of the first metatarsal bone with the subject standing erect.

Metatarsal-fibulare – the most laterally projecting point on the head of the fifth metatarsal bone with the subject standing erect.

Stature was measured using an anthropometer and was taken from the vertex to the floor in the anatomical position with the head oriented in the Frankfurt Plane (Fig. 1) [19]. Hand length was measured as the direct distance between the distal crease of the wrist joint and the distal end of the longest finger (Fig. 2) [19]. Hand breadth was measured as the direct distance from the lateral-most point on the head of the second metacarpal to the medial-most point located on the head of fifth metacarpal (Fig. 2) [19]. Foot length was measured as the distance from the most posterior point of the heel to the most anterior point of the longest toe (Fig. 3) [19]. Foot breadth was measured as the distance between the medial-most of the first and lateral-most of the fifth metatarsal bone head (Fig. 3) [19].

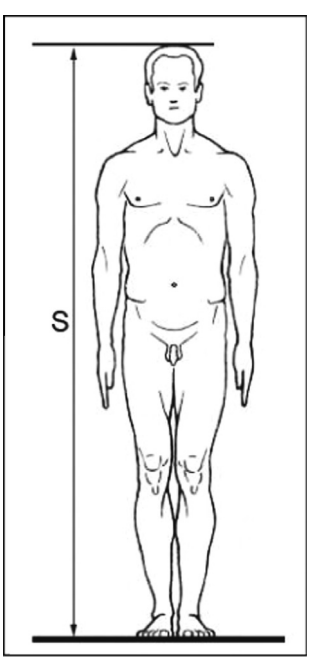

Fig. 1. Stature (S).

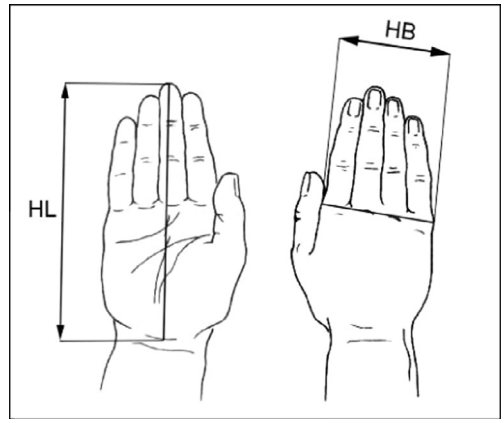

Fig. 2. Hand length (HL) and hand breadth (HB).

The accuracy in measurements is considered as in important element in studies based on anthropometry. Therefore, absolute technical error of measurement (TEM), relative technical error of measurement (rTEM), and coefficient of reliability (R) were calculated. Hand and foot measurements were taken on 25 subjects twice at different times by one examiner to determine intrapersonal precision. The technical error of measurement is defined as the square root of the sum of the squared deviations divided by twice the sample size – $TEM = \sqrt{(\Sigma d^2)/2N}$. The absolute TEM was transformed into relative TEM (rTEM) to obtain the error expressed as percentage corresponding to the total average of the variable to be analyzed – $rTEM = (TEM/VAV) \times 100$, where VAV is the variable average value (the arithmetic mean of the mean between both measurements). The coefficient of reliability (R) was calculated as percentage – $R = 1 - [(TEM^2)/SD^2]$, where SD^2 is the total intra-subject variance for the study [20,21].

2.2. Statistical analysis

Data were statistically analyzed using SPSS 17.0 for Windows and MS Office Excel 2007. The significance of sex and bilateral differences was tested using independent *t*-test. The association

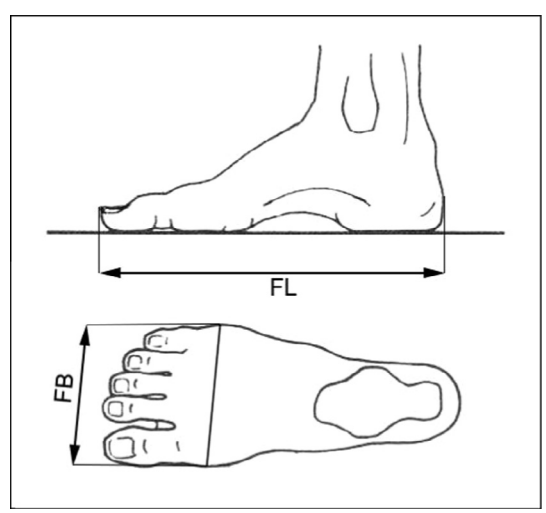

Fig. 3. Foot length (FL) and breadth (FB).