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TECHNICAL NOTE

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Prediction of Stature Based on Radiographic Measurements of Cadaver Long Bones: A Study of the Croatian Population*

ABSTRACT: We tested a new approach to the stature prediction that could be used in the identification process of human skeletal remains of unknown identity. The stature of 19 female and 21 male adult cadavers was measured within 24 h after death and considered to be equal to the living stature. The antero-posterior radiographs of all limbs were taken, and the maximum length of the six long bones was measured from radiographs. There was a significant difference in the stature and maximum length of long bones between female and male cadavers ($p < 0.001$ for all). The correlation between the stature and long bone length was the best for the humerus in females ($r = 0.792$) and the tibia in males ($r = 0.891$). Regression equations specific to the Croatian population were computed separately for each long bone in males and females and proven to be reliable in predicting the living stature of the individual.

KEYWORDS: forensic science, forensic radiology, body height, long bone length, Croatian population

Stature estimation is an indispensable part of the identification process of human skeletal remains or body parts (1–3). The accuracy of stature estimation depends on the completeness and state of preservation of the remains, which are often poor. It is, therefore, important to have reliable methods for calculation of stature that can be applied to different bones. In this article, we introduce a new approach to stature prediction based on the measurements of long bones by antero-posterior radiographic imaging.

Anthropometric investigations have shown that ratios between the stature, limb length, and long bone dimensions in an individual are constant during the period of growth and remain the same in adulthood, but they vary depending on stature and ancestry (3–5). Furthermore, recent studies have shown that long bone length might be calculated, and consequently used to estimate the stature, even in cases where only a part of the body (6) or part of the bone (7–9) are available for analysis.

The first comprehensive investigation in this field on European skeletons was conducted by Telkkä (10) in 1950. Trotter and Gleser (2) performed their research on a sample of North American skeletons. In their first study, they measured long bones of European American and African American skeletons from the Robert J. Terry Anatomical Skeletal Collection and long bones of the skeletons of military personnel killed during World War II in the Pacific war zone. In the next study, Trotter and Gleser (11) measured long bones from the skeletons of military personnel killed in the Korean War and found clear differences in the body proportions that depended on the ancestry (European American, African American, or Asian). Their study also showed differences in body proportions of European Americans of different ancestries (Mexican population vs. other European Americans) as well as differences in body proportions of European Americans of the same ancestry in the period from World War II to the Korean War. Their conclusions are considered fundamental in this field and still serve as guidelines for further studies.

Recent research in European population has been performed by De Mendonça (12) on a sample of a Portuguese population and by Rodoinova et al. (13) on a sample of a Bulgarian population. Both investigations were conducted on cadavers and measured the length of long bones in "fresh" condition, i.e. immediately after or before an autopsy, according to the standard anthropological techniques (14). De Mendonça (12) measured disarticulated right humerus and right femur after having removed the soft tissue, whereas Rodinova et al. (13) measured the lengths of right and left humeri, tibiae, and fibulae without disarticulating the joints or removing the soft tissues.

Muñoz et al. (15) carried out an investigation on a sample of a Spanish population. They measured the stature of healthy adults and then took antero-posterior teleradiographs of the right upper and right lower limb. The length of long bones was determined on the basis of teleradiographic findings. However, the authors did not follow the standard anthropological techniques (14).

A similar methodology to measure the length of long bones using of X-ray imaging was applied by Sarajlić et al. (16), who developed regression equations for stature calculation based on the lengths of the femur, tibia, and fibula of 50 Bosnian male ca-

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davers. Ross and Konigsberg (17) gave new formulae for estimating the stature of an Eastern-European male population based on the known lengths of the humerus, femur, and tibia.

So far, predictive regression equations for the stature have not been established for the Croatian population. It was a considerable problem for the identification team assembled by the Croatian Government to perform identification of human remains from the 1991–1995 war in Croatia.

As it is ethically unacceptable to inflict any unnecessary mutilation on the cadaver or irradiate living patients without a valid medical indication, we decided to use noninvasive methods to determine the stature of cadavers. The aim of our study was to introduce a new approach to stature estimation based on the cadaver body length and radiographically determined length of long bones. On the basis of these measurements, regression equations were created for the purpose of the identification of unknown skeletal remains recovered in Croatia. The accuracy of these equations was compared with the equations used in previous forensic and anthropological investigations in Croatia and equations derived from the data on populations of neighboring geographical regions (10,12,16–19).

Subjects and Methods

Subjects

The study of long bones in relation to stature was carried out at the Department of Forensic Medicine and Criminology, Zagreb University School of Medicine, between November 2000 and August 2003. Measurements had been made on cadavers before they underwent an autopsy.

Forty-three consecutive cadavers, 20 females and 23 males, were examined during the study period. There was a similar number of cadavers of each sex and each female cadaver was matched by age with a male cadaver ($\pm$ 5 years). Inclusion criteria were age $\geq$24 years; absence of physical injuries; absence of visible shortening of any of the limbs; absence of bone pathology, bone surgery, and any other pathological process in the medical history that might have influenced the length of long bones. The individuals included in the study either died of natural causes at home ($n = 3$) or at the Zagreb University Hospital Center ($n = 32$) or committed suicide by hanging ($n = 8$).

After radiography, three cadavers (one female and two males) were excluded from the investigation because of a previously existing fracture of at least one of the long bones. The final group consisted of 40 cadavers, 19 females (median age 67 years, range 35–82) and 21 males (median age 60 years, range 31–86). There was no statistically significant difference in age between female and male cadavers ($t = -1.74$, $p = 0.089$).

The control group consisted of three male and two female skeletons recovered during the identification process of victims of the 1991–1995 war in Croatia and one female who died of natural causes at the Zagreb University Hospital Center. Data on statures of three male war victims were obtained from the Croatian Army medical records. Data on the stature of two female war victims were obtained from their families, whereas the stature of the female cadaver was measured directly. All individuals were aged over 24 years at the time of death. In the control group, postcranial measurements were taken from the right side of the body according to anthropological rules (14). The length of skeletonized bone was increased by 2 mm to achieve comparability with the bone length on radiograph. This value, 2 mm, corresponds to the thickness of joint cartilage, which gradually disappears during the postmortem changes (2).

Methods

All the procedures used in the study were in accordance with the ethical standards of the Helsinki Declaration.

Cadaver Stature

In this study, we used a special tool for measuring the stature of cadavers. The tool, which was composed of a measuring panel and two boards, was installed on the X-ray table (Fig. 1). A metal gauge with a scale graduated in millimeters was fixed along the panel. The cadaver was placed in supine position on the panel and the top of the head (vertex) was brought into contact with the fixed board on the cranial end of the panel. The sliding board on the caudal end of the panel was positioned against the soles of the cadaver's feet. Cadaver's stature was measured in millimeters by the metal gauge and considered to be the same as the height of the living subject. For females older than 48 years and males older than 46 years, stature value was corrected according to Giles' tables (20) to compensate for the decline in stature due to aging.

Radiography

The cadaver was secured to the panel by self-adhesive tape to ensure immobility during radiography of the large joints of the limbs (21,22). Under control of a fluoroscope, an injection needle was positioned to indicate the center of the joint cavity. The skin under the needle in the correct position was marked at the point where the central, nondivergent X-rays passed through the center of the joint cavity. This method allowed us to minimize the magnification due to the conical divergence of X-rays (22). A standard cassette (Ortho Gradual Gevamatic Cassette, AGFA, Leverkusen, Germany) with a 30×90 cm X-ray film was used for radiography. Both upper limbs with their large joints fitted on a single radiograph and were displayed together on the same X-ray film (Fig. 2). Joints of lower limbs were X-rayed independently, each leg on a separate radiograph. The distance between the focus and X-ray film during radiography was 100 cm. Antero-posterior radiographs showed the ends of long bones in the position corresponding to the position of long bones on the osteometric board.

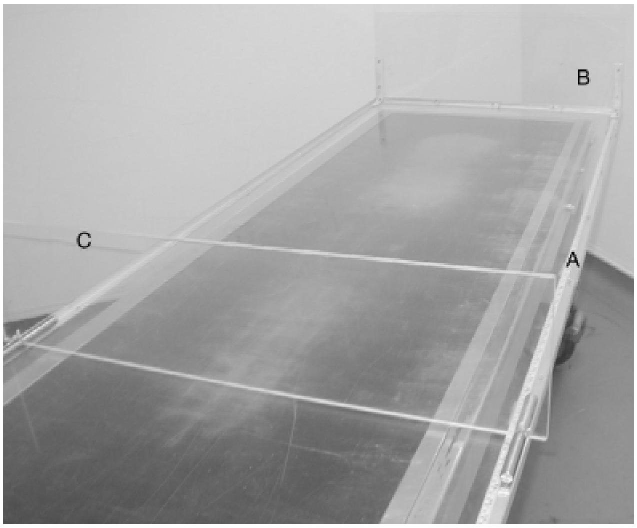

FIG. 1—*Tool for measuring the length of cadavers placed on the X-ray table. Measuring panel from transparent perspex with attached (A) metal gauge with scale graduated in millimeters; (B) fixed board on the cranial end; and (C) sliding board on the caudal end.*

FIG. 2—*Hand radiograph (subject from the study, female, age 31). Both hands, left (L) and right (R), are on the same radiograph. The ends of long bones are visible on antero-posterior radiographs of each large joint in order to enable the measurement of long bone lengths. Injection needles determine the centers of the joint cavities. Original film size: 30 × 90 cm.*

Measurement of Long Bone Length from X-ray Images

The maximum lengths of all six long bones were measured according to standard anthropological techniques (14) directly from the antero-posterior radiographs using a ruler with a measurement accuracy of 1 mm. The length of the long bones measured from antero-posterior radiographs equals the length of "fresh" long bones with joint cartilage (22).

Statistical Analysis

The normality of numerical data distribution was tested with the Kolmogorov–Smirnov test. Data were presented as means with standard deviation or 10–90% confidence intervals showing the data range. A two-way ANOVA was used to test the effect of two independent variables on numerical data.

The association of numerical parameters was assessed by Pearson's correlation coefficient r. Whenever r was significant, i.e., $r > 0.6$ (23), univariate regression equations were computed according to the equation $y = \beta_0 + \beta_1 x$, where y is a dependent variable, β_0 and β_1 are regression coefficients, i.e., intercept and slope, and x is the independent variable. Values of regression coefficients were presented with standard errors. The regression line on scattergrams was always shown with the 95% confidence interval limits.

Multiple regression equations were computed according to the equation $y = \beta_0 + \beta_i x_i$, where y is a dependent variable, β_0 and β_i are regression coefficients, and x_i are independent variables.

Statistical analysis was performed with MedCalc for Windows (version 7.5, Frank Schoonjans Inc., Mariakerke, Belgium) and SPSS for Windows (version 7.0, SPSS Inc., Chicago, IL). Only p values < 0.05 were considered to be significant.

Results

The difference in stature between female and male cadavers was significant ($p < 0.001$; Fig. 3).

A significant difference between females and males was also found in the length of all six long bones ($p < 0.001$ for all bones; Table 1). When the lengths of the right and left long bones of the same cadaver were compared, no difference was found ($p > 0.05$ for all, Table 1). Naturally, the length of each long bone used in further calculations was the average value of the length of the left and right long bone.

Correlation and univariate regression analyses showed that the association between the stature and the length of long bones was substantial, given the high and statistically significant values of Pearson's correlation coefficients, ranging from 0.649 (radius) to 0.792 (humerus) in females and from 0.815 (ulna) to 0.891 (tibia) in males (Table 2).

All regression coefficients were statistically significant (Table 2). Examples of regression equations with graphical presentation are given in Fig. 3 for calculating female stature from the humerus length, chosen according to the highest correlation coefficient in females (Fig. 4*A*), and for calculating male stature from the tibia length, chosen according to the highest correlation coefficient in males (Fig. 4*B*).

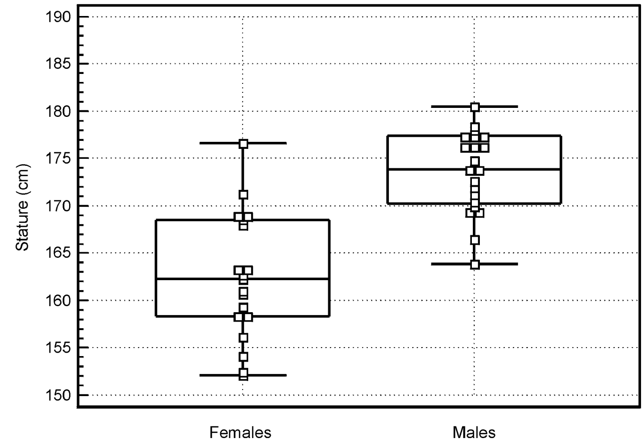

FIG. 3—*Box-and-whisker plot with a scattergram of stature in females (n = 19, mean ± SD = 162.4 ± 6.7 cm, 10–90% = 153.1–170.4 cm) and males (n = 21, mean ± SD = 173.6 ± 4.3 cm, 10–90% = 168.2–178.2 cm). The intersexual difference in stature was found to be significant (t = − 6.35,* p < *0.001).*

TABLE 1—*Long bone lengths (mean ± SD, in cm) in 40 cadavers according to sex and body side.*

Bone	Females ($n = 19$)		Males ($n = 21$)	
	Left	Right	Left	Right
Humerus	30.8 ± 1.8	30.9 ± 1.7	33.3 ± 1.4	33.5 ± 1.3
Ulna	24.8 ± 1.1	25.0 ± 1.2	26.9 ± 1.2	27.0 ± 1.2
Radius	22.7 ± 1.1	22.9 ± 1.2	24.8 ± 1.1	25.0 ± 1.1
Femur	43.3 ± 2.3	43.3 ± 2.4	46.7 ± 2.0	46.6 ± 2.1
Tibia	35.3 ± 2.2	35.4 ± 2.1	37.9 ± 2.0	37.9 ± 2.1
Fibula	34.9 ± 1.7	34.8 ± 1.7	37.8 ± 1.7	37.7 ± 1.8

Two-way ANOVA results used to calculate effect of sex ($p < 0.001$ for all bones), side of the body ($p > 0.05$ for all bones) and sex and side interaction ($p > 0.05$ for all) to the length of bones.

Additionally, we compared the correlation coefficients for each long bone of female and male cadavers (Table 2), but no significant difference was found (data not shown).

When a multiple stepwise regression model was applied, only the humerus in females and the tibia in males were found to be significant and independent estimators of human stature. The data obtained were similar to those from univariate regression analysis, with values of regression coefficients close to those presented in Table 2.

The actual stature of six control subjects was compared with statures calculated according to regression equations in Table 2 and with statures calculated according to regression equations published by seven other authors (Fig. 5). The statures according to other studies were calculated as an average of quoted regression factors, used by Rollet (18), or quoted regression equations from all other studies (10,12,16–19) for each long bone. The stature calculated according to the equations from the present study is close to the real stature of control subjects, with the greatest difference being 4 cm, found in one male subject (Fig. 5).

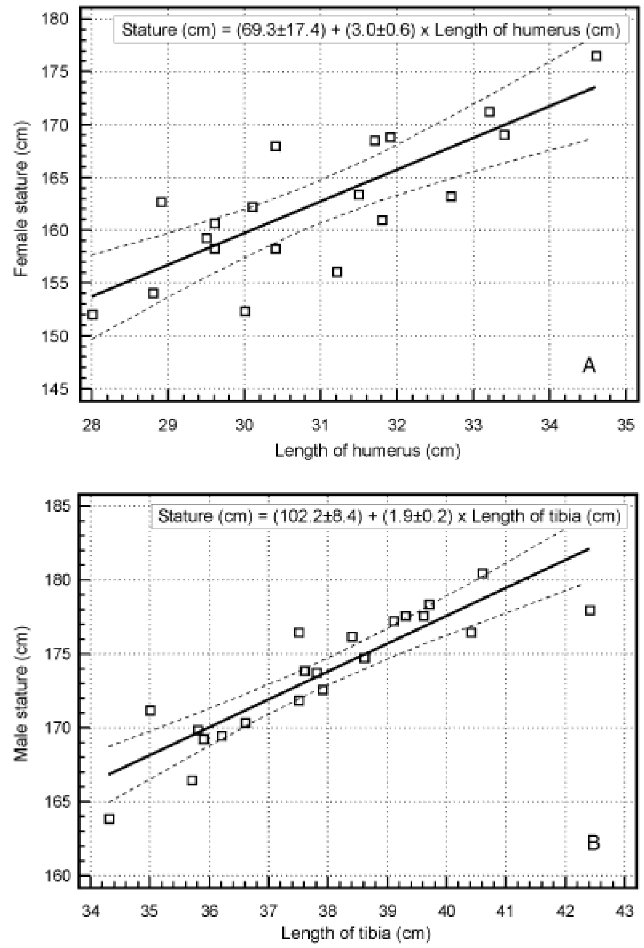

FIG. 4—*Regression lines with the 95% confidence level comparing the stature of the subjects (dependent variable, y) with the length of their humerus (A, for females) or tibia (B, for males) as an independent variable (x). Regression equations are from Table 2.*

Discussion

The mean statures of the subjects included in our study were in accordance with the reported data for the mean stature of the Croatian population (24). This is of particular importance for this study considering how well the studied sample represents the entire population. The values of body stature obtained in this study are almost identical to the results of Muñoz et al. (15) obtained on a Spanish population sample in 2001, with a mean of 161.2 ± 6.2 cm for females and 175.3 ± 6.8 cm for males. Interestingly, measuring stature in a Portuguese population sample in 2000, De Mendonça estimated the mean stature of females and males at 157.7 cm (range 145–175) and 167.9 cm (range 153–185), respectively (12), suggesting that the Portuguese may be shorter than Spaniards.

For females older than 48 years ($n = 17$) and males older than 45 years ($n = 17$) in our study, stature was corrected according to Giles' tables (20) to compensate for the decline in stature due to aging. In his work, Giles (20) showed that the process of height decline in men starts after the age of 45, somewhat earlier than in women in whom the decline in height begins after the age of 47, and hence these ages are considered a turning point for the correction of living stature. A similar practice was followed by Sarajlić et al. (16).

TABLE 2—*Correlation and univariate regression equations comparing stature of subjects (dependent variable, y) with length of long bones (independent variable, x). Each regression equation is computed as* $y = \beta_0 + \beta_1 x$*, separately for males and females.**

Bone	Females ($n = 19$)				Males ($n = 21$)			
	r	$\beta_0 \pm SE(\beta_0)$	$\beta_1 \pm SE(\beta_1)$	$SE(y)$	r	$\beta_0 \pm SE(\beta_0)$	$\beta_1 \pm SE(\beta_1)$	$SE(y)$
Humerus	0.792	69.3 ± 17.4	3.0 ± 0.6	4.15	0.823	82.1 ± 14.5	2.7 ± 0.4	2.52
Ulna	0.700	56.6 ± 26.2	4.2 ± 1.0	4.92	0.815	94.7 ± 12.9	2.9 ± 0.5	2.56
Radius	0.649	76.6 ± 24.4	3.8 ± 1.1	5.21	0.821	93.3 ± 12.9	3.2 ± 0.5	2.52
Femur	0.764	68.3 ± 19.3	2.2 ± 0.4	4.42	0.870	86.9 ± 11.3	1.9 ± 0.2	2.17
Tibia	0.701	83.3 ± 19.6	2.2 ± 0.6	4.91	0.891	102.2 ± 8.4	1.9 ± 0.2	2.00
Fibula	0.747	57.5 ± 22.7	3.0 ± 0.7	4.59	0.890	90.7 ± 9.8	2.2 ± 0.3	2.03

*Statistical note: r, Pearson's correlation coefficient; β_0, first regression coefficient (intercept) with standard error SE(β_0); β_1, second regression coefficient (slope) with standard error SE(β_1); SE(y), standard error of estimation. All correlation coefficients were found significant at $p \leq 0.001$ except $p = 0.003$ for the radius in females. All regression coefficients were found significant at $p < 0.05$. (No comparison between females and males was performed.)

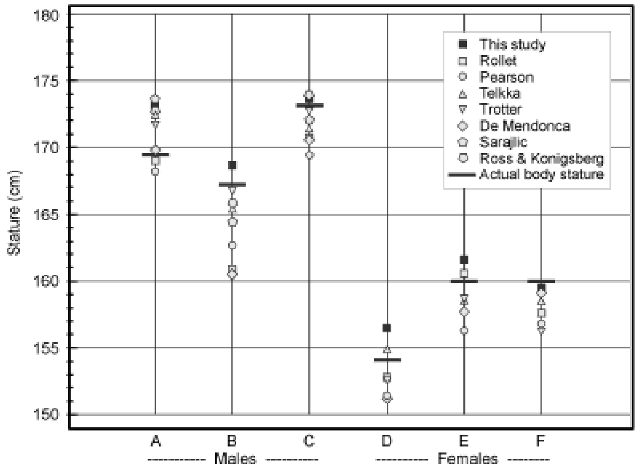

FIG. 5—*Comparison of body stature with stature calculated according to methods from six different, previously published studies. Control subjects are designated by letters A–F.*

The literature also quotes another approach of living stature correction with respect to the postmortem stature. Some studies (10,12) report a difference between the living stature and stature measured after death and that the stature of the cadaver is on average 2 cm taller than the stature of the living person. Trotter and Gleser (2) found that cadavers included in their study were on average 2.5 cm taller compared with their living stature. However, they concluded that a unique correction value could not be applied as the correction depended on the time interval between death and measurement, environmental conditions, and measurement method. Terry (25) described in detail the measurements of stature performed on donated corpses. As several days, sometimes even weeks, had elapsed between the time of death and the measurements he performed, Terry concluded that the increase in the stature of cadaver models under such circumstances resulted from the loss of water and muscle tonicity (25). In our study, we did not include this type of correction of body height. The measurements of body height and X-ray imaging of all cadavers in our study were performed within 24 h of death. As rigor mortis begins in this early postmortem interval and lasts on average 57 ± 14 h (26), neither the loss of muscle tonicity nor a significant water loss could have had a direct effect on the body height. This is also confirmed by the fact that the measurements of body height of subjects in this study match those of the contemporary Croatian population (24). Other authors also consider cadaver length to be the same as the living stature (16).

In our sample, no statistically significant difference was found in the bone length between the left and right limbs in either sex. However, further estimations were performed using the average left/right bone length. Other authors also used the average length of paired bones in their studies (2,10,16). Choi et al. (27) observed no discrepancy in the length of bones between the left and right side and performed regression analysis with right bone length only. Some other authors adopted a similar practice, measuring only the long bones of the right limbs (12,15).

The present study confirmed a very distinct and statistically significant correlation between the length of all long bones and the stature, which is consistent with findings of the previous studies. Some authors also reported a sex difference in the strength of this correlation. Trotter and Gleser (11), for instance, have demonstrated that long bones of the European American female population correlate with stature better than long bones of the European American male population. On the other hand, long bones of African American males showed a greater correlation with stature than long bones of African American females (2). Quite a similar observation was reported by Muñoz et al. (15).

In our study, the correlation coefficients were higher in male than female cadavers for all six long bones, suggesting that long bone length correlates with stature better in the male than in the female population. However, statistical analysis failed to confirm this observation.

In the present study, separate analysis of correlation of each long bone with the stature showed that the stature correlated best with the humerus in females ($r = 0.792$) and the tibia in males ($r = 0.891$). Telkkä (10) also found the greatest correlation between the stature and the humerus in females and the stature and the fibula in males. Most authors showed that the long bones of the leg correlated with body height better than the long bones of the arm in both sexes (2,3,15,27).

High and statistically significant correlation coefficients for six long bones allowed us to calculate the regression equations separately for females and males. Accordingly, the known maximum length of any of the six long bones allowed for the calculation of body stature. In identification practice, it means that the individual's living stature may be derived from postmortem remains if there is at least one complete long bone (humerus, radius, ulna, femur, tibia, or fibula). Thus, the best results are achieved with long bones that correlate best with stature. For our Croatian population sample, these bones were the humerus in females and the tibia in males.

Multiple regression analysis showed that the best results in calculating stature were obtained by including a single bone, the one that was considered to be in best correlation with the body stature. Adding values of any other long bone did not contribute to the accuracy of body height calculation. On the other hand, the results of multiple regression analysis from other studies showed that the most reliable estimates of stature were achieved by a combination of either two (2,27) or three long bones (15).

It is a common practice to check on a control group the applicability of equations derived from a population sample for which regression equations have not yet been computed and to compare them with already existing equations reported in other studies (12,27–29). In addition to the equations shown in Table 2, we also used equations derived from other European population samples (10,12,16–18), which are commonly used in investigations by forensic and anthropological experts in Croatia, as well as the best known and most frequently used equations for predicting stature derived from the series of European American population samples (19). Because the maximum lengths of long bones were measured according to anthropological techniques (14), the obtained values could be inserted into equations from the above-mentioned studies. According to Brogdon (22), the length of long bones measured from antero-posterior radiographs equals the length of "fresh" long bones with joint cartilage. Therefore, the long bone lengths measured from antero-posterior radiographs of the female cadaver in our control group were directly inserted into both the equations from this study and equations from De Mendonça's study (12). To use these measurements with other equations derived from skeletons (10,17–19), it was necessary to subtract 2 mm, i.e. the thickness of joint cartilage lost during postmortem decomposition (2). Other control subjects in our study were skeletons, and hence it was necessary to add 2 mm before inserting the lengths of their long bones into our equations and equations from the studies of De Mendonça (12) and Sarajlić et al. (16).

We showed that living statures of control subjects, estimated by equations from this study, had maximum deviations of ± 4 cm.

Similar deviations were reported by Trotter (19). When the equations of other authors were used, the deviations were even larger, with a maximum of ± 7 cm.

It must be pointed out that some of the studies used for comparison of the present results were published more than 100 years ago and that the correlation coefficients between the long bone lengths and the stature are characteristic for a particular population. Secular growth of the human population, together with the differences in the correlation between the stature and long bone length between ancestries, requires continuous updating and development of population-specific methods of stature estimation. The equations from our study are a useful tool for estimating the living stature. We are aware that our relatively small sample size could be a limitation of our study. However, taking into consideration the above factors, these equations could be used for more accurate stature estimation of unknown human remains recovered in Croatia. Future research could enhance the relevance of the present results.

These new regression equations for estimation of the living stature were derived from the contemporary Croatian population and they substantially contribute to the identification process of the victims of the 1991–1995 war in Croatia—the task that has become an everyday forensic practice in Croatia.

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References

1. Mall G, Hubig M, Büttner A, Kuznik J, Penning R, Graw M. Sex determination and estimation of stature from the long bones of the arm. Forensic Sci Int 2001;117:23–30.
2. Trotter M, Gleser GC. Estimation of stature from long bones of American whites and negroes. Am J Phys Anthropol 1952;10:463–514.
3. Duyar I, Pelin C. Body height estimation based on tibia length in different stature groups. Am J Phys Anthropol 2003;122:23–7.
4. Liharžik FP. La loi de la croissance et la structure de l'homme. Vienne: De l'imprimerie impériale royale de la cour et de l'état, 1862:7–12.
5. Aldegheri R, Agostini S. A chart of anthropometric values. J Bone Joint Surg Br 1993;75:86–8.
6. Ozaslan A, Iscan MY, Ozaslan I, Tugcu H, Koc S. Estimation of stature from body parts. Forensic Sci Int 2003;132:40–5.
7. Badkur P, Nath S. Use of regression analysis in reconstruction of maximum bone length and living stature from fragmentary measures of the ulna. Forensic Sci Int 1990;45:15–25.
8. Holland TD. Estimation of adult stature from fragmentary tibias. J Forensic Sci 1992;37:1223–9.
9. Prasad R, Vettivel S, Jeyaseelan L, Isaac B, Chandi G. Reconstruction of femur length from markers of its proximal end. Clin Anat 1996; 9:28–33.
10. Telkkä A. On the prediction of human stature from the long bones. Acta Anatomica 1950;9:103–17.
11. Trotter M, Gleser GC. A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Am J Phys Anthropol 1958;16:79–123.
12. De Mendonça MC. Estimation of height from the length of long bones in Portuguese adult population. Am J Phys Anthropol 2000;112:39–48.
13. Radoinova D, Tenekedjiev K, Yordanov Y. Stature estimation from long bone lengths in Bulgarians. Homo 2002;52:221–32.
14. Bass WM. Human osteology: a laboratory and field manual. 4th ed. Columbia: Missouri Archaeological Society, 1995.
15. Muñoz JI, Liñares-Iglesias M, Suárez-Peñaranda JM, Mayo M, Miguéns X, Rodríguez-Calvo MS, et al. Stature estimation from radiographically determined long bone length in a Spanish population sample. J Forensic Sci 2001;46:363–6.
16. Sarajlić N, Cihlarž Z, Klonowski EE, Selak I. Stature estimation for Bosnian male population. Bosn J Basic Med Sci 2006;6:62–7.
17. Ross AH, Konigsberg LW. New formulae for estimating stature in the Balkans. J Forensic Sci 2002;47:165–7.
18. Krogman WM, Iscan MY. The human skeleton in forensic medicine. 2nd ed. Springfield: Charles C Thomas, 1986.
19. Trotter M. Estimation of stature from intact long limb bones. In: Stewart TD, editor. Personal identification in mass disasters. Washington: National Museum of Natural History, Smithsonian Institution, 1970:71–83.
20. Giles E. Corrections for age in estimating older adults' stature from long bones. J Forensic Sci 1991;36:898–901.
21. Bešenski N, Škegro N. Radiografska tehnika skeleta [Radiografic technique of the skeleton, in Croatian]. 2nd ed. Zagreb: Školska knjiga, 1990:9–141.
22. Brogdon BG. Forensic radiology. Boca Raton: CRC Press, 1998.
23. Dawson-Saunders B, Trapp RG. Basic and clinical biostatistics. London, (Singapore): Prentice-Hall Int. Inc, 2001.
24. Mustajbegović J. Vrijednosti ventilacijskih funkcija pluća poljoprivrednih radnika. [Ventilatory capacity values in farmers, in Croatian]. Dissertation, Zagreb, Zagreb University School of Medicine, 1992, 48–50.
25. Terry RJ. On measuring and photographing the cadaver. Am J Phys Anthropol 1940;26:433–47.
26. Madea B, Krompecher T, Knight B. Muscle and tissue changes after death. In: Knight B, editor. The estimation of the time since death in early posmortem period. London: Edward Arnold, 1995:138–67.
27. Choi BY, Chae YM, Chung IH, Kang HS. Correlation between the postmortem stature and the dried limb-bone lengths of Korean adult males. Yonsei Med J 1997;38:79–85.
28. Kate BR, Mujumdar RD. Stature estimation from femur and humerus by regression and autometry. Acta Anatomica 1976;94:311–20.
29. Pelin IC, Duyar I. Estimating stature from tibia length: a comparison of methods. J Forensic Sci 2003;48:708–12.

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