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Research Article

The Stature Estimation Based on Cephalic Measurements in the Southwest Iranian Populations

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Abstract

Evaluating the correlation and driving the regression formula between stature and cephalic dimensions when skull remains can only be available for forensic examination have been the targets of scientists for many years. The present research aimed to make a cephalic measurements database, suggesting a regression formula for stature reconstruction and computation of the cephalic index for the Lur and Arab populations dwelling in the southwest of Iran. In this cross-sectional analytical study, three cephalic measurements, including maximum cephalic length (MCL), maximum cephalic breadth (MCB), maximum auricular head height (MAHH), and total height, were taken in 200 healthy students (100 males and 100 females, aged 18 - 30 years old) studying at Abadan University of Medical Sciences. Our findings revealed significant gender differences in all mean cephalic measurements ($P \leq 0.05$). According to the prediction final model, MCB and MAHH are effective variables in stature estimation. The stature estimation equation for southwest Iranian males and females is stature = 51.77 + 3.47 MCB + 3.86 MAHH + 0.53 MCL. The computation of the cephalic index represented that most female subjects had mesocephalic (medium-headed) and most male subjects had brachycephalic (short-headed) cephalic categories. This study showed a significant correlation between cephalic dimensions and stature. The obtained regression formula of this study can be used in medico-legal subjects to diagnose the personal identity of a southwest Iranian corpse.

Keywords: Stature, Cephalic Measurements, Anthropometry, Regression Analysis

1. Background

Human identification based on the estimation of biological profiles is an essential aspect of forensic science and archeology. Evaluation of the anthropometric ratios is useful for forensic analysis that can help identify the age, gender, and race of human remains after death (1, 2). Stature is one of the helpful criteria in forensic examination, particularly in unknown and mutilated human corpses (3, 4). Based on different studies, stature exhibits proportional biological ratios with different body segments, such as head, trunk, and extremities, and varies significantly with age and gender between racial groups (5-7). Cephalometry is a practical measurement of head and face soft and hard tissues for clinical and research purposes (8). In some situations, only skull remains are brought for forensic examination, so accurate identification and stature estimation can be carried out based on cephalofacial dimensions (9). As we know, hereditary and environmental factors, diet quality, and ethnicity can influence craniofacial dimensions among different populations (5). Considering these facts, the scientists' conclusions have been different. Some of these conclusions have shown strong correlations between cephalic dimensions and stature, whereas others have not (10-13).

2. Objectives

Besides these reasons, in order to reveal gender differences and compare cephalic racial, genetic, and cultural background populations (14-16), we designed this study to elucidate the norms of cephalic dimensions in the southwest Iranian population to provide a convenient database in forensic medicine. Based on collected data, we can determine the cephalic index and anatomical types of the head associated with growth patterns and health status (17). By recognizing the cephalic index, we can make orthodontic and clinical diagnosis and treatment methods easier (18). These basic databases can be used to process images by computer to detect racial variations in forensic sciences (19). Finally, another purpose of this study is to test the efficacy and validity of gender-specific regression models for stature prediction using linear cephalic dimensions in the Iranian southwest population.

3. Methods

This prospective cross-sectional study was conducted after obtaining the institutional ethical clearance for 200 healthy medical students (100 males and 100 females, age range: 18 - 30 years) from Abadan University of Medical Sciences. The samples were assessed from Khuzestan province by special questionnaires, meaning that their parents were born in Khuzestan. Only healthy subjects without any apparent craniofacial deformity, trauma, or surgery were included. The individual's height was measured as the vertical distance from the plane where the participant stands barefooted to the vertex on the head in a standing erect anatomical position using a tape meter. External cephalic linear dimensions were maximum cephalic length (MCL) measured as the distance between the glabella, the most prominent point at the root of the nose (glabella) to the most prominent point on the occipital bone (onion) in the median sagittal plane. Maximum cephalic breadth (MCB) is the maximum distance between the most lateral points of the parietal bones. Maximum auricular head height (MAHH) is the distance from the external acoustic meatus to the highest point on the vertex. In all measurements, a person's head should be to the front side, eyes and ears parallel to the ground. All participants were measured by the same investigator three times (between 10 AM and 12 PM) with the help of a standard spreading caliper and Collis. All measurements were entered into the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 19.0. IBM Corp., Armonk, New York). Karl Pearson's correlation coefficient of all cephalic parameters with stature was calculated. Simple linear regression analysis was performed, and regression equations were derived for stature estimation using each independent variable for males and females separately. After deriving the stature estimation from these tested equations, the difference between the estimated and observed stature was computed to note the best regression for the stature estimation. Finally, the accuracy of the computed equations was tested on 50 randomly selected participants from each group. The method proposed by Williams et al., which utilizes the cephalic index, was used to determine the head. Based on the horizontal cephalic index, the head shape was categorized into the following four categories: Dolichocephalic (long head) <74.9, mesocephalic (moderate head) 75 - 79.9, brachycephalic (short head) 80 - 84.90, and hyperbrachycephalic (very short head) 85< (20).

- Cephalic index: Maximum head breadth × 100 maximum head length

4. Results

The mean ages of the research subjects (male: 21.34 ± 2.03; female: 21.43 ± 2.28) were not significantly different between the two genders. The mean height of the male participants was found to be significantly high; males appeared to be noticeably taller than females (Table 1).

Table 1. Subjects' Height and Age

Parameter	Female (N = 100), Mean ± SD	Male (N = 100), Mean ± SD
Age, y	21.34 ± 2.03	21.43 ± 2.28
Height, cm	163.66 ± 5.51 [a]	178.21 ± 5.99

[a] Significant at P $\leq$ 0.05

A significant gender difference was detected where the mean ± standard deviation of MCL, MCB, and MAHH were found to be significantly more in males than in females (Table 2). The computation of the cephalic index represented that most female subjects had mesocephalic (medium-headed) and most male subjects had brachycephalic (short-headed) cephalic categories (Table 2).

Table 2. Cephalic Dimensions and Cephalic Index in Male and Female Subjects

Parameters (mm)	Male (N = 100), Mean ± SD	Female (N = 100), Mean ± SD
MCL	186.51 ± 7.06 [a]	182.43 ± 7.95
MCB	156.79 ± 7.7 [a]	149.76 ± 6.09
MAHH	152.55 ± 7.87 [a]	137. 50 ± 9.38
CI	84.73 [a]	82.69

Abbreviations: MCL, maximum cephalic length; MCB, maximum cephalic breath; MAHH, maximum auricular head height; CI, cephalic index; SD, standard deviation.
[a] Significant at P $\leq$ 0.05

The relationship between the cranial measurements and their height was examined using Pearson's correlation coefficient in both male and female populations. Pearson's correlation coefficient (r) was shown to be significant between MCB, MAHH, and stature in male subjects, as well as between MCB and stature in female subjects (Table 3).

Table 3. Pearson's Correlation Coefficient (r) Between Stature and Cranial Measurements for Male and Female Subjects

Parameters	Male, (r)	Female, (r)
MCL	0.12	0.15
MCB	0.23 [a]	0.27 [a]
MAHH	0.19 [a]	0.15

Abbreviations: MCL, maximum cephalic length; MCB, maximum cephalic breath; MAHH, maximum auricular head height.
[a] $P \leq 0.05$

For stature estimation, MCL, MCB, and MAHH were used as independent variables for drawing linear regression analyses. The relationship between the cephalic measurements and their height was analyzed in male and female populations using the linear regression (backward) method (Table 4). According to this table, the stature equation of males and females is as follows:

Male stature = 127.29 + 1.53 cephalic breadth (CB) + 0.47 cephalic length (CL) + 1.16 MAHH

Female stature = 116.13 + 2.02 CB + 0.48 CL + 0.61 MAHH

The results of variance analysis showed that this model was significant in male subjects (P-value = 0.03) but not in female subjects (P-value = 0.06). Due to these results, this model cannot anticipate stature changes in female subjects.

In the backward model, nonsignificant variables have been deleted, and it is finally suggested that all remaining variables have a significant difference with independent variables. It has been shown that MCB is an effective variable in male stature estimation cases. In female cases, MCB can be anticipated by 0.04 stature change, and one unit in MCB increase caused a 2.09 increase in stature (Table 5).

According to regression linear analysis data, the stature estimation equation of males and females is:

Stature =51.77 + 3.47 CB + 3.86 MAHH + 0.53 CL

According to the results of the variance analysis, the whole model is credible (P-value = 0.000). The amount of adjusted R^2 has shown that this model can anticipate 0.43 of stature estimation. Assessing every variation has shown that MCB and MAHH are significant variables, but MCL is not (Tables 6 and 7).

5. Discussion

The present anthropometric study reveals that we can estimate stature from selected cephalic dimensions when residual skulls are discovered during forensic investigations. In these cases, stature, along with age and gender, is a reliable criterion for eliciting racial and geographic peculiarities and can help narrow down the human remains identification (21, 22). In our country, regardless of the significant progress in forensic fields, less attention has been paid to the stature prediction model based on cephalic dimensions in different races dwelling in various regions (23-25). In this regard, the present study could prepare basic data on cephalic measurements and stature prediction in the adult southwest Iranian population for the first time. The first remarkable point in our research is that the male subjects had significantly greater stature and cephalic dimensions than females. This issue could be explained by maturation and hormonal influence on craniofacial morphology that has been different between males and females (26). Identification of these diversities is a critical aspect of knowledge of morphological variation between human populations. In this regard, many researchers have established this gender diversity for stature and cephalic dimensions in different countries (27-32). It is obvious from (Table 3) that the highest correlation coefficient with stature was exhibited by MCB (r = 0.23) and MAHH (r = 0.19) in male subjects and by MCB (r = 0.27) in female subjects. According to regression linear analysis data, the stature estimation equation of males and females is stature = 51.77 + 3.47 CB + 3.86 MAHH + 0.53 CL. The results of the variance analysis have shown that the whole model is credible. Aligned with our study, Kalia found a highly positive correlation between height and head circumference in 100 Mysorean patients (27). Ilayperuma recommended the positive relationship between the height of Sri Lankan adults and their cranial dimensions, and they could predict equation stature in both males and females (11). In a similar study, Agnihotri et al. indicated a certain correlation between stature and cranial measurements in both males and females (16). It has been found by Khan et al. that Pearson's correlation coefficient between stature and cephalic parameters in 260 Panjabi adult individuals was highly positive for both genders (33). In Introna et al.'s research, maximum anterior-posterior and lateral cephalic diameters in male subjects had a significant correlation with stature (r = 0.38, 0.60) that had been similar to our study (34). Reddy et al. suggested that reported measured cephalofacial parameters were significantly correlated with stature, and unlike our study, MCL had a higher r value with stature (28). In our research, the amount of adjusted R^2 showed that our final model could anticipate 0.43 of stature estimation in both genders. However, some researchers showed a weak relationship between stature and craniofacial measurements and found a statistically insignificant relationship between them in both males and females (35, 36). As we know, the equation calculated for a specific population upon regressive analysis cannot

Table 4. Male and Female Stature Prediction Model According to Cephalic Measurements Using Linear Regression

Variables	B	SE	Beta	*t*	P-Value [a]
Male					
MCB	1.53	0.84	0.19	1.82	0.07
MCL	0.47	0.84	0.05	0.56	0.57
MAHH	1.16	0.88	0.13	1.31	0.19
Adjusted R^2 = 0.05; R = 0.29; R^2 = 0.08					
Female					
MCB	2.02	0.89	0.22	2.25	0.02
MCL	0.48	0.7	0.06	0.69	0.49
MAHH	0.61	0.61	0.1	1.01	0.31
Adjusted R^2 = 0.04; R = 0.26; R^2 = 0.07					

Abbreviations: MCL: Maximum cephalic length; MCB: Maximum cephalic breath; MAHH: Maximum auricular head height.
[a] Significant at $P \leq 0.05$

Table 5. The Final Model of Male and Female Stature Estimation Based on Maximum Cephalic Bread Variation Using Linear Regression

Variables	B	SE	Beta	*t*	P-Value
MCB/male	2.02	0.78	0.25	2.57	0.01
Adjusted R^2 = 0.05 R = 0.25 R^2 = 0.06					
MCB/female	2.09	0.89	0.23	2.34	0.02
Adjusted R^2 = 0.04; R = 0.23; R^2 = 0.05					

Abbreviations: MCB, maximum cephalic breath

Table 6. Stature Estimation Based on Maximum Cephalic Length, Maximum Cephalic Breath, and Maximum Auricular Head Height Factors Using Linear Regression Analysis

Variables	B	SE	Beta	*t*	P-Value
MCB	3.47	0.71	0.29	4.81	0.000
MAHH	3.86	0.51	0.46	7.46	0.000
MCL	0.53	0.67	0.04	0.79	0.43
Adjusted R^2 = 0.43; R = 0.66; R^2 = 0.43					

Abbreviations: MCL, maximum cephalic length; MCB, maximum cephalic breath; MAHH, maximum auricular head height

Table 7. The Final Model of Stature Estimation Using Linear Regression Analysis

	B	SE	Beta	P-Value
MCB	3.52	0.71	0.29	0.000
MAHH	3.97	0.49	0.47	0.000
Adjusted R^2 = 0.43; R = 0.66; R^2 = 0.44				

Abbreviations: MCB, maximum cephalic breath; MAHH, maximum auricular head height.

be used for another population worldwide. The results of this study may be very effective for forensic medicine in our country, particularly in problems like identifying missing people after war, earthquakes, floods, mass graves, or identification of unknown skeletal remains, which are very actual. Thus, similar studies, particularly on different races distributed in various regions of Iran, must be conducted to prepare extensive stature estimation information for forensic experts. As we know, the cephalic index can play a useful role in identifying cephalic morphometry between parents, offspring, and relatives and provide basic data on inheritance patterns (37). The differences in cephalic index and shape can reveal that racial variations are affected by genetic, environmental, gender, and ethnic aspects (38). According to our results, the cephalic index of male subjects was significantly higher than that of females, and the most common shape for male subjects was brachycephalic (short-headed), and for female subjects, it was mesocephalic (medium-headed). The cephalic index classification reported in our study was similar to that reported by Abolhasanzadeh and Farahani but different from Madadi et al.'s research in Iran (38, 39). Based on previous research, the mean cephalic index varied in different regions (38). So, the longer head shape (dolichocephalic) has been detected in tropical regions, while the round head shape (mesocephalic or brachycephalic) has been detected in temporal regions (40). The former studies revealed that the brachycephalic type, which is selected as a consequence of evolutionary forces, can be altered by improvement in nutrition (40, 41). The data from this research will be useful in anthropology, genetics, and forensic medicine.

5.1. Conclusions

The results obtained in the current anthropometric study on the adult southwest Iranian population presented basic data concerning developing standards for cephalic dimensions and stature. These results are also helpful in gross anatomy education and archeological and anthropological research studies, and they can be used by forensic scientists and basic medical researchers for personal identification when only skull remains of the body are found in mass disasters, accidents, etc. This issue must be taken into account, that recruiting larger samples with non-contact measurements will be helpful in identifying the adult Iranian population's craniofacial anthropometric profiling.

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Footnotes

Authors' Contribution: M.B.: Investigation and data collection; F.A. and F.N.: Writing and preparing the original draft and editing; A.Z.: Data analysis.

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