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Adult stature estimation from radiographically determined metatarsal length in Egyptian population[☆]

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ABSTRACT

Background: Estimation of the stature might be critical in the identification of skeletal remains. Usually, the small bones found among human remains are not only the most numerous, but also the best-preserved parts.
Objective: The primary aim of this work is to determine whether metatarsals can be used for the estimation of adult stature in an Egyptian population using radiologically determined metatarsal lengths and to propose regression equations and test the formulae for determining adult stature.
Subjects and methods: The 1st and 2nd metatarsals of the left foot of the 220 healthy adult participants were assessed by plain X-ray in a dorso-plantar position utilizing a digital radiography machine commonly used in hospitals. The measurements were obtained by default program on console of the machine that offers manipulation and measurements on the obtained images.
Results: The study clearly illustrated that the 1st metatarsal maximum length (M1) in males was the most noteworthy correlation with the true stature. The derived regression equation is as per the following: $S = 851.52 + 12.26\ M1$, $R = 0.8904\ M1$. Our findings in the current study were more accurate when comparing our study statistical findings with the results of other population groups.
Conclusion: the regression equations for stature estimation obtained in our study may be utilized for the identification of stature of skeletons among adult Egyptians from medicolegal point of view.

1. Introduction

Stature reconstruction plays an important role as it provides a forensic estimate of the living body height which has a vital role in the person identification. The parts of human body are assumed to be proportionate to each other and therefore, it is mostly agreed that there is a great relationship between different body parts and height [1–4].

Identification of the remains of human skeletal has an important role of forensic assessment. Identification is a process that involves some steps including; determining the species of origin, age, sex and stature from these remains [5]. Second step is the identification of the personal identity through Systematic comparison of ante-mortem and post-mortem data as fingerprints; dental radiographs; DNA samples from the human remains with reference samples; Other unique identifiers, such as unique physical or medical traits, including skeletal radiographs, Numbered surgical implants/prostheses [6,7].

It is well known that certain factors such as heredity, environment, nutrition, sex, age, physical activity, socio-economic status, races, rituals have influence over the stature [8]. Bone growing is affected by many elements as the races and the geographical areas which cause different proportions between the various bones [9].

In the area of forensic anthropology, the biological profile is assessed mostly by main four components, stature estimation is considered one of them, which is used for skeletal remains identification. In the past years, long bone lengths have been mainly utilized in several researches [8–13] for stature estimation.

Adult stature is generally attained through late-teens in males and mid-teens in females [14]. For many years, anthropologists have focused over the relationship between the body parts dimensions and the entire body. Individual stature prediction involves a vital status in anthropometric studies and is one of the vital and valuable anthropometric parameter that aides in defining the individual identity [15,16].

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Individual ancestry, sex, age-at-death and stature assumes an essential role in the identification, particularly in medico-legal practice. In some situations, remains of soft tissues are discovered disposed off in the open, in trench, or junk dumps, etc. and these fragments are conveyed to be examined by the forensic pathologist [17]. The issue of identification fundamentally emerges in these sorts of cases [18].

The published studies of Pearson [19] indicated that stature estimation from the skeletal fragments of the distort body parts was chiefly of the long bones measurements. It has been exhibited that the femur, tibia, humerus and ulna as long bones give more precise stature estimation [9,12,13,20]. Practically speaking, separate bone fragments can be found, along these lines making stature estimation considerably more strenuous [21].

Earlier studies had been done to estimate stature in the Egyptian population through hand and phalanges lengths [22], handprint dimensions [23], hand measurements [24] and radiological determination of humerus and femur lengths [25]. These studies have helped to establish population specific regression formula for stature estimation of an individual from different parameters.

To our best of knowledge, the correlation between height and the metatarsal measurements had been studied in few researches in the past, so our study was embraced to assess the relationship between the metatarsal measurements which determined by radiograph and the body stature in healthy adults.

In order to assess the usefulness of utilizing the measurements of the metatarsals as a tool for the estimation of adult stature in our participants, a technique was designed for estimating the adult's Egyptian stature utilizing metatarsal lengths determined by radiograph.

2. Patients and research methods

This research was conducted in the Forensic Medicine and Clinical Toxicology department in collaboration with the Radiology department, Faculty of Medicine, Suez Canal University (SCU), Egypt.

This study included 220 adult Egyptian volunteers (110 males and 110 females) recruited in the period from February 2015 to October 2015 in harmony with the guidelines of the declaration of Helsinki and the research ethics committee for human experimentation of SCU. Their ages ranged between 21 and 62 years and all were of Egyptian descent. The lower age limit was 21 years to be sure of completion of skeletal development and attaining maximum growth and maximum length of different body parts.

All research subjects with any skeletal deformities, diseases or fractures that may interfere with rigorous stature and metatarsal measurements were excluded from the research. The research subjects were enrolled from Ismailia city and the surrounding villages.

2.1. Measurement of Stature

Stature was measured utilizing a criterion hospital-measuring scale. It was measured as vertical distance from the vertex to the foot. Measurement was taken by making the research participant to stand erect with barefoot in upright posture on a horizontal resting plane while looking upwards with his back against a graded ruler. The back was extended and arms held to the sides. The instrument vertical plane came in contact with the participant head, buttocks and heels. The Frankfurt plane (an imaginary line from the inferior orbital rim on the same horizontal plane as the external auditory canal) was utilized for the horizontal reference. The movable rod of the tool was depressed obligingly, flattening the hair and conveying touch with the vertex of the skull of the participant. The measurements were registered two times and recorded to the nearest millimeters. The regression equations were designed utilizing the mean.

Stature and metatarsal measurements were obtained in the same time every day to exclude diurnal variation and by the same researcher to avoid inter-observer error.

Fig. 1. Dorso-plantar screening of the left foot, demonstrating 1st (M1) and 2nd (M2) metatarsal bone, with a metallic ruler on the right.

First (M1) and second (M2) metatarsals lengths of the left foot of 220 research subjects were estimated by plain X-ray in a dorso-plantar position utilizing a digital radiography machine (APOLLO DRF - Villa Sistemi Medicali, Italy). The measurements were obtained by default program on console of the machine that offers manipulation and measurements on the obtained images. The digital measurement is adjusted by the system in the machine itself, but a metallic ruler was utilized in order to minimize errors to affirm the accuracy. All measurements were done three times and recorded in millimeters.

2.2. Measurements description, according to Cordeiro et al. [26]

M1. 1st metatarsal maximum length: the maximum dimension that extend from the tip of the tuberosity to the most distal point of the head (Fig. 1).

M2. 2nd metatarsal maximum length: the maximum dimension that extend from the proximal tip to the most distal point of the head (Fig. 1).

2.3. Statistics

All the collected data were statistically analyzed utilizing the SPSS program for statistics (SPSS 22.0 for Windows). The data analysis included means (m), standard deviations (SD), the correlation coefficient (R), standard error of estimate (SEE), adjusted determination coefficient (adj R2) and Linear Regression Model (LRM). Additive Models (AM), which are generally utilized as a protraction of traditional linear models (LMs) particularly if continuous covariates are existing, were gained via a supplementary statistical package (http://cran.es.r-project.org/web/packages/mgcv/index.html). We studied n models in our research in order to make the calculation of a non-biased prediction error, bringing out from each of these a predictable notice without allowing it share in the assessment. Cross Validation (CV) is the name which is commonly given to that tool and is a criterion means to build up the predictive power of a non-biased model. Statistical significance was set