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Anthropometric Characteristics of Young Turkish Male Athletes

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ABSTRACT

Comparative reports on the anthropometric characteristics of athletes are certainly important in modern sports and have long been studied by sports scientists. Studies on Turkish athletes however, are limited. In the present study physical characteristics of athletes active in various sports (American football, basketball, volleyball and football) were observed and compared to each other and to those of non-athlete individuals. 153 volunteer male subjects participated in the study. All of the athletes were licensed members of teams in inter-university leagues. All subjects were given information about the objectives of the study and were advised of the manner with which the anthropometric measurements would be obtained. In addition to 17 anthropometric values, body mass index (BMI) and somatotype components were calculated and evaluated. Length, breadth, and girth values were evaluated by ANCOVA and height and weight were used as co-variate factors. The other variables were evaluated by metric and non-metric ANOVA. The results of the study indicate that basketball and volleyball players were characteristic with their longer lower limb length; American football players were with their wider biiliac breadth and higher girth values; and football players with their small structure. It was also observed that Turkish athletes have higher endomorphy and lower mesomorphy values when compared to athletes from other countries.

Key words: *anthropometry, physical differences, somatotype, sports*

Introduction

Detailed information about anthropometric characteristics of athletes is certainly important in modern sports, and they have long been studied by sports scientists. It is a well known fact that most of the anthropometric characteristics are almost exclusively genetically determined. Length and breadth measurements are especially difficult to influence with training[1.] Morphological structure however, has a direct influence on an athlete's performance and is primarily important for planning an effective training program. Besides the relationship with physical performance, anthropometric status is also important for sports trainers in order to direct young athletes into the sports they are best suited to at the beginning of their careers in sports. It is also known that differences in anthropometric characteristics exist even across some playing positions in some sports[2]. Studies on the physical characteristics of the human body to-date indicate that the morphological characteristics of athletes successful in a specific sport differ in somatic characteristics from the general population. Basketball and volleyball players are typically tall while badminton players are shorter[3]. Since the previously mentioned two games require handling the ball above the head, having a tall stature is an advantage in these sports[4,5]. Higher body mass however, is a hurdle for volleyball players in attaining good jumping[6]. In a rugby team on the other hand, bigger and heavier athletes have an advantage in gaining possession of the ball, while players with a lower body mass are more successful in sprints[7]. For swimmers upper extremity length is an advantage in attaining higher performance[8]. Athletes who are specialized in throwing events are typically taller, heavier, and have a more muscular structure[9]. In a study on Javelin throwers it was reported that athletes were mesomorphic with increased body mass and height and had pronounced transversal measures such as biacromial width, as well as joint diameters, particularly of the elbow and knee[10,11]. A statistically significant correlation between the anthropometric characteristics of athletes and their competitive results however, does not always exist[12]; and a specific

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anthropometric characteristic is not always necessary for a certain sport[13].

A way of determining the morphological characteristic is somatotyping in which body shape rather than size is expressed[3]. Somatotyping has three classifications: endomorphy, mesomorphy, and ectomorphy. Endomorphy represents body fat proportion, mesomorphy, musculoskeletal development, and ectomorphy represents linearity[14].

Several studies on the anthropometric characteristics or somatotypes of athletes in western countries have been reported in the literature, however similar studies in Middle Eastern countries are limited. In the present study physical characteristics of Turkish athletes, active in various sports were determined and compared to each other and to those of non-athlete individuals.

Material and Methods

Subjects

153 volunteer male subjects participated to the study. All subjects were given information about the objectives of the study and the manner with which the anthropometric measurements would be obtained. Of these 153 subjects 27 were American football players, 26 played volleyball, 31 were basketball players, 34 were football players, and 35 were non-athlete individuals. All of the athletes were licensed members of teams in inter-university leagues. The non-athlete subjects were students of medicine and dentistry at Baskent University. All were sedentary students who were not active in any type of sport. The mean age and playing experience of the groups are illustrated in Table 1. There were no statistically significant differences between the mean ages of the athletes and the mean ages of the non-athlete subjects. Playing experience of the athletes (with the exception of the American football players) averaged 7–8 years. Since the American football league is a relatively new one in Turkey, the mean playing experience of the American football players was lower than that of the other athletes.

Anthropometric measurements

In addition to stature and body weight the following 17 anthropometric measurements were taken from each subject's arm length, forearm length, femur length, tibia length, sitting height, iliospinal height, biacromial breadth, biiliac breadth, humerus breadth, femur breadth, arm girth, calf girth, biceps, triceps, sub-scapular and suprailiac skinfold thicknesses. A Holtain caliper was used to measure skinfolds, and a Martin type anthropometry set was used to obtain the other measurements. All of the measurements were taken by the same researcher to the nearest 0.1 cm at the same time of the day. In addition to absolute anthropometric values, body mass index (BMI) and somatotype component values were calculated and evaluated. Somatotype components of the subjects were calculated according to the Heath – Carter method[14], using the following equations.

$$\text{Endomorphy} = 0.7182 + 0.1415(X) – 0.00068(X^2) + 0.0000014(X^3)$$

X=triceps+sub-scapular 4 supraspinale skinfolds

$$\text{Mesomorphy} = [(0.858^* \text{ humerus breadth}) + (0.601^* \text{ femur breadth}) + (0.188^* \text{ corrected arm girth}) + (0.161^* \text{ corrected calf girth})]$$
$$(\text{height}^* \ 0.131) + 4.50$$

$$\text{Ectomorphy} = \text{HWR}^* \ 0.732 – 28.58 \ (\text{if HWR} \geq 40.75)$$
$$= \text{HWR}^* \ 0.463 – 17.63 \ (\text{if } 40.75 > \text{HWR} > 38.25)$$
$$= 0.1 \ (\text{if HWR} \leq 38.25)$$

$$\text{HWR} = \text{height (m)}/\sqrt[3]{\text{weight}}$$

Statistical analysis

In order to evaluate the intra-observer differences, repeated measurements were taken from 15 randomly selected subjects. Intra-class correlation coefficients were evaluated by reliability analysis. There was high reliability in all measurements (all rs=0.80 to 0.98, all ps<0.001).

The differences in body height, weight, BMI, and somatotype components between the groups were tested by one way analysis of variance (ANOVA); and multiple comparisons between pairs of groups were carried out according to the Duncan test. Length, breadth and girth measurements were compared by one way analysis of covariance (ANCOVA); and multiple comparisons between pairs of groups were carried out according to the Sidak test. In this analysis, weight and height were controlled as co-variates. Since ratios and skinfold thickness were not normally distributed for these variables, groups were compared by Kruskal-Wallis one-way analysis of variance by ranks test; and then multiple comparisons between pairs of groups were carried out according to the Dunn test. Statistical analysis was performed using the SPSS 13.0 for Windows (Statistical Package for the Social Sciences, version 13.0, SSPS Inc, Chicago, IL, USA).

TABLE 1
AVERAGE AGE AND PLAYING EXPERIENCE OF THE STUDY GROUPS

	American Football	Volleyball	Basketball	Football	Students
Age (years)	21.9±2.5	22.4±2.1	21.2±2.2	22.6±2.0	21.4±2.0
Playing experience (years)	3.8±2.0	7.8±3.2	8.1±2.3	7.6±2.7	0.0

Results

Table 2 shows the descriptive statistics for stature, body weight and BMI. No statistically significant difference was observed between the football players and the non-athlete students in relation to stature. Similarly volleyball and basketball players showed no significant difference; however mean statures for the above mentioned two groups were statistically different from each other ($p<0.01$). Mean body height of American football players was significantly lower than those of basketball and volleyball players, but higher than football players ($p<0.01$). The basketball players had the highest mean for stature, and this was followed by volleyball and American football players. Body weight was significantly different in the individuals in different groups ($p<0.05$). American football players had the highest body weight, and they were followed by basketball, volleyball and football players and the non-athlete group respectively. When BMI was evaluated, no statistically significant difference was observed among the groups except American football players. The highest mean for BMI belongs to American football players ($p<0.05$).

In Table 3 descriptive statistics for length measurement values are depicted. Both arm and forearm lengths were observed to be relatively longer for basketball and volleyball players. When body height was controlled as co-variate this difference between basketball and volleyball players, and the other groups was decreased. For American football players arm and forearm lengths were longer when height was controlled, but this difference was only significant between American football and football players for arm length. On the other hand football players and sedentary students have shorter forearm lengths when height was controlled. No significant difference was observed between American football, basketball, and volleyball groups. When absolute values were evaluated volleyball and basketball players were observed to have longer femur, tibia and iliospinal lengths as expected. When stature was controlled however, no statistically significant difference was observed between the groups for tibia length. On the other hand femur and iliospinale lengths were significantly longer for volleyball and basketball players. When sitting height was evaluated (corrected with body height) no statistically significant difference was observed between the groups.

TABLE 2
DESCRIPTIVE STATISTICS FOR STATURE, BODY WEIGHT, AND BMI

	American Football $\bar{X}$±SD (Median)	Volleyball $\bar{X}$±SD (Median)	Basketball $\bar{X}$±SD (Median)	Football $\bar{X}$±SD (Median)	Students $\bar{X}$±SD (Median)
Stature	1779.19±57.26[a] (1764.00)	1823.85±68.64[c] (1836.50)	1856.23±87.03[c] (1868.00)	1734.50±63.66[b] (1749.50)	1761.93±53.71[ba] (1760.00)
Weight	88.26±19.36[a] (82.00)	80.85±10.85[b] (79.50)	85.10±10.50[c] (85.00)	79.41±9.92[d] (70.50)	72.86±12.85[c] (69.00)
BMI	27.76±5.18[a] (25.37)	24.29±2.90[b] (23.85)	24.70±2.65[b] (24.19)	23.37±2.78[b] (23.03)	23.42±3.62[b] (22.03)

Different letters represent the statistically significant differences between the group means according to ANOVA (For all Leven's F statistics *ps*>0.05)

TABLE 3
DESCRIPTIVE STATISTICS FOR LENGTH MEASUREMENTS

	American Football $\bar{X}$±SD (Median)	Volleyball $\bar{X}$±SD (Median)	Basketball $\bar{X}$±SD (Median)	Football $\bar{X}$±SD (Median)	Students $\bar{X}$±SD (Median)
Arm length	336.37±29.12[a] (334.00)	340.15±21.99[ab] (342.00)	347.13±24.33[ab] (350.00)	318.26±17.26[b] (320.50)	328.36±15.86[ab] (325.50)
Forearm length	278.59±15.46[a] (274.00)	280.65±12.32[bed] (280.00)	290.19±13.57[cab] (290.00)	265.53±15.97[df] 266.00	270.64±14.42[ef] (270.50)
Femur length	504.15±32.67[a] (496.00)	513.69±33.03[b] (513.50)	523.58±42.90[cb] (518.00)	476.00±25.19[da] (479.00)	483.54±21.54[a] (490.00)
Tibia length	396.63±26.43[a] (396.00)	408.12±36.17[a] (409.50)	418.10±30.56[a] (423.00)	384.94±27.22[a]	391.54±22.47[a] (392.00)
Sitting height	926.78±32.54[a] (926.00)	944.85±35.68[a] (950.50)	958.39±37.31[a] (959.00)	911.35±31.38[a] (918.00)	919.43±28.09[a] (927.00)
Iliospinale length	985.22±34.37[a] (981.00)	1034.77±62.09[b] (1025.50)	1063.03±78.77[cb] (1088.00)	974.59±51.13[d] (967.00)	999.68±38.87[ed] (996.50)

Different letters represent the statistically significant differences between the group means according to ANCOVA (For all Leven's F statistics *ps*>0.05)

When breadth and girth measurements were evaluated after body height and weight had been controlled (Table 3), no difference in the humerus and knee breath was observed between the groups. Although basketball players seem to have the widest biacromial breadth when body height and breadth was controlled, biacromial breadth was significantly lower for these athletes when compared to American football and volleyball players. When the absolute values for biiliac breadth were evaluated, basketball and American football players were observed to have higher values. When height and weight were controlled however, biiliac breadth for American football players was significantly wider when compared to other groups. No statistically significant difference was found between the other groups. Since arm and calf girth measurements reflect the bone, muscle and fat mass of the limbs, these two variables have also been evaluated in the study. As illustrated in Table 4, American football players have the highest arm and calf girth values. On the other hand when body height and weight were controlled, the above mentioned two variables were again observed to be significantly higher for American football players. No significant difference was observed in arm girth between basketball and volleyball players. Similarly there was no difference between football players and sedentary students, but arm girth values were significantly higher for basketball and volleyball players when compared to football players and students.

Descriptive statistics of skinfold values are shown in Table 5. The highest total body fat values belong to

TABLE 4
DESCRIPTIVE STATISTICS FOR BREADTH AND GIRTH MEASUREMENTS

	American Football $\bar{X}$±SD (Median)	Volleyball $\bar{X}$±SD (Median)	Basketball $\bar{X}$±SD (Median)	Football $\bar{X}$±SD (Median)	Students $\bar{X}$±SD (Median)
Humerus breadth	67.96±5.52[a] (68.00)	67.58±4.33[a] (68.00)	69.10±4.11[a] (70.00)	65.47±4.11[a] (66.00)	66.18±3.69[a] (66.00)
Knee breadth	92.85±8.68[a] (93.00)	91.65±7.46[a] (92.50)	91.77±9.30[a] (92.00)	90.09±7.57[a] (90.00)	90.25±9.30[a] (92.50)
Biacromial breadth	402.81±24.15[a] (401.00)	403.73±18.29[a] (405.00)	415.03±25.14[b] (414.00)	387.18±19.25[ab] (386.00)	382.25±20.11[ab] (381.50)
Biiliac breadth	295.85±30.23[a] (291.00)	289.81±17.47[b] (285.00)	295.94±20.01[b] (299.00)	275.24±16.12[b] (278.00)	275.04±23.08[b] (272.00)
Arm girth	348.85±39.49[a] (345.00)	320.08±29.59[b] (317.00)	330.23±19.97[cb] (333.00)	293.59±24.56[d] (294.00)	297.96±25.98[ed] (290.50)
Calf girth	398.78±33.61[a] (390.00)	382.46±26.09[b] (375.00)	388.16±22.72[b] (386.00)	361.97±26.09[b] (363.50)	368.25±32.88[b] (367.00)

Different letters represent the statistically significant differences between the group means according to ANCOVA (For all Leven's F statistics *ps*>0.05)

TABLE 5
DESCRIPTIVE STATISTICS FOR SKINFOLDS

	American Football $\bar{X}$±SD (Median)	Volleyball $\bar{X}$±SD (Median)	Basketball $\bar{X}$±SD (Median)	Football $\bar{X}$±SD (Median)	Students $\bar{X}$±SD (Median)
Biceps	7.77±0.3.74[a] (7.07)	5.14±2.48[b] (4.23)	5.79±2.13[c] (5.40)	5.11±1.91[d] (4.54)	6.76±3.45[e] (5.50)
Triceps	14.49±5.86[a] (13.47)	8.86±4.33[b] (7.70)	10.20±3.54[c] (10.07)	9.20±3.65[d] (8.57)	12.25±4.66[e] (12.07)
Subscapular	19.74±9.07[a] (16.20)	12.46±4.12[b] (11.74)	12.65±3.82[b] (11.27)	11.84±4.47[c] (10.50)	14.50±6.18[d] (13.07)
Suprailiac	14.29±6.77[a] (13.53)	9.91±5.11[b] (7.87)	10.46±3.75[c] (9.93)	8.97±4.19[d] (7.27)	11.33±4.89[e] (10.10)
Medial calf	11.11±4.97[a] (9.47)	8.87±4.27[b] (7.97)	9.47±3.24[b] (9.13)	7.92±3.35[b] (7.37)	12.66±8.33[a] (10.77)
Total fat	67.40±27.95[a] (61.53)	45.25±18.31[b] (38.30)	48.56±13.93[c] (49.73)	43.03±15.41[b] (38.20)	57.50±21.75[d] (51.37)
Limbs / Trunk	1.03±0.04[a] (1.05)	1.03±0.04[a] (0.97)	1.12±0.04[a] (1.12)	1.10±0.04[a] (1.06)	1.25±0.06[b] (1.25)

Different letters represent the statistically significant differences between the group means according to Kruskal-Wallis ANOVA

American football players ($p<0.001$) and these were followed by non-athlete students. When the ratio of total fat value of the limbs (biceps+triceps+calf skinfold thickness) to total truncal fat, the non-athlete students were observed to have significantly higher limb fat value when compared with truncal fat, with a difference of ($p<0.01$) from the sports groups.

Table 6 summarizes the descriptive statistics of the somatotype components. In relation to endomorphy (the component that indicates the total fat amount of the body), significant differences were observed between the groups ($p<0.001$). The highest endomorphy component was in the American football group. This was followed by the non-athlete students, and by the basketball, football and volleyball groups, respectively. Although the difference between the volleyball and football groups was not statistically significant, the endomorphy value for the football players was higher than that of the volleyball group.

When the mesomorphy component (the component which relates to the total muscular and bone mass of the body) was evaluated, the values were significantly higher for American football players ($p<0.001$). High values both for endomorphy and mesomorphy components reflect the large body structure of the American football players. No difference was found between football, basketball and volleyball players with respect to mesomorphy. The mesomorphy value of the non-athlete students was significantly lower when compared to those of the sports groups ($p<0.05$).

As was expected, ectomorphy values of the American football players were significantly lower than those of the other groups ($p<0.001$). No significant difference was found between the other groups; however the highest ectomorphy value belongs to volleyball players among the sports groups in this study.

Discussion

In the present study the anthropometric characteristics of the athletes have not been evaluated in relation to their performance; but were instead compared with each other. This study indicates the existence of differences among the sports groups and the control group when absolute values were evaluated. It is believed however, that the evaluation of anthropometric characteristics (after body height and weight have been controlled) provide more reliable results in relation to the morphological structure of the body.

In this study, American football players were separated from the other athletes by their high body weight BMI. Endomorphy and mesomorphy values of American football players were also higher than those of the other groups. In addition, American football players were characteristic with their relatively wider biiliac breadth, and higher arm and calf girth values. Basketball players on the other hand were characteristic with their long stature, higher mesomorphy value, and longer lower limbs when stature was controlled. Volleyball players were as tall as basketball players, and similarly have long lower limbs when stature was controlled. The volleyball players in this study were also as mesomorphic as basketball players; however their body weight and BMI are lower when compared to American football and basketball players. Lower endomorphy values and relatively higher ectomorphy values of the athletes playing volleyball reflect their lean body structure. The results of the present study indicate that football players had a small structure. Their body height and BMI were lower than those of the non-athlete subjects; however the mesomorphy values of football players were higher and the endomorphy values were lower than the non-athlete students. The non-athlete students differed significantly from the other groups with their higher endomorphy values and higher ratio of total fat amount with limb localization over total truncal fat.

Comparative studies, representing the anthropometric characteristics of athletes, are not common in eastern countries. In a study on Malaysian male athletes, relatively long stature of basketball players had been reported when compared to other sport groups[15]. Similarly in the present study the average heights of the basketball and volleyball players were higher than those of the other sports groups and the non-athlete students. Since basketball and volleyball require handling the ball above the head, body height is considered to be the most important physical attribute. In the study on Malaysian male athletes however, the stature had not been controlled,

TABLE 6
DESCRIPTIVE STATISTICS FOR SOMATOTYPE COMPONENTS

	American Football $\bar{X}$±SD (Median)	Volleyball $\bar{X}$±SD (Median)	Basketball $\bar{X}$±SD (Median)	Football $\bar{X}$±SD (Median)	Students $\bar{X}$±SD (Median)
Endomorphy	4.51±1.71^{a} (4.50)	2.91±1.24^{b} (2.53)	3.08±0.94^{d} (3.13)	2.94±1.10^{b} (2.65)	3.68±1.32^{c} (3.44)
Mezomorphy	6.02±4.84^{a} (5.07)	3.78±1.09^{b} (3.84)	3.74±1.22^{b} (3.85)	3.86±1.17^{b} (3.73)	3.62±1.26^{c} (3.72)
Ectomorphy	1.37±1.19^{a} (1.21)	2.44±1.12^{b} (2.59)	2.43±1.14^{b} (2.31)	2.32±1.10^{b} (2.30)	2.54±1.40^{b} (2.69)

Different letters represent the statistically significant differences between the group means according to ANOVA (For all Leven's F statistics *ps*>0.05)

nor had the proportional values been evaluated. In addition to tall stature, leg length relative to body height is also of importance for the basketball and volleyball players since being able to jump high is a requirement[16]. In a study similar to this present study, Spurgeon et al.[17] reported higher lower limb length relative to body height for basketball players. It is well known that this proportionality characteristic is advantageous for all jumping athletes[18]. This proportionality characteristic would be mechanically advantageous for jumping, provided the athlete can develop sufficient power in the extensor muscles of the thighs, legs and feet.

In a study on Italian male volleyball players mean somatotype values were 2.4, 4.5, 2.8, and they were reported as balanced mesomorphs[19]. In the present study the mean mesomorphy value for the volleyball players was lower, but the endomorphy value was higher than those of Italian athletes. Advantage of high ectomorphy scores for volleyball players, especially for the center had been reported in previous studies[20]. In the present study volleyball players had the highest ectomorphy values among other sports groups. It is well known that athletes involved in sports where body size is a definite advantage, such as volleyball and basketball, tend to have a larger lean body mass index[21]. The high mesomorphy values for volleyball and basketball players in the present study partially reflect this fact, but their endomorphy values were also higher when compared with literature findings.

Physiological and anthropometric characteristics of soccer players are mainly obtained from the athletes originating from Western Europe and North America. Studies on eastern athletes are limited. In a study on Hong Kong's elite soccer league, players' body height and weight had been observed as 173.4±4.6 cm and 67.7±5.0 kg respectively[22]. For Indonesian athletes the average stature for football players was 166 cm, and body weight was 58 kg[3]. In the present study these values were 173.5 cm and 79.4 kg respectively. Carter and Heath in their studies on the athletes from Bratislava, Southern Australia, Nigeria, Brazil, Cuba and Bolivia reported that the stature was between 169–178 cm and body weight was between 69–75 kg. Body weight of the football players in the present study was higher when compared with the other athletes. Somatotype components of Indonesian soccer players[3] were reported as 2.7, 4.9, and 3.0. In another study on South American football players somatotype values were as follows[23]: 2.2, 5.4, 2.2. In the present study the somatotype profile of the football players was 2.94, 3.86, and 2.32. When compared with South American and Indonesian athletes the mesomorphy component was lower and the endomorphy component was higher in Turkish football players.

In the sports like rugby or American football, to have a bigger and heavier body is an advantage for the athletes in gaining possession of the ball[7]. Besides a higher BMI, higher arm and calf girth values were characteristic for the American football players in the present study. When the Turkish athletes were compared with the ones from South America, Turkish players were observed to be shorter and heavier; however the values were not significantly different from one another. Somatotype profiles for South American athletes, on the other hand, were 2.3, 5.9, and 1.5 while they were 4.5, 6.0, and 1.4 for Turkish athletes. Though mesomorphy and ectomorphy values were similar, endomorphy values for the Turkish athletes were significantly higher.

Conclusion

In the descriptive studies on athletes to-date, body structure had been determined based on absolute anthropometric values. In the present study body height and weight were controlled by using one way analysis of covariance (ANCOVA) in order to determine the morphological characteristic in a more reliable manner. The results of this study indicate that basketball and volleyball players were characteristic with their longer lower limb length relative to stature and American football players were with their wider biiliac breadth and higher girth values. The morphometric characteristics of football players were similar to those of the non-athlete subjects. In addition, when the body structures of Turkish athletes were compared to those of others reported in the literature, it was observed that Turkish athletes had higher endomorphy values while their mesomorphy values were lower. It has been reported in most of the studies reviewed, that an increase in body fat negatively influences athletic performance[24-26]. The high endomorphy values in the Turkish athletes therefore, could be viewed as a disadvantage in relation to their performance. Some authors however, assert that body fat is not correlated with performance[27].

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ANTROPOMETRIJSKE KARAKTERISTIKE MLADIH TURSKIH SPORTAŠA

S A Ž E T A K

Komparativni izvještaji o antropometrijskim karakteristikama sportaša zasigurno su važni u modernom sportu i već su duže vrijeme istraživani od strane sportskih znanstvenika. No, istraživanja provedena na turskim sportašima su do sada bila vrlo ograničena. U ovoj studiji proučavane su fizičke karakteristike aktivnih sportaša iz raznih sportova (američki nogomet, košarka, odbojka i nogomet) i rezultati su uspoređivani međusobno te sa rezultatima nesportaša. U studiji su sudjelovala 153 muška volontera. Svi sportaši su punopravni članovi timova raznih sveučilišnih liga i svi su obaviješteni o ciljevima istraživanja i načinu na koji će se vršiti antropometrijska mjerenja. Uz 17 antropometrijskih vrijednosti, računat je i indeks tjelesne mase te somatotipske komponente. Vrijednosti dužine, širine i opsega su procijenjene ANCOVA metodom, dok su visina i težina korištene kao kovarijantni faktori. Ostale varijable su izračunate ANOVA metodom. Rezultati ove studije pokazuju da su igrači košarke i odbojke bili specifični po svojim dugim donjim ekstremitetima, igrači američkog nogometa po svojim širim zdjelicama i višim vrijednostima opsega, a igrači nogometa po svojoj sitnijoj građi. Također je utvrđeno da turski sportaši imaju više vrijednosti endomorfije i niže vrijednosti mezomorfije u usporedbi sa sportašima iz drugim zemalja.