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Estimation of human physique in forensic anthropological cases

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Abstract

Human physique has been ignored in forensic field up to date, but for a reliable identification it is without doubt of importance. The main aim of the present study is to examine whether it is possible to estimate the somatotype components from anthropometric measurements and/or proportions and to evaluate its use in forensic anthropology. The study was held on 220 healthy male subjects aged between 18.05-62.52 years. After anthropometric measurements had been taken, somatotypes of each individual were rated by Heath-Carter technique. Additionally, some proportional variables were also evaluated. Of 220 subjects randomly selected 170 were accepted as calibration group and the remaining 50 as validation group. Regression equations were established to estimate somatotype components depending on the measurements taken from the calibration group by stepwise regression model and tested on the validation group. The results of our statistical analysis indicate that proportional variables are better predictors for somatotype components than direct anthropometric measurements. The ratios of knee, hip and elbow breadth over body height are the best indicator respectively for body typology. On the other hand, when the anthropometric measurements were evaluated knee breadth was observed to be the best indicator for somatotype prediction. Mesomorphy is the somatotype component that could be estimated with a maximum reliability, followed by ectomorphy and endomorphy. The tests on the validation group shows that somatotype components could be estimated with an estimation error about one unit. As a conclusion, our findings indicate that body typology could be estimated depending on anthropometric measurements or ratios and used for identification in forensic field.

Introduction

In forensic anthropology, the most important components of identity are sex, age, and body height or stature (Atamtürk, 2016). Although the above-mentioned characteristics are crucial steps in the identification process of individuals who are decomposed or completely skeletonized, profiling these features does not mean that all aspects of identity will be revealed. A more detailed identification requires the presence of advanced information of human physique. For example, one of the two people of about the same stature may have a robust, muscular, and athletic body, while other may be thin-bony and skinny. Therefore, determination of body typology or somatotype plays an important role of forensic identification.

Somatotype rating technique that is commonly used in biological anthropology and sport sciences was first established by Sheldon in 1940s (Duyar, 1999). Later, Heath and Carter (1967) modified the technique in order to estimate somatotype in an easier way depending on anthropometric measurements only. According to this approach, human physique consists of three components coming together in different ratios. The first component, endomorphy, refers to the proportion of fat in the body, and a higher value means that the individual has a large amount of fat in his body. The second component, mesomorphy, reflects the relative development of the muscles and bones in human body. Typical mesomorphs are muscular, robust, and athletic in appearance. The last component, ectomorphy, gives information about the relationship between body height and weight. The typical ectomorphs are thin and slim individuals (Carter and Heath, 1990).

Although these physical features form important parts of biological or forensic identity, it can be said that they are largely ignored in identification procedures. As a matter of fact, when the legal medicine and forensic anthropology literature examined, it is seen that there are almost no studies aiming to predict body typology from the decomposed and/or skeletonized human remains. One of the most detailed study on this subject was carried out by Porter (1999). In this study, various indices of physical structure (such as body mass index and ponderal index) have been tried to be determined from the bone dimensions. Some researchers have tried to determine body weight from various dry bone measurements (Hauser et al., 1980) or percutaneous bone measurements taken from living people (Ruff, 2000; Atamtürk, 2007; Atamtürk and Duyar, 2008). In addition, there are studies to estimate the overall robustness from small-sized bones such as metacarpals and phalanges (Zvyagin et al., 2003). In some other studies body weight was aimed to be estimated from bone dimensions (Hauser et al., 2003) or measurements form bony landmarks (Ruff, 2003).

The main aim of this study is to determine whether bone measurements and body proportions provide information about somatotype components of unrecognizable corpses or human remains that were not completely skeletonized. In this context, the extent to which these findings can be used for identification in forensic anthropology.

Subjects and methods

The study was held on 220 healthy male subjects aged between 18.05 and 62.52 years with a mean of 24.03 years (SD = 6.74). All the anthropometric measurements were taken by the authors (İ.D., C.P.) using a Martin type anthropometer at the same time of the day. During the measurement process the subjects were required to wear a tennis short and a T-shit leaving their limbs exposed.

In order to determine the anthropometric somatotype, 10 measurements were taken from each individual (Heath and Carter, 1990). Measurements are body height and mass, upper arm girth (elbow flexed and tensed), calf girth, biepicondylar breadth of the humerus and biepicondylar breadth of the femur, triceps, subscapular, supraspinale, and medial calf skinfold thicknesses. Somatotype components were rated by using the regression equations given by Heath and Carter (1990) and endomorphy component multiplied by 170.18 for calculating height-corrected endomorphy.

In forensic anthropological cases, the material to be identified varies; sometimes there may be a body part (for example, only one arm or leg) that is intact in the hand, sometimes there are parts of the body that cannot be identified. Sometimes only dry bones are available. In this study, whether the dimensions of the bone have a predictive value about the body typology, the variables where the bone dimensions are measured with minimum error by somatometric techniques—such as elbow or knee width—are considered. Five anthropometric measurements (in addition to the above-mentioned ten) were taken in this study. These additional measurements and how they are taken are as follows:

1. *Upper arm length:* The distance between the acromion process of the scapula to the olecranon process of the ulna with the subject's forearm held against the body, perpendicular to the upper arm (Duyar, 2000).
2. *Forearm length:* The distance between the olecranon process and the most distal point of styloid process of ulna (Martin et al., 1998)
3. *Upper leg length:* The distance between the trochanterion process on femur and the most protruding point of patella when the subject was sitting. During the measurement the anthropometer was held parallel with the long axis of femur.
4. *Tibia length:* The distance between the most proximal point on medial epicondyle of tibia and the most distal point of medial malleolus when the subject was sitting with his ankle on the opposite knee (Martin et al., 1998).
5. *Bi-iliac breadth:* The distance between the most distant two points on iliac crests on the horizontal plane on a standing subject (Wilmore et al., 1988).

In the first step the relationships between the somatotype components (endomorphy, mesomorphy, ectomorphy) with the anthropometric dimensions and proportions were determined by Pearson correlation coefficient (*r*). Then, univariate and multivariate linear regression equations were generated by using anthropometric measurements and proportions taken from 170 subjects in the calibration group. Stepwise regression technique was used to obtain the best linear regression models. At the last stage, the regression equations were applied to the validation group (*n* = 49). The individuals in the validation group were determined randomly. The root mean square error (RMSE) value is used to a measure of the goodness of fit of the deviations of the predicted values from the observed ones. RMSE statistics are calculated as follows:

$$\text{RMSE} = \sqrt{\frac{\Sigma\,(\text{observed} - \text{predicted})\,2}{(n - p - 1)}}$$

where n is the number of observation and p is the number of predictor variables.

Statistical Package for Social Sciences (SPSS, version 20.0) was used for all the calculations and statistical tests. The statistical significance level was accepted as *P*<0.05.

Results

Descriptive statistics of all the anthropometric measurements, proportional variables, and somatotype components of the total sample are given in Table 1. As can be seen here, there is a wide range of distribution in terms of body weight, stature, and somatotype components among the individuals. The distribution pattern and range of all the variables mentioned above reflects the general anthropometrical characteristics of the male population of Turkey.

In addition to the anthropometric measurements, descriptive statistics of the 11 proportional variables are shown in Table 2. Seven of the 11 variables were obtained by ratio to body height, two to the length of the upper arm, and the remaining two to the length of the upper leg.

The Pearson correlation coefficient values between the anthropometric measurements and the somatotype components are given in Table 3. The anthropometric measurement showing the highest relationship with the endomorphic component is the hip width. The most associated variables with both the components of mesomorphy and ectomorphy are tibia and upper leg length, respectively. These variables show a negative correlation with mesomorphy, but a positive correlation with ectomorphy.

Table 1. Descriptive statistics of anthropometric traits and somatotype components

	n	Mean	St. Deviation	Minimum	Maximum
Weight (kg)	220	71,93	12,20	44	138
Stature (mm)	220	1758,65	93,55	1523	1950
Upper arm length (mm)	219	351,80	22,95	297	420
Forearm length (mm)	220	276,57	18,21	234	326
Upper leg length (mm)	218	484,60	31,55	407	557
Tibia length (mm)	217	391,98	29,89	326	467
Hip width (mm)	219	280,58	20,77	238	360
Elbow width (mm)	220	69,89	3,66	59	81
Knee width (mm)	220	98,48	5,33	82	112
Endomorphy	220	3,29	1,48	0,82	10,03
Mesomorphy	220	4,79	1,36	1,72	9,97
Ectomorphy	220	2,61	1,39	,056	5,88

Table 2. Descriptive statistics of relative anthropometric measurements

	n	Mean	St. Deviation	Minimum	Maximum
Upper arm length/Stature	219	0,200	0,008	0,18	0,22
Forearm length/Stature	220	0,157	0,006	0,14	0,17
Upper leg length/Stature	218	0,276	0,008	0,25	0,30
Tibia length/Stature	217	0,223	0,008	0,20	0,24
Hip width/Stature	219	0,160	0,001	0,14	0,20
Elbow width/Stature	220	0,040	0,002	0,04	0,05
Knee width/Stature	220	0,056	0,003	0,05	0,07
Forearm length/Upper arm length	219	0,787	0,040	0,67	0,89
Elbow width/Upper arm length	219	0,281	0,017	0,22	0,35
Knee width/Upper leg length	218	0,204	0,012	0,17	0,25
Tibia length/Upper leg length	216	0,809	0,275	0,72	0,87

Table 3. Correlation coefficients between direct anthropometric variables and somatotype components

		Endomorphy		Mesomorphy		Ectomorphy	
	n	*r*	*P*	*r*	*P*	*r*	P
Upper arm length	219	-0,109	0,107	-0,340	0,000	0,333	0,000
Forearm length	220	-0,036	0,598	-0,233	0,000	0,317	0,000
Upper leg length	218	-0,068	0,319	-0,400	0,000	0,407	0,000
Tibia length	217	-0,101	0,137	-0,413	0,000	0,433	0,000
Hip width	219	0,279	0,000	0,056	0,409	-0,060	0,375
Elbow width	220	0,056	0,412	0,224	0,001	0,015	0,823
Knee width	220	0,191	0,004	0,269	0,000	-0,095	0,159

Table 4. Correlation coefficients between relative anthropometric variables and somatotype components

		Endomorphy		Mesomorphy		Ectomorphy	
	n	*r*	*P*	*r*	*P*	*r*	P
Upper arm length/Stature	219	-0,036	0,599	0,060	0,378	-0,113	0,096
Forearm length/Stature	220	0,089	0,189	0,226	0,001	-0,131	0,053
Upper arm length/Stature	218	0,049	0,474	-0,051	0,456	0,016	0,818
Tibia length/Stature	217	-0,058	0,393	-0,209	0,002	0,206	0,002
Hip width/Stature	219	0,408	0,000	0,439	0,000	-0,469	0,000
Elbow width/Stature	220	0,186	0,006	0,756	0,000	-0,529	0,000
Knee width/Stature	220	0,329	0,000	0,785	0,000	-0,626	0,000
Forearm length/Upper arm length	219	0,097	0,152	0,127	0,060	-0,016	0,809
Elbow width/Upper arm length	219	0,178	0,008	0,572	0,000	-0,357	0,000
Knee width/Upper leg length	218	0,261	0,000	0,698	0,000	-0,544	0,000
Tibia length/Upper leg length	216	-0,103	0,132	-0,171	0,012	0,193	0,004

Table 5. Univariate regression equations for estimating somatotype components

Regression equations	R^2	SEE	RMSE
Endomorphy			
Endomorphy = -0.007 UPPERARM + 5.776	0.012	1.475	1.419
Endomorphy = -0.003 FOERARM + 4.098	0.001	1.482	1.431
Endomorphy = -0.003 UPPERLEG + 4.847	0.005	1.484	1.403
Endomorphy = -0.005 TIBIA + 5.278	0.010	1.483	1.412
Endomorphy = 0.020 HIP - 2.283	0.078	1.424	1.440
Endomorphy = 0.022 ELBOW + 1.723	0.003	1.481	1.416
Endomorphy = 0.053 KNEE - 1.922	0.036	1.456	1.403
Endomorphy = -6.832 UPPERARM/STATURE + 4.668	0.001	1.483	1.429
Endomorphy = 21.079 FOERARM/STATURE - 0.020	0.008	1.477	1.429
Endomorphy = 9.509 UPPERLEG/STATURE + 0.682	0.002	1.486	1.412
Endomorphy = -11.486 TIBIA/STATURE + 5.860	0.003	1.488	1.422
Endomorphy = 56.965 HIP/STATURE - 5.810	0.166	1.354	1.440
Endomorphy = 143.332 ELBOW/STATURE - 2.408	0.035	1.457	1.382
Endomorphy = 173.125 KNEE/STATURE - 6.41	0.109	1.400	1.337
Endomorphy = 3.562 FOERARM/UPPERARM + 0.497	0.009	1.477	1.446
Endomorphy = 25.704 ELBOW/UPPERARM - 3.910	0.089	1.417	1.387
Endomorphy = 32.555 KNEE/UPPERLEG - 3.326	0.068	1.436	1.370
Endomorphy = -5.581 TIBIA/UPPERLEG +7.818	0.011	1.486	1.423
Mesomorphy			
Mesomorphy = -0.020 UPPERARM + 11.886	0.115	1.285	1.062
Mesomorphy = -0.017 FOERARM + 9.611	0.054	1.326	1.185
Mesomorphy = -0.017 UPPERLEG + 13.153	0.160	1.250	1.104
Mesomorphy = -0.019 TIBIA + 12.209	0.171	1.249	1.058
Mesomorphy = 0.004 HIP + 3.763	0.003	1.364	1.236
Mesomorphy = 0.083 ELBOW - 1.020	0.050	1.329	1.221
Mesomorphy = 0.069 KNEE - 1.963	0.072	1.313	1.248
Mesomorphy = 10.563 UPPERARM/STATURE + 2.683	0.004	1.363	1.176
Mesomorphy = 49.321 FOERARM/STATURE - 2.963	0.051	1.328	1.249
Mesomorphy = -9.061 UPPERLEG/STATURE + 7.283	0.003	1.362	1,777
Mesomorphy = -37.809 TIBIA/STATURE + 13.214	0.044	1.341	1.118
Mesomorphy = 56.483 HIP/STATURE - 4.225	0.192	1.228	0.804
Mesomorphy = 535.566 ELBOW/STATURE - 16.517	0.572	0.891	0.628
Mesomorphy = 379.140 KNEE/STATURE - 16.462	0.616	0.845	1.202
Mesomorphy = 4.301 FOERARM/UPPERARM + 1.406	0.016	1.355	1.031
Mesomorphy = 48.031 ELBOW/UPPERARM - 6.682	0.365	1.088	0.926
Mesomorphy = 79.746 KNEE/UPPERLEG - 11.451	0.487	0.978	1.183
Mesomorphy = -8.485 TIBIA/UPPERLEG + 11.645	0.029	1.349	0.628
Ectomorphy			
Ectomorphy = 0.020 UPPERARM - 4.481	0.111	1.313	1.207
Ectomorphy = 0.024 FOERARM - 4.066	0.100	1.318	1.232
Ectomorphy = 0.018 UPPERLEG - 6.085	0.165	1.275	1.299
Ectomorphy = 0.020 TIBIA - 5.311	0.187	1.261	1.180
Ectomorphy = -0.004 HIP + 3.743	0.004	1.388	1.323
Ectomorphy = 0.006 ELBOW + 2.209	0.000	1.340	1.322
Ectomorphy = -0.025 KNEE + 5.051	0.009	1.384	1.326
Ectomorphy = -20.218 UPPERARM/STATURE + 6.653	0.013	1.384	1.299
Ectomorphy = -29.026 FOERARM/STATURE + 7.175	0.017	1.378	1.359
Ectomorphy = 2.857 UPPERLEG/STATURE + 1.821	0.000	1.395	1.321
Ectomorphy = 38.106 TIBIA/STATURE - 5.883	0.043	1.369	1.302
Ectomorphy = -61.521 HIP/STATURE + 12.440	0.220	1.228	1.217
Ectomorphy = -381.949 ELBOW/STATURE + 17.808	0.280	1.179	1.148
Ectomorphy = -308.396 KNEE/STATURE + 19.899	0.392	1.084	1.052
Ectomorphy = -0.564 FOERARM/UPPERARM + 3.052	0.000	1.393	1.321
Ectomorphy = -35.989 ELBOW/UPPERARM + 12.703	0.197	1.248	1.212
Ectomorphy = -63.578 KNEE/UPPERLEG + 15.553	0.296	1.171	1.120
Ectomorphy = 9.835 TIBIA/UPPERLEG - 5.347	0.037	1.375	1.308

Table 6. Univariate and multivariate regression equations for estimating somatotype components

Regression equations	R^2	SEE
Endomorphy		
Endo (1) = 57.212 (HIP/STATURE) - 5.842	0,166	1,36
Endo (2) = 49.593 (HIP/STATURE) + 18.295 (ELBOW/UPPERARM) - 9,556	0,195	1,34
Mesomorphy		
Meso (1) = 381,2 (KNEE/STATURE) - 16,582	0,618	0,85
Meso (2) = 251,8 (KNEE/STATURE) + 311,0 (ELBOW/STATURE) - 21,695	0,738	0,71
Ectomorphy		
Ecto (1) = -312,3 (KNEE/STATURE) + 20,115	0,397	1,09
Ecto (2) = -370,2 (KNEE/STATURE) + 0,066 (KNEE) + 16,846	0,447	1,05

SEE: Standard error of the estimation

Table 7. Comparison of rated and estimated somatotype components

	n	Rated somatotype (mean)	Estimated somatotype (mean)	Difference* (mean)	St. Dev.	*t*	*P*
Endomorphy							
Endo1	50	3,490	3,379	0,111	1,424	0,550	0,585
Endo2	48	3,475	3,370	0,105	1,405	0,521	0,605
Mesomorphy							
Meso1	50	4,759	4,779	-0,020	0,833	-0,167	0,868
Meso2	50	4,759	4,767	-0,008	0,622	-0,091	0,928
Ectomorphy							
Ecto1	50	2,461	2,613	-0,152	1,034	-1,040	0,304
Ecto2	50	2,461	2,590	-0,129	0,961	-0,953	0,345

* Difference: Rated somatotype - Estimated somatotype

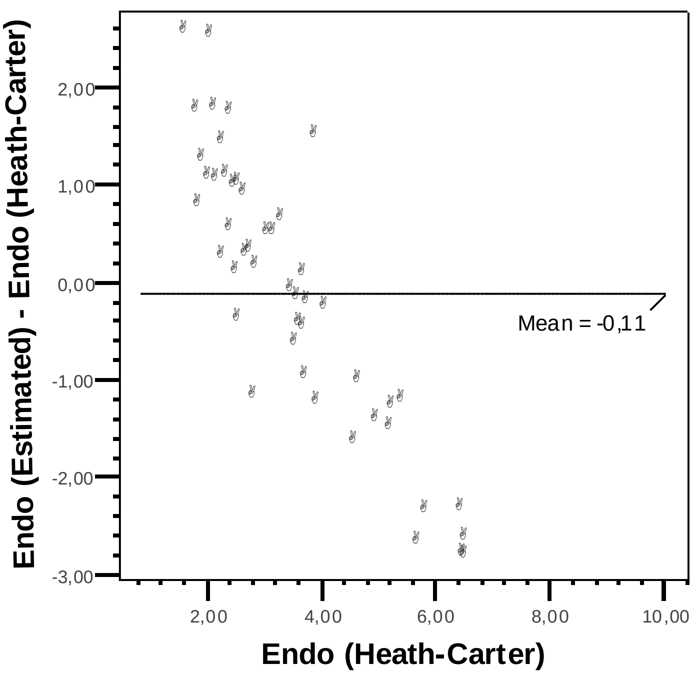

Figure 1. Scatterplots of rated and estimated somatotype components (endomorphy)

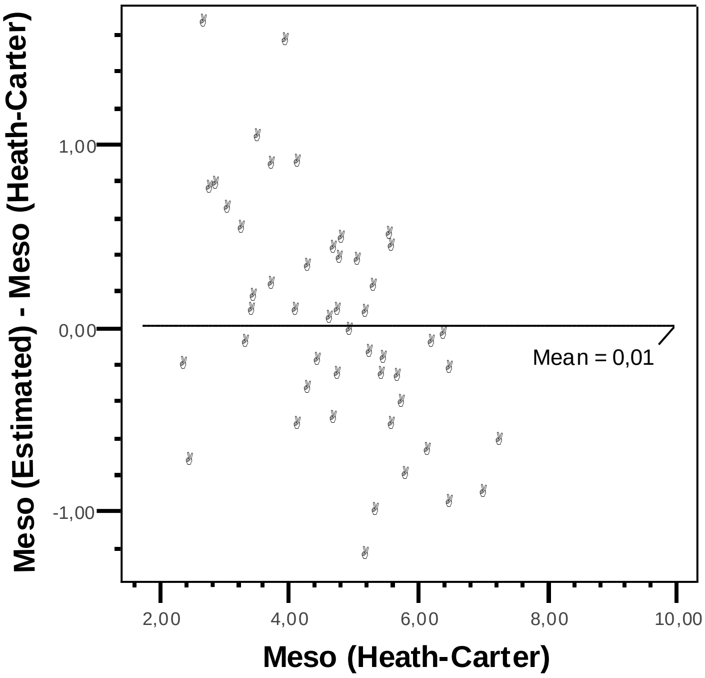

Figure 2. Scatterplots of rated and estimated somatotype components (mesomorphy)

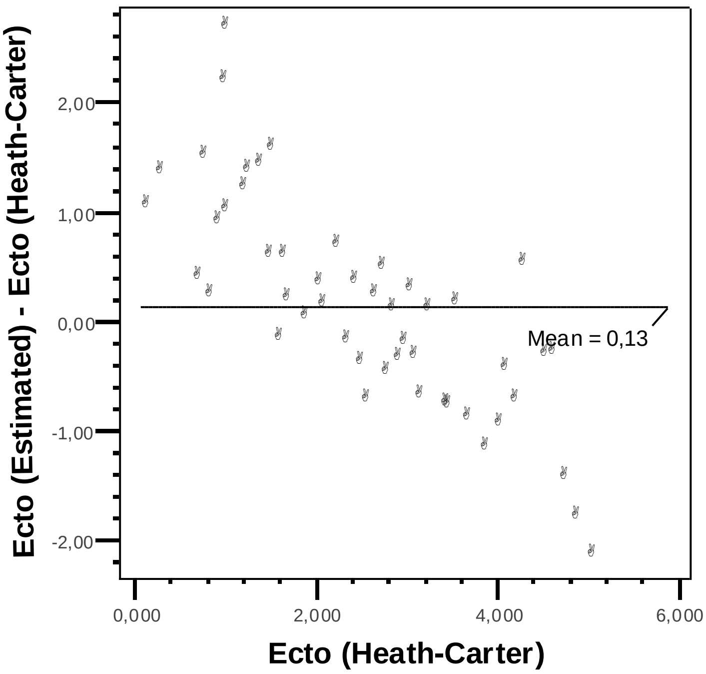

Figure 3. Scatterplots of rated and estimated somatotype components (ectomorphy)

For the correlations of somatotype components with proportional variables, see Table 4. The first thing that draws attention in the table is that the correlation coefficients for proportional variables give relatively higher values when compared with dimensional variables. Based on these data, we can claim that proportional variables are more helpful in predicting somatotype. When the measurements showing the highest correlation are transformed into proportional variables, the correlation coefficient values increase significantly. For example, while the correlation coefficient (r) between mesomorphy and elbow width was 0.224 it increases into 0.756, when the proportional value of it over stature was used. Similarly, the ratio of knee breadth over stature gives higher results when compared with the absolute value of knee breadth.

In general, it is seen that the proportional variable showing the most association with somatotype components is the ratio of knee width over stature. This proportional variable is significantly related to all three components. The correlation of knee width with the components of endomorphy and mesomorphy was positive, whereas it was negative with ectomorphy. The ratio of elbow width to stature presents a similar pattern. Another proportional variable showing relatively a high correlation with somatotype components is the ratio of bi-iliac breadth over stature. Since there is a significant correlation between the somatotype components and anthropometric measurements or proportional variables, these could be used as independent variables for estimating somatotype components. Thus, we first constructed univariate regression equations based on anthropometric measurements and proportional variables.

The fact that there are correlations between somatotype components and direct anthropometric and proportional variables means that these variables can be used to predict body typology. Therefore, firstly univariate and then multivariate stepwise regression techniques were used to determine more reliable somatotype models. The results of these analyzes were tabulated considering the coefficient of determination (R2), the standard error of the estimation (SEE) and the RMSE. Table 5 shows the regression equations based on single variables.

According to R2 values, two variables are considerable in determining the endomorphy component in the analysis using single variable: hip width/stature and knee width/length (Table 5). It is noteworthy that these two variables are proportion. Endomorphy is the component that is estimated with the least reliability among all somatotype components. When the equations created for the endomorphy component are examined, it is seen that the coefficient of determination (R2) is relatively low and that 16.6-19.5 percent of the variation in the endomorphy can be explained by these two derived variables.

The coefficient of determination values show that we need two variables when we want to estimate the mesomorphy with the least error. These variables are knee width/stature and elbow width/stature, respectively. If we look at RMSE, it is understood that a third variable can be added to the above two variables: tibia length/upper leg length. On the other hand, it should be emphasized that mesomorphy is the best predictable somatotype component. The ratios of knee and elbow widths to stature explains 61.8-73.8 percent of the variation observed in mesomorphy. The fact that the standard error of the estimation gives the lowest value for this component also supports this finding.

Knee width/stature ratio are the most valuable variable to be used in estimating ectomorphy. Ectomorphy can be predicted with higher reliability than endomorphy and lower than mesomorphy. According to the coefficient determination values, 39.7 percent of the total variation in this component can be explained by knee width/stature and 44.7 percent by knee width.

In Table 6, univariate and bivariate regression equations are given using stepwise regression technique. As can be seen here, the use of two variables increases the success rate in estimating somatotype components. In multivariate regression equations, the knee width/stature ratio is the main variable in determining the mesomorphy and ectomorphy components. The main variable for the endomorphy component is the hip width/stature ratio, and the second important variable is the knee width/upper arm girth ratio.

The reliability of these equations was tested on the validation group. The differences between measured and the estimated values were tested by dependent t-test. The results of this test can be viewed in Table 7. The difference between the mean somatotype values and the calculated average values in the test group was not statistically significant (P> 0.05). In general, it can be said that the equations with two variables yield less estimation error than univariate equations. According to the results of the dependent t-test, the equation which gives the least difference between the values measured and the calculated ones in mesomorphy component. This is followed by ectomorphy and endomorphy components, respectively. While the equations for mesomorphy and ectomorphy produce overestimations, the equation for endomorphy yields underestimations.

The distribution pattern of the differences between the components estimated and rated somatotype by Heath–Carter technique were illustrated in Figures 1–3. For all components individuals who have lower values were overestimated while the ones having higher values were underestimated. Figure 2 indicates that the estimates for mesomorphy are more reliable when compared with the other somatotype components.

As seen in the table canonical correlation and Eigen values of axillar border length and glenoid cavity length are higher than those of the other variables. In Table 4, accuracy of discriminant functions by leave-one-out method are seen.

Discussion

In forensic anthropological cases, the physical appearance of the deceased before death can sometimes be an important clue in the identification. By appearance, we refer to the body typology of the individual, if expressed in a more specific term, somatotype. Though it is relatively easy to presume the physique of an individual at the beginning of the decomposition process, it is nearly impossible to estimate its body typology after severe decomposition or if only the skeletal remains were available. On the other hand, it is evident that the somatotype of corpses will make valuable contributions to identification in decompensated or fully skeletonized individuals. Although it is known that determination of body type is so important in terms of identification, researchers have not focused much on this subject; more attention was directed to estimation of body height and weight. There are many studies in the literature on how to estimate the height of different body parts (e.g., Pearson, 1899; Trotter and Gleser, 1952, 1958; Sjovold, 1990; Konigsberg et al., 1998; Duyar and Pelin, 2003; Sargın et al., 2012; Raxter et al., 2006). Estimation of body weight is an area in which researchers are relatively less interested (e.g., Ruff, 2000; Suskewicz 2004; Atamtürk, 2007; Atamtürk and Duyar, 2008; De Groote and Humphrey, 2011; Ruff et al., 2012).

Although there are very limited number of studies aimed at determining somatotype in the field of forensic anthropology, there are some studies that address the general body type of a person. The most emphasized issue in these studies is the fatness or thinness of the person. We can go back to the nineteenth century, the beginning of forensic anthropology. For example, Kollmann and Büchly realized that soft tissue thicknesses changed in obese and thin individuals during their facial reconstruction studies in the late 19th century and considered alternative soft tissue thicknesses for these bodily types (Krogman and İşcan, 1986:422). The effects of being obese or lean are discussed in various aspects not only in forensic anthropology but also in forensic medicine. For example, Al-Alousi et al. (2002) tried to answer the question of whether fatness or thinness is effective on body cooling in the postmortem stage.

Since bones are the most important material in forensic anthropology, some researchers have tried to make predictions about the general body typology based on one or more parts of the human skeleton. However, these studies are not intended to determine somatotype or its components. For example, while Hauser et al. (1980) made a study to estimate the body height and weight from femur, Zvyagin et al. (2003) conducted studies to predict skeletal size from carpal and metacarpal bones. Probably, the most detailed study on estimating physique from the elements of human skeleton was performed by Porter (1999). In his study Porter aimed to predict of stature, body weight, and ponderal index.

As can be seen from the short list of literature given above and the evaluation of the researches in this field, studies aimed at determining the body type in forensic anthropological cases are either considered as secondary factor or roughly considered as “obese” or “thin” types. Therefore, this study can be said to be the first study to estimate the somatotype and its components.

A forensic anthropologist, who has to make an identification, usually has either an unidentified corpse or an incomplete body part(s) or material that has become completely dry bone. The expert has to develop a different strategy for each of these situations. In the present study, measures to determine somatotype were taken from living individuals by classical anthropometric techniques. It is therefore not recommended to apply these equations directly to skeletal material. However, what is important here is to confirm the idea that various bone dimensions, and in particular proportions, can be used to determine somatotype. Therefore, in the future, studies can be conducted to determine the physical typology based on the measurements taken from dry bones.

Our results indicate that mesomorphy is the somatotype component that could be predicted with the highest accuracy. It is known that mesomorphy reflects the bony and muscular structure (Carter and Heath, 1990). Since the measurements in this study were mainly taken from the bony landmarks it is obvious that they would reflect mesomorphy better than the other components. In most of the forensic cases skeletal remains are the commonly available material. So the equations presented in the study for mesomorphy could be used in practice. Though Porter (1999) did not mainly interest in somatotype components, he/she had studied patella width related with somatotype components and parallel with our finding he reported relatively a higher correlation with patella width and mesomorphy.

Equations for ectomorphy and endomorphy do not give reliable results as the ones for mesomorphy. However, they still help the forensic practitioners to have an idea for the body typology of the victims. Between the latter two components ectomorphy is the one that could be estimated more accurately probably because the lengths of the limbs have potential to reflect the linearity of the body.

Another point that should be emphasized is the best independent variables for estimating physique are not the absolute or direct anthropometric measurements but the proportional or relative anthropometric variables. For example, the ratio of knee breadth/stature is a better indicator than the absolute value of knee breadth for estimating mesomorphy and ectomorphy. Same thing is valid for bi-iliac breadth/stature and elbow breadth/stature.

Conclusion

Our findings can be easily applied to corpses that have started to decay or to cases whose integrity has been impaired but not exposed to decay. Another remarkable finding in our study is that it is understood that relative variables give more reliable results than absolute measures. Based on these findings, it can be argued that proportional variables reflect body typology better, especially the aspect ratio of knee, elbow and hip widths are the first variables to be considered in this sense.

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