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Stature determination from different body dimensions: a systematic review appraisal

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Abstract

Forensic anthropology is a special sub-field of biological anthropology (the study of human remains) that involves applying skeletal analysis and techniques in archaeology and forensic sciences to solving identity cases. Generally speaking forensic anthropology is the examination of human skeletal remains for law enforcement agencies to help with the recovery of human remains, determine the identity of unidentified human remains, interpret trauma, and estimate time since death. Through the established methods, a forensic anthropologist can aid law enforcement in establishing a profile of the unidentified remains. The profile includes sex, age, ancestry, height, length of time since death, and sometimes the evaluation of trauma observed on bones. In many cases after identity of an individual is made, the forensic anthropologist is called to testify in court regarding the identity of the remains and/or the trauma or wounds present on the remains. In the era of uncertainty of life and uplifment of criminal activities, there should be an enriched stock of scientific weapons for investigation and identification. In this context, the present review analysis initiated for the prediction of stature of an individual from different body parts that could enhance the procedures of identification as well as investigation.

Keywords: Forensic Anthropology, Anthropometry, Stature, Body Measurements

Introduction

Forensic anthropometry, a specialized branch of forensic anthropology, arose to deal with the purpose of personal identification especially in medico-legal cases with the help of anthropometric techniques. It mainly works on anthropometric measurements in individual as well as population level. In modern era, it is often seen that several kinds of incidents are taking place in various corners of the globe,

some of these are naturally being occurred, some are completely human-made and some are indirectly caused by human's attitude to nature. As a result, dismembered body parts of human being are often found in the place of disaster, which are initially not supposed to be identified. To overcome the difficulties in initial identification of dismembered body or body parts, forensic anthropometry has come down to the field much effectively. However, now a day, increased events of assassination have become a criminal trend besides natural disasters like earthquake, land-slide, tsunami etc and man-made disasters like building collapse, bomb explosion, arsons, mining accidents, air crash, road accidents, railway accidents etc, where the dead body is mutilated by the murderer to erase all traces of evidences and also to facilitate the disposal of the body. Forensic anthropometry plays there a vital role for providing a tentative identification of the body by formulating a biological profile of the dead body from its dismembered body parts. Although the biological profile includes determination of stature, age, sex and ethnicity, determination of stature is considered as the most important parameter for personal identification in forensic investigation as stature is a complex expression of genetics and environment (Varu et al., 2015).

Stature can be measured by anatomical or fully method and mathematical method. Anatomical or Fully method reconstructs stature by summing the measurements of the skeletal elements that contribute to stature and adding a correction factor for the soft tissues. Mathematical method derives regression formula and multiplication factor to determine stature from bone or body part. Mathematical method is more useful in medico-legal cases as it can be applied even when only part of body is available. However, due to difference in body proportions between populations such as the relative lengths of the limbs and trunk, population-specific regression formula and multiplication factor should be used for this purpose (Varu et al., 2015).

Stature reconstruction is very important in identification of individuals as it can provide a tentative forensic anthropological estimation of body height of a person in his living state. Stature estimation from the measurements of various long bones has been attempted by several researchers with variable degree of success (Meena et al., 2013). Scholars like Pearson (1899), Trotter and Glesser (1952) have formulated their own formulae for estimating stature from the measurements of long bones. Besides, foot dimension can also give better prediction in stature estimation since ossification and maturation in the foot occurs earlier than long bones. Rutishauser (1968), for the first time, showed that the reliability of prediction of stature from foot print was as high as that from long bones. Apart from that in medico-legal cases foot and hand dimensions are most relevant as prints of foot and hand are often found in crime scenes. Therefore it can be an initial clue to presume the structure of the criminal as well as of the victim (Agarwal et al., 2015). Contrariwise, stature determination from every dimension of body is important in mass disaster cases in sake of personal identification.

Methodology

For the systematic review on this topic, mostly open accessible research papers and published documents, available on internet, have been collected and studied minutely. Apart from that, several abstracts of relevant and most important papers on this particular

topic which are not available with full text on internet, have also been considered for the study. For searching the relevant articles for this review, Google search engine has been used broadly. To make the search of most relevant articles and sources from the bulk of articles on such kind of topic more specific, the abbreviated title of this study has been put on search engine. And then most relevant articles have been sorted out and downloaded for further use.

Systematic review analysis

Stature reconstruction of an individual from different body dimensions plays a vital role for personal identification in medico-legal cases and several scholars have been working on it since earlier times. Besides, Pearson (1899), Trotter and Glesser (1952) many studies on stature estimation in Indian context have been conducted with the use of different dimensions of the body by many scholars like Athwale et al., (1963), Patel et al., (1964), Joshi et al., (1964), Lal and Lala (1972), Kalte and Bansal (1974), Saxena (1984), Bhatnagar et al., (1984), Thakur and Rai (1987). Some recent studies, conducted by Babu et al., (2013), Moorthy and Zulkifly (2014), Agarwal et al., (2015), Varu et al., (2015), Hasan et al., (2017), Mudasir et al., (2017), Yadav and Pathak (2018), Singh et al., (2019), exhibited positive and significant correlation between different body dimensions with stature with various degree of success. A similar study, conducted by Patel et al., (2007), performed on 502 medical students (278 males and 224 females) between 17 to 22 years of age, stated that r-value between stature or body height and foot length was higher in female (r= 0.80) than male (0.65) though it showed strong and statistically significant relationship with stature in both the sexes. This study suggested that there has a strong bonding between stature and foot length and if any one of the measurements was previously known, the other could be calculated with great reliability using regression method. Another study, conducted by Sen and Ghosh (2008), established sex-specific and sex-independent regression equation for estimating stature from foot dimensions bilaterally with statistically significant correlation coefficient of stature with FL (r= 0.813) and FB (r=0.693) at 0.01 significant level. Babu et al., (2013), in their study that was conducted on 104 participants (54 males and 50 females) in Secunderabad within the age limit of 21 to 35 years, suggested that foot length among all the variables provided highest reliability and accuracy in estimating stature of an unknown individual. He found positive r-value between stature and FLL (0.585), stature and FLR (0.583) in case of male and found 0.653 and 0.660 in case of female FLL and FLR, respectively, which were statistically significant. Correspondingly, study conducted by Pandey et al., (2014) on 200 medical students (100 males and 100 females) of ages ranging 18 to 23 years of MGM Medical College, Navi Mumbai, India, exhibited that all the foot measurements of male showed statistically significant difference from those of female ($P< 0.001$). Bilateral asymmetry was not found in case of foot length of male. It exhibited that male stature was significantly correlated with both the foot lengths (right r-value= 0.451 and left r-value= 0.452, $P< 0.001$). Female stature showed similar result with both the foot lengths, where right r-value= 0.421 and left r-value= 0.506, $P< 0.001$. This study formulated both simple linear regression and multiple regression equations to estimate stature from foot measurements. Similar study conducted on hand dimensions by Moorthy and Zulkifly (2014) presented that r-

value between stature and hand length was higher than hand breadth and finger length measurements. Females' hand length r= 0.630-0.673) showed more reliability in estimating stature than that of male (r= 0.604-0.610) of the studied population. In the study of Sen et al., (2014), Stature was observed to be significantly and positively correlated with finger lengths such as LIF (r= 0.731), LRF (r= 0.721), RIF (r= 0.718), RRF (r= 0.711) at 0.01 level. Both sex-specific and sex-independent regression model were established with higher degree of success. A study, conducted by Agarwal et al., (2015) among 1000 participants (500 males and 500 females) of North India, found positive and statistically significant correlation coefficients of foot lengths and knee height with body height. This study also exhibited that knee height (r= 0.782) had the highest correlation with stature followed by foot lengths (r for right foot length= 0.747 and for left foot length= 0.743). Varu et al., (2015) established that both the hand lengths (r= 0.639-0.556) were more reliable in estimating stature than both the hand breadth measurements (r= 0.535-0.423). According to the study, regression and multiplication factor, both are useful to determine stature from hand dimensions but regression model measures stature more precisely. Pal et al., (2016) in his study with hand measurements showed that hand length (r= 0.683 and 0.682, bilaterally) and palm length (r= 0.644 and 0.642, bilaterally) had higher and significant correlation coefficient (r) with stature than finger length measurements, therefore HL and PL could determine stature more reliably. Mudasir et al., (2017) in their study, carried out among 200 Kashmiri medical students (100 males and 100 females), found bilateral asymmetry in all the hand measurements except hand length in males. He showed highest r-value in RHL (0.626) in males and in LHL (0.695) in females. Hand breadths showed least correlation coefficient with stature (0.046 in males and 0.386 in females). Yadav and Pathak (2018) in a similar study found all the studied measurements having higher and statistically significant correlation coefficient (r) with stature among them leg length had the highest r-value (0.8847) and foot length had the least (r= 0.7664). Similarly, study conducted by Singh et al., (2019) on 226 Gorkha personnel of Indian Armed Forces of 18-48 years of age, explored that leg length had strongest correlation (r= 0.816) with stature compared to other variables such as arm length, foot length, hand length. It was also stated that hand length had weakest correlation with stature (r-value= 0.544). It was also concluded that standing knee height (r= 0.686) and arm length (r= 0.653) could also be good predictors in stature estimation. It derived equations for estimating stature using simple linear and multiple regression models.

Unlike the above studies Vardhan and Pandey (2016) in their study performed on 185 participants (92 males and 93 females) of 19-25 years of age, in the department of anatomy, Katihar Medical College & Hospital, Bihar, concluded that foot length in males (r for RFL= 0.37 and r for LFL= 0.34) and females (r for both FL= 0.47) showed medium correlation with stature; so foot length provided the medium reliability and accuracy in estimating stature.

Discussion

By analysing the earlier studies on this particular issue, it has been concluded that different body dimensions showed uneven relationship with stature in different population throughout the world. But among all the studied variables, leg length, foot length and knee height exhibited stronger correlation with

stature in most of the populations. It has also found from the reviews that gender disparity in the relationship of body parts with stature is also an observable fact in this case. However, in broader aspect, it has been understood that this kind of study is entirely population-based, therefore, regression method and multiplication factor method could be much reliable tools for establishing population specific and sex specific formulas in prediction of stature in medico-legal investigation.

Stature is that genetic feature in which every anatomical part of body contributes with different ratio, therefore, population specific regression equations should be established from all such body dimensions that are statistically related with stature. This kind of study should be performed on different population of the world in large scale for the advancement of medico-legal investigation.

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References

Agarwal, S., Zaidi, S. H. H. and Agarwal, S. K. (2015). Correlation of body height by foot length and knee height measurements in population of north India. *International Journal of Anatomy and Research*. 3(3): 1225-1229.

Athwale, M. C. (1963). Estimation of height from length of forearm bones: A study of 100 Maharashtrian male adults of ages between 25 to 30 years. *American J. Physical Anthropology*. 21: 105-112.

Babu, R. S., Deepika, V. and Potturi, B. R. (2013). Estimation of stature from foot length. *International Journal of Pharmacy and Biological Sciences.* 3(3): 266-270.

Bhatnagar, D. P., Thapar, S. P., and Batish, M. K. (1984). Identification of personal height from the somatometry of the hand in Punjabi males*. Sci Inter*. 24: 137-141.

Hasan, K. R., Ara, S. and Banna, F. A. M. H. (2017). Correlation of Index Finger Length (2D) with height, weight and BMI in adult Bangladeshi male. *Journal of Enam*. (Medical College). 7(2): 90-94.

Joshi, N. B., Patel, M. P. and Dongre, A. V. (1964). Regression equation of height from ulna length. *Ind. J. Med. Res.* 52:1 088-1091.

Kalte, P. M. and Bansal, P. C. (1974). Determination of regression formulae for reconstruction of stature from long bones of upper limbs in Maharashtrians and Marathwara region. *Journal of Anatomical Society* (India). 23: 6-11.

Lal, C. S. and Lala, J. K. (1972). Estimation of stature from tibial and ulnar lengths in North Bihar. *Journal of Medical Association*. 58: 120-121.

Meena, M. C., Singh, J. P., Rani, Y. and Sharma, G. K. (2013). Stature estimation from the dimensions of foot in females. *Antrocom Online Journal of Anthropology*. 9(2): 237-241.

Moorthy, E. N. and Zulkifly, N. R. B. (2014). Regression analysis for stature determination from hand anthropometry of Malaysian Malays for forensic investigation. *Journal of Forensic Medicine, Science & Law*. (Sri Lanka). 5(2): 8-15.

Mudasir, A. K., Sheikh, I. B., Majid, A. K. and Shaheen, S. (2017). Determination of stature from measurements of hand length and hand breadth:An anthropometric study of Kashmiri population. *International Journal of Anatomy and Research*. 5(2.3): 3968-3875.

Pal, A., De, S., Sengupta, P., Maity, P. and Dhara, P. C. (2016). Estimation of stature from hand dimensions in Bengalee population, West Bengal, India. *Egyptian Journal of Forensic Sciences*. 6(2): 90-98.

Pandey, N., Roshan, S., Kharate, R., Sonawane, M., Bhivate, V. and Ujwal, N. S. (2014). Prediction of stature based on foot length. *Journal of Nobel Medical College*. 3(1): 66-70.

Patel, M. P., Joshi, N. B. and Dongre, A. V. (1964). Regression equation of height on tibial length. *Indian Journal of Medical Research*. 52: 531-534.

Patel, S.M., Shah, V. and Patel, S. V. (2007). Estimation of height from measurements of foot length in Gujarat Region. *J. Anat. Soc. India*. 56(1): 25-27.

Pearson, K. (1899). Mathematical contributions to the theory of evaluation on the reconstruction of the stature of prehistoric races. *Philosophical Transection of Royal Society*, London. 192: 167-244.

Rutishauser, I. H. E. (1968). Prediction of height from foot length. *Archives of Disabled Child*. 43: 310-315.

Saxena, S. K. (1984). A study of correlation and estimation of stature from hand length, hand breadth and sole length. *Anthropol. ANZ.* 42(4): 271-276.

Sen, J. and Ghosh, S. (2008). Estimation of stature from foot length and foot breadth among the Rajbanshi: An indigenous population of North Bengal. *Forensic Science International*. 181: 55.e1- 55. e6.

Sen, J., Kanchan, T., Mondal, N. and Krishan, K. (2014). Estimation of stature from lengths of index and ring fingers in a North-eastern Indian population. *Journal of Forensic and Legal Medicine*. 22: 10-15.

Singh, I. L., Varte, R. and Rawat, S. (2019). Estimation of stature from different anthropometric measurements of Gorkha soldiers. *Defence Life Science Journal*. 4(1): 33-37.

Thakur, S. D. and Rai, K. S. (1987). Determination of stature from hand measurement. *Medicine Science and Law*. 78: 25-28.

Trotter, M. and Glesser, G. C. (1952). Estimation of stature from long bones of American Whites and Negros. *American J. Physical Anthropology*. 10: 463-514.

Vardhan, H. and Pandey, N. K. (2016). Personal height of an individual person from measuring foot length. *International Journal of Medical and Health Research*. 2(8): 14-17.

Varu, P. R., Manvar, P. J., Mangal, H. M., Kyada, H. C., Vadgama, D. K. and Bhuva, S. D. (2015). Determination of stature from hand dimensions. *The Journal of Medical Research*. 1(3): 104-107.

Yadav, S. and Pathak, B. (2018). Estimation of stature from the measurement of forearm, hand, leg, and foot dimensions in Uttar Pradesh region. *International Journal of Therapeutic Applications*. 35: 49-53.