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Forensic anthropology population data

Estimation of stature from cephalo-facial anthropometry in north Indian population[☆]

Kewal Krishan [*]

Department of Anthropology, Panjab University, Chandigarh 160 014, India

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ABSTRACT

Estimation of stature is considered as an important parameter in medico-legal and forensic examinations. When highly decomposed and mutilated dead bodies with fragmentary remains are brought for postmortem examination, it becomes difficult to identify the deceased. Sometimes, cephalo-facial remains are brought in for forensic and postmortem examination. In such a situation, estimation of stature becomes equally important along with other parameters like age, sex, race, etc. (the 'Big Four' of forensic anthropology). The present investigation attempts to estimate stature from various anthropometric measurements of cephalo-facial region of individuals belonging to an endogamous group in north India. The material for the present study comprises 996 adult male Gujjars of north India ranging in age from 18 to 30 years. Five cephalo-facial measurements were taken on each subject following internationally recommended standard methods and techniques. The results indicate that all the cephalo-facial measurements are strongly and positively correlated ($p < 0.001$) with stature. The measurements of the cephalic region have strong correlation with stature than those of facial region. The regression analysis also showed that the cephalic measurements give better prediction of stature. The regression formulae were checked for their accuracy and reliability not only in the sample which was originally used for making these formulae (genetically disparate population, $n = 996$) but also in a mixed population of north India (heterogeneous population, $n = 100$).

1. Introduction

Estimation of stature is an important tool in forensic examination especially in unknown, highly decomposed, fragmentary and mutilated human remains. In such cases while conducting a medico-legal autopsy, forensic pathologist is often asked to opine about the identity of the deceased. Stature being one of the criteria of personal identification helps in narrowing down the investigation process, and thus provides useful clues to the investigating agency.

Stature has a definite and proportional biological relationship with each and every part of the human body, i.e. head, face, trunk, extremities. This relationship helps a forensic scientist to calculate stature from dismembered and mutilated body parts in forensic examinations. For such a calculation, two methods, i.e. regression method and multiplication method have been extensively used by the scientists all over the world, and it has been universally concluded that the regression analysis provides best estimates for stature reconstruction [1–5].

Many studies have been conducted on the estimation of stature from various body parts like hands, trunk, intact vertebral column, upper and lower limbs, individual long and short bones, foot and footprints [4–39]. Since all these parts of the body and bones are not always available for forensic examination, it becomes necessary to make use of other parts of the body like head and face region. But only a few studies have been conducted on cephalo-facial region with respect to estimation of stature.

There are plenty of studies which focus on other aspects of the cephalo-facial identification. Determination of sex and race from cephalic region, various methods of reconstructing the face appearance in an individual from the bones of the skull, new facial soft tissue depth data, ultrasound, computerized tomography-scans, 3D reconstruction computer programs are in full development throughout the world [40–52]. In many cases, brought for medico-legal and forensic examinations, where only the cephalo-facial region is available [53–68], it becomes difficult for the forensic scientist to identify the deceased in the absence of any detailed and

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* Tel.: +91 172 2534230/2541998 (O)/+91 172 2687372 (R).
E-mail address: gargkk@yahoo.com.

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in depth study on this region. Sometimes, the forensic scientist cannot apply the techniques of facial reconstruction may be due to lack of expertise, standardized data and equipment. In these cases, stature estimation from the cephalo-facial region can always supplement the identification data collected by using the techniques of facial reconstruction, and consequently can help in narrowing down the process of forensic investigation.

Introna et al. [69] provided the correlation between stature and cranial diameters and proposed a mathematical formula for determination of living stature in an Italian population. Chiba and Terazawa [70] successfully estimated stature from anthropometry of skull in 124 Japanese cadavers and calculated regression formulae. Patil and Mody [71] predicted stature from measurements of radiographic lateral cephalogram in central Indian population and proposed some formulae by regression analysis. Krishan and Kumar [72] calculated regression formulae for estimation of stature from 16 cephalo-facial measurements in a sample of 252 Koli male adolescents in north India. Ryan and Bidmos [73] took several measurements on skulls taken from 99 complete skeletons of indigenous South Africans from Raymond A. Dart collection, and successfully derived regression formulae for estimation of total skeletal height from these skull measurements. They also explained the utility of these measurements in estimation of stature with certain precautions.

Looking at the paucity of studies pertaining to estimation of stature from cephalo-facial dimensions and the usefulness of these studies in medico-legal and forensic investigations, the present study provides anthropometric correlation of five important cephalo-facial dimensions with stature and also devises regression formulae for reconstruction of stature from these dimensions. The study is further aimed to test the reliability and accuracy of regression formulae in the same population which was originally used to make these formulae and in another sample taken from mixed population of north India.

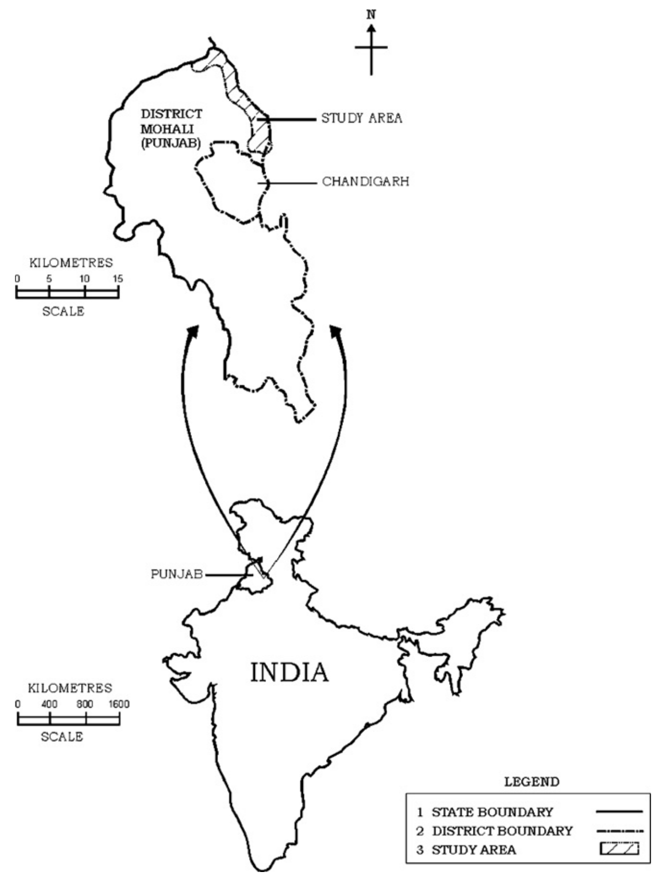

Fig. 1. Location map of the study area in India.

2. Material and methods

2.1. Sample

The data for the present study were based upon a sample of 996 adult male Gujjars ranging in age from 18 to 30 years. The subjects were randomly selected from 16 villages in Siwaliks and its adjoining plains near Chandigarh city of north India (Fig. 1). The villages include Nada, Parachh, Kahne Ka Bara, Kraunde Wala, Jainti Majri, Gurha, Kasauli, Chhoti Naggal, Bari Naggal, Pallanpur, Gochar, Mirzapur, Tarapur, Majri, Sukho Majri and Prempura. These villages are predominantly occupied by Hindu Gujjar community. The Hindu Gujjars of this region are an endogamous caste group (marrying within the same caste). They are sedentary and agriculturist having animal husbandry as a secondary occupation.

2.2. Methodology and data collection

Besides stature, five cephalo-facial measurements were taken on each subject. All the measurements were taken according to the landmarks and procedures recommended by Krishan and Kumar [72], Weiner and Lourie [74], Lohman et al. [75] and Hall et al. [76]. The anthropometric measurements are defined as:

Stature: The subject should stand on a horizontal platform with his heels together, stretching upward to the fullest extent, aided by gentle traction by the measurer on the mastoid processes. The subject's back should be as straight as possible, which may be achieved by rounding or relaxing the shoulders and manipulating the posture. The marked Frankfurt plane must be horizontal. Either the horizontal arm of an anthropometer, or a counter weighted board, is brought down on to the subject's head. If an anthropometer is used, one measurer should hold the instrument vertical with the horizontal arm in contact with the subject's head, while another applies the gentle traction. The subject's heels must be watched to make sure they do not leave the ground.

Maximum head length: It measures straight distance between glabella (the most prominent point on the fontal bone above the root of the nose, between the eyebrows) and the opisthocranion (the most prominent portion of the occiput, close to the midline on the posterior rim of the foramen magnum).

Maximum head breadth: It is the maximum biparietal diameter and is the distance between the most lateral points of the parietal bones.

Horizontal circumference of head: It is the maximum circumference of the head (usually horizontal just above the eyebrow ridges), measured from just above the glabella area to the area near the top of the occipital bone (opisthocranion).

Bigonial diameter: It is the maximum breadth of the lower jaw between two gonion (It is the most posterior, inferior and laterally situated point on the external angles of the mandible) points on the angles of mandibles.

Morphological facial length: It is the straight distance from the nasal root (nasion) to the lowest point on the lower border of mandible in the mid sagittal plane (gnathion).

The measurements were taken with the help of an anthropometric rod, sliding caliper, spreading caliper and measuring steel tape to the nearest 0.1 cm. Only healthy subjects without any physical body abnormality were included in the study.

A similar data on 100 individuals of the same age range from mixed population of Chandigarh city (sample representative of north India) were also collected, so that validity of the regression formulae obtained from Gujjar population (genetically disparate population) can also be tested on the mixed population.

The data thus collected were subjected to statistics like mean, S.D., Karl Pearson's correlation coefficient, regression analysis, etc. and were analyzed using Statistical Package for Social Sciences (SPSS) on Windows XP-Professional.

3. Results

Table 1 presents means, standard deviations, minimum and maximum value of stature and cephalo-facial anthropometric measurements of adult male Gujjars of north India. In the sample of 996, the adult male Gujjars have an average stature of 172.31 cm.

Table 2 displays Karl Pearson's correlation coefficients between stature and various cephalo-facial anthropometric measurements in adult male Gujjars of north India. All the cephalo-facial anthropometric measurements show significant correlation with

Table 1
Descriptive statistics for stature and cephalo-facial anthropometric measurements in adult male Gujjars of north India ($n = 996$)

Measurement (in cm)	Mean	S.D.	Minimum	Maximum
Maximum head length	17.832	0.892	14.5	18.5
Maximum head breadth	13.917	0.622	11.6	15.7
Horizontal circumference of head	53.214	2.573	49.2	58.9
Bigonial diameter	9.783	0.377	6.6	10.8
Morphological facial length	10.81	0.735	8.7	12.4
Stature	172.31	6.83	151.2	186.4

Table 2
Correlation coefficients between stature and various cephalo-facial measurements in adult male Gujjars of north India ($n = 996$)

Measurement (in cm)	Correlation coefficient (r)	Standard error
Maximum head length	0.775*	0.063
Maximum head breadth	0.682*	0.061
Horizontal circumference of head	0.781*	0.059
Bigonial diameter	0.462*	0.081
Morphological facial length	0.455*	0.047

* $p < 0.001$.

Table 3
Regression equations for estimation of stature (in cm) from cephalo-facial measurements in adult male Gujjars of north India ($n = 996$)

Measurement (in cm)	Regression equation	±SEE
Maximum head length	88.671 + 4.647MHL	±4.136
Maximum head breadth	98.056 + 5.320MHB	±4.792
Horizontal circumference of head	65.156 + 2.034HCOH	±3.726
Bigonial diameter	109.991 + 6.483BD	±5.131
Morphological facial length	121.869 + 4.618MFL	±5.820

stature ($p < 0.001$). The measurements of the head exhibit higher correlation coefficients (value of 'r') than those of the facial measurements. The highest correlation coefficient is exhibited by maximum head length ($r = 0.775$) and the lowest by morphological facial length ($r = 0.455$).

Table 3 shows regression equations for estimation of stature (in cm) from five cephalo-facial measurements in adult male Gujjars of north India. There are separate equations for each cephalo-facial dimension which can help in estimation of stature from individual part of head and face. The regression equations have been calculated by regression analysis of the data, and the values of constants 'a' and 'b' are calculated; where 'a' is the regression coefficient of the dependant variable, i.e. stature, and 'b' is the regression coefficient of the independent variable, i.e. any measurement out of five cephalo-facial measurements. Hence, stature = $a + bx$, where, 'x' is any cephalo-facial measurement. The regression formulae have been calculated separately from various cephalo-facial measurements with stature by substituting the appropriate values of constants 'a' and 'b' in the standard equation of regression line.

The table also presents the standard error of estimate (SEE) calculated separately for each regression formula for estimation of stature. The SEE tends to predict the deviation of estimated stature from the actual stature. It ranges between ±4.136 and ±5.820. A low value is indicative of the greater reliability of prediction from a particular measurement and the higher value of SEE denotes less reliability of prediction. Cephalic dimensions exhibit lower values of SEE than those of facial dimensions, suggesting that the prediction of stature from the cephalic dimensions is more reliable than that of facial dimensions. Horizontal circumference of head shows the lowest value (±3.726) than that of any other cephalo-facial measurement. Similarly, the highest value of SEE is exhibited by morphological facial length (±5.820).

4. Discussion

The results indicate that one can successfully estimate stature from different cephalo-facial dimensions in situations where cephalo-facial remains are brought for forensic examinations. The stature estimation in these cases can supplement the other personal identification data like estimation of age, sex, race, and identification from facial morphological characteristics as well as peculiar individualistic features.

Utmost care was taken while measuring the subjects for stature and cephalo-facial measurements [77]. All the instruments were regularly checked for accuracy and precision while collecting data. To avoid inter-observer error, all the subjects were measured by the author himself. To calculate intra-observer error, all the measurements were taken twice on 30 subjects taken from the sample. The intra-observer error was calculated following Dangour [78] and Dangour [79]. The obtained values of the intra-observer error of the measurements fall within the prescribed limits [80] indicating that the measurements are reproducible without significant intra-individual error.

The findings of the study indicate that the all the five cephalo-facial measurements are positively and significantly correlated with stature. Cephalic dimensions show stronger correlation with stature than those of facial dimensions. The statement is confirmed by the lower SEE in case of the cephalic dimensions. It means that the regression formulae calculated for the cephalic measurements give high degree of reliability and accuracy than those of the facial measurements. However, it must be kept in mind that precise prediction of stature from cephalo-facial dimensions may be an unachievable and unnecessary goal; there would always be an estimation error of a few centimeters.

The findings of the present study are also supported by Krishan and Kumar [72] who successfully estimated stature from 16 cephalo-facial measurements in *Koli* adolescents – an endogamous population of north India. They took 16 cephalo-facial measurements for the study, however, in the present study, only five measurements of head and face are taken into consideration. These five measurements are also important as far as anthropological, evolutionary, nutritional and human biological studies are concerned. Moreover, the sample size (996 *Gujjars* + 100 mixed subjects) of the present study is much larger than that of Krishan and Kumar (252 *Kolis* + 90 mixed subjects). There is no doubt, that both studies have taken subjects from two different endogamous populations of north India thus making them anthropologically, genetically and forensically important. However, in the previous study, the regression formulae for estimation of stature have been devised on adolescent sample. On the other hand, the present study has taken adult individuals raging in age from 18 to 30 years. In the adolescent, the stature is correlated with age but is complicated by the differences in rates of growth among individuals [81]. The ongoing physical growth of the long bones which contribute substantially to stature and continuing growth of the head and face have also some effect on the estimation of stature [76] in the adolescent. In other words, stature is usually a straight forward parameter to establish in the adult individual.

The results of the present study can be compared with similar available studies on different populations of the world. Chiba and Terazawa [70] reported SEE of 6.97 cm using regression equations for estimating stature from sum of the diameter and circumference of the skull in Japanese cadavers. Patil and Mody [71] showed somewhat higher standard errors for most of the variables except head length which showed high degree of reliability (SE = 3.71) in estimating stature. Krishan and Kumar [72] reported 4.41–7.21 cm SEE in estimating stature from sixteen cephalo-facial measurements in their sample on Koli male adolescents of north India. Ryan

Table 4
Comparison of actual stature and stature estimated from cephalo-facial measurements in adult male Gujjars of north India ($n = 996$)

Estimated stature using regression equations for:	Minimum estimated stature	Maximum estimated stature	Mean estimated stature
Maximum head length	156.052	174.641	171.536
Maximum head breadth	159.768	181.580	172.094
Horizontal circumference of head	165.228	184.958	173.393
Bigonial diameter	152.778	180.007	173.414
Morphological facial length	162.045	179.132	171.789
Actual stature	151.2 (minimum)	186.4 (maximum)	172.31 (mean)

Table 5
Comparison of mean actual stature (170.53) and mean estimated stature in the subjects ($n = 100$) from mixed population of north India

Estimated stature using regression equations for (in cm):	Mean estimated stature	Differences between means = mean actual stature − mean estimated stature
Maximum head length	169.105	1.425
Maximum head breadth	168.582	1.948
Horizontal circumference of head	169.793	0.737
Bigonial diameter	168.913	1.617
Morphological facial length	168.953	1.577

and Bidmos [73] presented SEE from 4.37 to 6.24 cm in their study on estimation of stature from skulls of indigenous South Africans from Raymond Dart's collection. In the present study, the value SEE is comparatively lower that these studies, i.e. from 3.726 to 5.820 cm. In other words, in the present study, the stature estimation from cephalo-facial dimensions has greater reliability of estimate when compared with other similar studies. This greater reliability of estimate can be attributed to the homogeneous nature of the sample (an endogamous or genetically disparate population) in the present case. All the other studies excepting one by Krishan and Kumar [72] involved study samples from mixed population.

There may be a little effect of the ossification of the bones of the lower limb on estimation of stature. As per the standard figures available for western world, condyles of femur, proximal end of tibia, base first metatarsal and head 2–5th metatarsals completely fuse from about 18 to 20 years of age. As the process of ossification depends upon a number of factors, generally speaking, ossification activities occur earlier in Indian population than in Western population [82].

The regression formulae obtained were checked for their accuracy. Table 4 presents a comparison of actual stature and stature estimated from cephalo-facial measurements using regression analysis. Minimum, maximum and mean values of the measurements were substituted in their respective regression equations, and estimated stature was calculated. It is clear from the table that in every cephalo-facial measurement, minimum estimated stature is greater than the actual minimum stature of 151.2 cm. On the other hand, the value of maximum estimated stature in case of each measurement underestimates the actual stature of 186.4 cm. However, the mean value estimates (mean estimated stature) are close to actual stature. This is due to the fact that the regression equations are calculated from measures of central tendency.

In order to test the applicability and reliability of the obtained regression formulae on mixed north Indian population, a sample of 100 individuals within the same age range was taken using the same set of cephalo-facial measurements as followed in the main study (Table 5). The stature was estimated using the already computed regression formulae for the five measurements. The mean estimated stature was calculated and compared with the mean actual stature of these subjects. The difference between the mean actual stature (170.53 cm) and mean estimated stature ranges from 0.737 to 1.948 cm. In other words, the calculated regression formulae also hold true for the mixed population from north India.

5. Conclusion

From the present study, it has been concluded that, like other parts of the human body, the cephalo-facial dimensions can also be used for estimation of stature when cephalo-facial remains are brought for forensic examination. The measurements of the cephalic region give better reliability of estimate than that of the facial measurements. When the values of Karl Pearson's correlation coefficients and the standard error of estimate of each cephalo-facial measurement are compared with one another, the horizontal circumference of head is found to be the best parameter for estimation of stature. It is further concluded that the calculated regression formulae show good reliability and applicability of estimate not only in the sample which was originally used (genetically homogeneous population) in the calculation of the regression formulae but also in another sample taken from mixed population (genetically heterogeneous population) of north India. While applying these formulae, one should keep in mind that these are population specific; these cannot be used on other populations of the world.

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References

[1] W.M. Krogman, M.Y. Iscan, The Human Skeleton in Forensic Medicine, Charles C. Thomas, Springfield, IL, 1986.
[2] K. Krishan, Limb bilateral asymmetry and footprints of male adult Gujjar population in parts of Punjab and Haryana (Unpublished PhD Dissertation), Panjab University, Chandigarh, India, 2002.
[3] M.Y. Iscan, Forensic anthropology of sex and body size, Forensic Sci. Int. 147 (2005) 107–112.
[4] K. Krishan, Estimation of stature from footprint and foot outline dimensions in Gujjars of North India, Forensic Sci. Int. 175 (2008) 93–101.

[5] K. Krishan, Determination of stature from foot and its segments in a north Indian population, Am. J. Forensic Med. Path., in press.
[6] D.P. Bhatnagar, S.P. Thapar, M.K. Batish, Identification of personal height from the somatometry of the hand in Punjabi males, Forensic Sci. Int. 24 (1984) 137–141.
[7] J. Boldsen, A statistical evaluation of the basis for predicting stature from lengths of long bones in European populations, Am. J. Phys. Anthropol. 65 (1984) 305–311.
[8] A.K. Abdel-Malek, A.M. Ahmed, S.A.A. Sharkawi, N.M.A. Hamid, Prediction of stature from hand measurements, Forensic Sci. Int. 46 (1990) 181–187.
[9] K. Terazawa, H. Alkabane, H. Gotouda, K. Mizukami, M. Nagao, T. Takatori, Estimating stature from the length of the lumbar part of the spine in Japanese, Med. Sci. Law 30 (1990) 354–357.
[10] T.D. Holland, Estimation of adult stature from fragmentary tibias, J. Forensic Sci. 37 (1992) 1223–1229.
[11] D.R. Jason, K. Taylor, Estimation of stature from the length of the cervical, thoracic and lumbar segments of the spine in American Whites and Blacks, J. Forensic Sci. 40 (1995) 59–62.
[12] C.P. Campobasso, G. Di Vella, F. Introna Jr., Using scapular measurements in regression formulae for the estimation of stature, Boll. Soc. Ital. Biol. Sperim. 74 (1998) 75–82.
[13] N.K. Mohanty, Prediction of height from percutaneous tibial length amongst Oriya population, Forensic Sci. Int. 98 (1998) 137–141.
[14] M.C. De, Mendonca, Estimation of height from the length of long bones in a Portuguese adult population, Am. J. Phys. Anthropol. 112 (2000) 39–48.
[15] J.I. Munoz, M. Linares-Iglesias, J.M. Suarez-Penaranda, M. Mayo, X. Miguens, M.S. Roriguez-Calvo, L. Concheiro, Stature estimation from radiographically determined long bone length in a Spanish population sample, J. Forensic Sci. 46 (2000) 363–366.
[16] G. Mall, M. Hubig, A. Buttner, J. Kuznik, R. Penning, M. Graw, Sex determination and estimation of stature from the long bones of the arm, J. Forensic Sci. 117 (2001) 23–30.
[17] D. Radoinova, K. Tenekedjiev, Y. Yordanov, Stature estimation from long bone length in Bulgarians, Homo 52 (2002) 221–232.
[18] A. Ozaslan, M.Y. Iscan, I. Ozaslan, H. Tugcu, S. Koc, Estimation of stature from body parts, Forensic Sci. Int. 132 (2003) 40–45.
[19] C. Pelin, I. Duyar, Estimating stature from tibia length: a comparison of methods, J. Forensic Sci. 48 (2003) 708–712.
[20] M.A. Bidmos, On the non-equivalence of documented cadaver lengths to living stature estimates based on Fully's method on bones in the Raymond A. Dart collection, J. Forensic Sci. 50 (2005) 501–506.
[21] M.A. Bidmos, S. Asala, Calcaneal measurement in estimation of stature of South African blacks, Am. J. Phys. Anthropol. 126 (2005) 335–342.
[22] R. Hauser, J. Smolinski, T. Gos, The estimation of stature on the basis of measurements of the femur, Forensic Sci. Int. 147 (2005) 181–184.
[23] H. Ozden, Y. Balci, C. Demirustu, A. Turgut, M. Ertugrul, Stature and sex estimate using foot and shoe dimensions, Forensic Sci. Int. 147 (2005) 181–184.
[24] C. Pelin, I. Duyar, E.M. Kayahan, R. Zagyapan, A.M. Agildere, A. Erar, Body height estimation based on dimensions of sacral and coccygeal vertebrae, J. Forensic Sci. 50 (2005) 294–297.
[25] M. Bidmos, Adult stature reconstruction from the calcaneus of South Africans of European descent, J. Clin. Forensic Med. 3 (2006) 247–252.
[26] I. Duyar, C. Pelin, R. Zagyapan, A new method of stature estimation for forensic anthropological application, Anthropol. Sci. 114 (2006) 23–27.
[27] K.R. Nagesh, G.P. Kumar, Estimation of stature from vertebral column length in South Indians, Leg. Med. 8 (2006) 269–272.
[28] A. Ozaslan, S. Koç, I. Ozaslan, H. Tuğcu, Estimation of stature from upper extremity, Mil. Med. 171 (2006) 288–291.
[29] T. Kanchan, R.G. Menezes, R. Moudgil, R. Kaur, M.S. Kotian, R.K. Garg, Stature estimation from foot dimensions, Forensic Sci Int 179 (241) (2008) e1–e5.
[30] M.A. Bidmos, Estimation of stature using fragmentary femora in indigenous South Africans, Int. J. Legal Med 122 (2008) 293–299.
[31] K. Chibba, M.A. Bidmos, Using tibia fragments from South Africans of European descent to estimate maximum tibia length and stature, Forensic Sci. Int. 169 (2007) 145–151.
[32] K. Krishan, A. Sharma, Estimation of stature from dimensions of hands and feet in a north Indian population, J. Forensic Leg. Med. 14 (2007) 327–332.
[33] B.K. Ozer, T. Gültekin, M. Sağir, Estimation of stature in Turkish adults using knee height, Anthropol. Anz. 65 (2007) 213–222.
[34] M.H. Raxter, C.B. Ruff, B.M. Auerbach, Technical note: revised fully stature estimation technique, Am. J. Phys. Anthropol. 133 (2007) 817–818.
[35] M. Steyn, J.R. Smith, Interpretation of ante-mortem stature estimates in South Africans, Forensic Sci. Int. 171 (2007) 97–102.
[36] S.L. Smith, Stature estimation of 3–10-year-old children from long bone lengths, J. Forensic Sci. 52 (2007) 538–546.
[37] C.L. Giroux, D.J. Wescott, Stature estimation based on dimensions of the bony pelvis and proximal femur, J. Forensic Sci. 53 (2008) 65–68.
[38] P. Rastogi, K.R. Nagesh, K. Yoganarasimha, Estimation of stature from hand dimensions of north and south Indians, Leg. Med. 10 (2008) 185–189.
[39] M.H. Raxter, C.B. Ruff, A. Azab, M. Erfan, M. Soliman, A. El-Sawaf, Stature estimation in ancient Egyptians: a new technique based on anatomical reconstruction of stature, Am. J. Phys. Anthropol. 136 (2008) 147–155.
[40] W.D. Turner, R.E. Brown, T.P. Kelliher, P.H. Tu, M.A. Taister, K.W. Miller, A novel method of automated skull registration for forensic facial approximation, Forensic Sci. Int. 154 (2005) 149–158.
[41] P. Claes, D. Vandermeulen, S. De Greef, G. Willems, P. Suetens, Craniofacial reconstruction using a combined statistical model of face shape and soft tissue depths: methodology and validation, Forensic Sci. Int. 159 (2006) 147–158.
[42] W. Turner, P. Tu, T. Kelliher, R. Brown, Computer-aided forensics: facial reconstruction, Stud. Health Technol. Inform. 119 (2006) 550–555.
[43] S. De Greef, P. Claes, D. Vandermeulen, W. Mollemans, P. Suetens, G. Willems, Large-scale in-vivo Caucasian facial soft tissue thickness database for craniofacial reconstruction, Forensic Sci. Int. 159 (2006) 26–146.
[44] C. Rynn, C.M. Wilkinson, Appraisal of traditional and recently proposed relationships between the hard and soft dimensions of the nose in profile, Am. J. Phys. Anthropol. 130 (2006) 364–373.
[45] D. Vandermeulen, P. Claes, D. Loeckx, S. De Greef, G. Willems, P. Suetens, Computerized craniofacial reconstruction using CT-derived implicit surface representations, Forensic Sci. Int. 15 (2006) 159.
[46] F. Ramsthaler, K. Kreutz, M.A. Verhoff, Accuracy of metric sex analysis of skeletal remains using Fordisc based on a recent skull collection, Int. J. Legal Med. 121 (2007) 477–482.
[47] J.M. Starbuck, R.E. Ward, The affect of tissue depth variation on craniofacial reconstructions, Forensic Sci. Int. 172 (2007) 130–136.
[48] H. Utsuno, T. Kageyama, T. Deguchi, Y. Umemura, M. Yoshino, H. Nakamura, H. Miyazawa, K. Inoue, Facial soft tissue thickness in skeletal type I Japanese children, Forensic Sci. Int. 172 (2007) 137–143.
[49] T.W. Fenton, A.N. Heard, N.J. Sauer, Skull-photo superimposition and border deaths: identification through exclusion and the failure to exclude, J. Forensic Sci. 53 (2008) 34–40.
[50] E.H. Kimmerle, A. Ross, D. Slice, Sexual dimorphism in America: geometric morphometric analysis of the craniofacial region, J. Forensic Sci. 53 (2008) 54–57.
[51] M.M. Roelofse, M. Steyn, P.J. Becker, Photo identification: facial metrical and morphological features in South African males, Forensic Sci. Int. 177 (2008) 168–175.
[52] D. Sahni, G. Sanjeev, I. Singh, Jit P. Singh, Facial soft tissue thickness in northwest Indian adults, Forensic Sci. Int. 176 (2008) 137–146.
[53] P.D. Prichard, A suicide by self decapitation, J. Forensic Sci. 38 (1993) 981–984.
[54] A. Tracqui, K. Fonmartin, A. Geraut, D. Pennera, S. Doray, B. Ludes, Suicidal hanging resulting in complete decapitation: a case report, Int. J. Legal Med. 112 (1998) 55–57.
[55] M.A. Rothschild, V. Schneider, Decapitation as result of suicidal hanging, Forensic Sci. Int. 106 (1999) 55–62.
[56] M. Hitosugi, K. Fukui, A. Takatsu, Incomplete decapitation of a motorcyclist from hyperextension by inertia: a case report, Med. Sci. Law 41 (2001) 174–177.
[57] R.W. Byard, J.D. Gilbert, Cervical fracture, decapitation and vehicle assisted suicide, J. Forensic Sci. 47 (2002) 392–394.
[58] K. Shorrock, Suicidal decapitation by guillotine: case report, Am. J. Forensic Med. Pathol. 23 (2002) 54–56.
[59] R. Rautji, A. Rudra, V. Dixit, D.N. Bharadwaj, T.D. Dogra, Decapitation in road traffic accidents—a case report, Forensic Sci. Int. 135 (2003) 237–238.
[60] R.W. Byard, J.D. Gilbert, Characteristics features of deaths due to decapitation, Am. J. Forensic Med. Pathol. 25 (2004) 129–130.
[61] E.E. Türk, M. Tsokos, Vehicle-assisted suicide resulting in complete decapitation, Am. J. Forensic Med. Pathol. 26 (2005) 292–293.
[62] F. Dedouit, G. Tournel, A. Bécart, V. Hédouin, D. Gosset, Suicidal hanging resulting in complete decapitation—forensic, radiological, and anthropological studies: a case report, J. Forensic Sci. 52 (2007) 1190–1193.
[63] T. Konopka, M. Strona, F. Bolechała, J. Kunz, Corpse dismemberment in the material collected by the Department of Forensic Medicine, Cracow, Poland, Leg. Med. 9 (2007) 1–13.
[64] M.K. Mohanty, M.K. Panigrahi, S. Mohanty, K.K. Patnaik, Death due to traumatic railway injury, Med. Sci. Law 47 (2007) 156–160.
[65] S. Racette, T.T. Vo, A. Sauvageau, Suicidal decapitation using a tractor loader: a case report and review of the literature, J. Forensic Sci. 52 (2007) 192–194.
[66] M. Tsokos, R.W. Byard, K. Püschel, Extensive and mutilating craniofacial trauma involving defleshing and decapitation: unusual features of fatal dog attacks in the young, Am. J. Forensic Med. Pathol. 28 (2007) 131–136.
[67] C. Behera, R. Rautji, T.D. Dogra, Decapitation with egg shelling of the skull in a road traffic accident: a case report, Med. Sci. Law 48 (2008) 87–88.
[68] K. Töro, I. Kristóf, E. Keller, Incomplete decapitation in suicidal hanging—report of a case and review of the literature, J. Forensic Leg. Med. 15 (2008) 180–184.
[69] F. Introna Jr., G. Di Vella, S. Petrachi, Determination of height in life using multiple regression of skull parameters Boll, Soc. Ital Biol. Sperim. 69 (1993) 153–160.
[70] M. Chiba, K. Terazawa, Estimation of stature from somatometry of skull, Forensic Sci. Int. 97 (1998) 87–92.
[71] K.R. Patil, R.N. Mody, Determination of sex by discriminant function analysis and stature by regression analysis: a lateral cephalometric study, Forensic Sci. Int. 147 (2005) 175–180.
[72] K. Krishan, R. Kumar, Determination of stature from cephalo-facial dimensions in a North Indian population, Leg. Med. 9 (2007) 128–133.
[73] I. Ryan, M.A. Bidmos, Skeletal height reconstruction from measurements of the skull in indigenous South Africans, Forensic Sci. Int. 167 (2007) 16–21.
[74] J.S. Weiner, J.A. Lourie, Human Biology—A Guide to Field Methods, Blackwell Scientific Publications, Oxford and Edinburgh, 1981.
[75] T.G. Lohman, A.F. Roche, R. Martorell, Anthropometric Standardization Reference Manual, Human Kinetics Publications Inc., Champaign, IL, 1988.
[76] J.G. Hall, U.G. Froster-Iskenius, J.E. Allanson, Hand book of Normal Physical Measurements, Oxford University Press, Oxford, New York, Toronto, 2003.

[77] K. Krishan, Anthropometry in forensic medicine and forensic science—'Forensic Anthropometry', Internet J. Forensic Sci. 2 (2007).
[78] A.D. Dangour, Growth of upper and lower body segments in Patamona and Wapishana Amerindian children (cross-sectional data), Ann. Hum. Biol. 28 (2001) 649–663.
[79] A.D. Dangour, Cross-sectional changes in anthropometric variables among Wapishane and Patamona Amerindian adults, Hum. Biol. 75 (2003) 227–240.
[80] S.J. Ulijaszek, D.A. Kerr, Anthropometric measurement error and the assessment of nutritional status, Br. J. Nutr. 82 (1999) 165–177.
[81] L. Scheuer, Application of osteology to forensic medicine, Clin. Anat. 15 (2002) 297–312.
[82] K. Vij, Textbook of Forensic Medicine and Toxicology—Principles and Practice, 3rd edn, Elsevier—A division of Reed Elsevier India Private Limited, New Delhi, 2005 .