

ANTHROPOMETRIC PARAMETERS IN NATIONAL FOOTBALLERS IN THE REPUBLIC OF MACEDONIA

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Abstract

Objectives: The focus of this study is on anthropometric characteristics of footballers in the Republic of Macedonia, and the aim is to provide normative data for selected anthropometric parameters for adult male footballers in our country.

Material and method: The study included eight hundred (800) adult male footballers, aged $24.06 \pm 4.8y$ (age range 18–35y), who have undertaken routine sport medical examinations over a ten-year period. The football players were divided into six age – specific subgroups ("up to 20"; "up to 22"; "up to 24"; "up to 26"; "up to 28" and "over 28" years). Anthropometric measurements were made by Matiegka's protocols and body composition components were determined.

Results: Average values of body height (178.8 ± 6.7 cm), body weight (77.72 ± 7.9 kg), lean body mass (66.21 ± 6.36 kg), body components (MM% = 53.04; BM% = 17.15; FM% = 14.7%) and a large series of anthropometric measurements which define the footballers' anthropometric dimensions were obtained. The distribution of the adipose tissue regarding the body and limbs showed that the skinfolds were thickest on the lower limbs and thinnest on the arms.

Conclusions: The adult football players in Republic of Macedonia were insignificantly variable in height and body mass from their counter parts from European and American teams. The football players up to 20 year, who played in the senior national football league were lighter and smaller than their older colleagues. The football players aged from 20 to 35 years were insignificantly variable in height, body mass, and anthropometric dimensions of limbs and trunk.

Key words: football, adult, anthropometry, body composition, skinfolds, diameters.

Introduction

Football is the most popular game in the world, which is the reason why enormous number of athletes, male and female, young and adults, amateurs and professionals participate in this sport. Besides fitness and the technical skills of the footballers, anthropometric indicators and body composition play an important role in successful performance [1]. Anthropometry has been widely applied in a broad range of disciplines, such as ergonomics and health sciences. Because of its convenience, anthropometry has also been used to understand phy-

sical characteristics of athletes in the field of sports science which targets improvement of athletic performance [2]. The assumption that anthropometric parameters have an impact on the physical components of footballers' performance has been thoroughly investigated [3]. The reported results provide evidence for sports officials (coaches, managers) as well as for football players about the importance of anthropometry [4].

A footballer is expected to have certain morphological and physiological attributes in order to make a continuous and successful ca-

reer. A significant correlation between body mass, muscle mass and work-rate profile has been established [5]. Studies with young footballers have indicated that age and physical characteristics are important indicators in identifying talented players and selection for the game [6]. It is not necessary for the players to possess outstanding characteristics in strictly defined areas of physical skills, but it is essential for them to show reasonably high characteristics in all areas [7]. There are trends towards more systematic training and selection which influence the anthropometric profiles of players who compete at the highest level [8].

Despite the recognition of the importance of anthropometric parameters for the process of selection and training of football players, there is a lack of precise and accurate published information on the anthropometric characteristics of athletes, especially footballers in the national league in our country. Moreover, there is a lack of comparative studies of anthropometric properties between Macedonian athletes and athletes from other countries. This study was designed with the aim of revealing some of the vast data of anthropometric parameters, which exists in the Laboratory of functional testing in Department of Physiology and Anthropology at the Medical Faculty in Skopje.

The aim of this paper was to determine the morphological characteristics and body composition of footballers who play in the first league clubs in the Republic of Macedonia and to identify possible differences in the examined characteristics related to age. The primary purpose of this study was to determine the normative values for anthropometric parameters and body composition components of adult male Macedonian footballers. The results of this study could provide useful information for sports officials in order to create a successful training model for their football players and to identify young talented players.

Methods

The study was performed in the Laboratory of Functional Testing, Department of Physiology and Anthropology at the Medical Faculty in Skopje, where all athletes in the Republic of Macedonia are obliged to have regular sports medical health check-ups at least two times per year.

The current investigation involved an analytic-comparative design to evaluate the an-

thropometric characteristics of the First Division football players. The data from footballers who have played in the first national league and have undertaken routine sports medical examinations over the ten-year period (2000–2010) were analysed in this study. Prior to the initiation of the tests the purpose and procedures were explained to all the footballers. Data were confidential and data protection was observed.

Participants

The study involved eight hundred (800) male Macedonian national league club footballers, age range from 18 to 35, mean age 24.06 ± 4.41 years. The participants were divided into six (6) different age-specific subgroups: "up to 20" (n = 130); "up to 22" (n = 120); "up to 24" (n = 120); "up to 26" (n = 140); "up to 28" (n = 135); and "over 28 years" (n = 155).

Anthropometric procedure

Body composition was assessed using the anthropometric measurement protocol by Matiegka. Besides the standing height and weight anthropometric parameters, limb circumferences (upper arm relaxed and flexed, forearm, thigh and calf), limb diameters (wrist, elbow, ankle and knee) and seven skinfolds (biceps, triceps, forearm, subscapular, thigh, calf, suprailiac) were also measured in this study. Participants' height was measured to the nearest 0.1 cm with a fixed stadiometer (Holtain Ltd., Crymich, U.K.), body weight to the nearest 0.1 kg using the SECA beam balance (Seca, Hamburg, Germany). Harpenden skinfold caliper (British indicators Ltd., Luton) was used to take skinfold thickness with 0.1 mm accuracy and the ankle diameter was measured using a Vernier caliper. Elastic tape was used to take circumferences with 0.01 accuracy.

An anthropometry expert performed the anthropometric measurements according to the guidelines of the International Society for the Advancement of Kinanthropometry. Personal information of the participants (full name, date of birth, activity record) as well as anthropometric data were filled in on special forms. All measurements were performed on the right side of the body.

Statistical Analyses

Statistical analysis of the obtained results was made using the statistical program for

Windows, STATISTICA 7.1. Descriptive statistics including mean values, standard deviation, and \pm 95 confidence interval, minimum and maximum values were used for series with numerical attributes. Analysis of variance was used (F; p) for inferential statistics. The significance level was set at $p < 0.05$.

Results

The descriptive statistics of the cohort (N = 800) for the general parameters (age, height, weight) and body mass components is shown in Table 1. The descriptive statistics of all the participants for various anthropometric variables (four diameters of joints, five circumferences of limbs and seven skinfolds) are shown in Table 2.

Table 1

Physical characteristics and body mass components of Macedonian National League club footballers

	Mean	Confidence -95.00%	Confidence +95.00%	Minimum	Maximum	St dev
Age	24.06	23.77	24.38	18	35	4.08
Height (cm)	178.8	178.00	178.78	161.00	193.5	6.7
Weight (kg)	77.73	74.72	75.74	57.0	101.0	7.87
LBM	66.21	63.80	64.63	50.18	84.58	6.36
MM%	53.08	52.86	53.22	48.13	60.18	2.43
BM%	17.01	17.21	17.38	14.37	21.71	1.23
FM%	14.76	14.44	14.72	11.82	19.38	1.43

Table 2

Various anthropometric parameters of Macedonian National League club footballers

	Mean	Confidence -95.00%	Confidence +95.00%	Minimum	Maximum	St dev
DIAMETERS (mm)						
wrist	56.61	55.91	56.34	47.00	77.00	4.07
elbow	79.97	78.70	79.50	61.00	98.00	5.95
knee	101.15	100.61	101.21	90.00	115.00	4.37
ankle	75.52	74.54	75.10	64.00	97.00	4.40
CIRCUMFERENCES (mm)						
Upper arm relaxed	285.62	278.47	281.05	185.00	350.00	17.36
Upper arm flexed	314.97	307.84	313.72	265.00	515.00	57.8
forearm	264.32	260.28	262.35	210.00	310.00	15.5
thigh	577.6	564.95	570.17	470.00	660.00	30.04
calf	381.42	374.79	377.89	265.00	565.00	19.7
SKINFOLDS (mm)						
biceps	4.27	3.81	5.34	2.4	12.6	1.11
triceps	7.88	7.63	8.24	3.0	20.3	2.49
forearm	4.93	4.79	4.92	2.6	11.3	1.27
sub scapular	10.86	9.99	10.35	3.2	23.3	2.79
Front thigh	12.77	11.89	12.43	4.3	38.0	5.4
Calf back	7.00	7.30	7.66	2.6	18.9	2.43
Suprailiac	8.12	7.07	7.57	2.6	29.6	4.69

Mean values (and SD) for physical characteristics and body mass components of football players for different age-specific subgroups are shown in Table 3. There was no significant difference in body height between different age-specific subgroups. The body mass showed an increasing trend with advancing age with statistically significant difference between age subgroups ($p < 0.005$). There was a significant difference in body mass/weight between different age

subgroups, for $F = 18.81$ and $p < 0.001$. The youngest group had a significantly lower body weight than all other age subgroups. The relative muscle mass (component) was similar in all groups. The relative bone mass (BM%) was significantly higher in the subgroups aged "up to 20" and "up to 22" compared to other age-specific subgroups. The relative fat mass (FM%) was significantly lower in those two groups compared to other subgroups.

Table 3

Comparison of physical characteristics and body mass components of Macedonian National League club footballers between different age-specific subgroups [Mean (SD)]

groups	Up to 20	Up to 22	Up to 24	Up to 26	Up to 28	Over 28
Age (year)	18.27 (0.68)	20.45 (0.5)	22.57 (0.5)	24.51 (0.5)	26.54 (0.5)	30.63 (2.51)
Height (cm)	178.14 (6.2)	178.71 (5.85)	178.61 (6.15)	178.78 (5.81)	178.78 (5.79)	178.8 (6.42)
Weight (kg)	72.58 (7.75)	73.8 [‡] (7.19)	75.88 [‡] (7.58)	76.25 [‡] (7.56)	77.30 [‡] (7.30)	77.73 [‡] (7.87)
LBM	62.23 (6.4)	63.28 (5.8)	64.67 (6.00)	64.86 (5.99)	65.97 (5.66)	66.21 (6.36)
MM%	52.21 (3.64)	53.36 (1.88)	53.05 (2.5)	53.19 (2.84)	53.41 (3.33)	53.08 (2.43)
BM%	17.78 (1.29)	17.42 (1.19)	17.23 (1.21)	17.06 (1.31)	17.02 (1.28)	17.01 (1.23)
FM%	14.2 (1.72)	14.20 (1.41)	14.7 (1.66)	14.81 (1.56)	14.6 (1.19)	14.76 (1.43)

[‡] Significantly higher than up to 20

Mean values (and SD) for diameters, circumferences and skinfolds for the different age-specific subgroups of football players in our participants are shown in Table 4. The diameter of the wrist (ANOVA: $F = 4, 41, p <$

$0,001$) and the diameter of the ankle (ANOVA: $F = 6.74, p < 0.001$) were significantly different among the age-specific subgroups. There was no difference in the diameters of the elbow and the knee among the age-specific subgroups.

Table 4

Comparison of various anthropometric parameters of Macedonian National League club footballers

	Up to 20	Up to 22	Up to 24	Up to 26	Up to 28	Over 28
DIAMETERS (mm)						
wrist	55.72	55.27	56.02	55.97	56.53	56.91 [‡]
elbow	77.89	78.64	79.64	79.56	79.29	79.9
knee	100.25	100.51	101.03	100.85	101.43	101.37
ankle	73.63	74.64	74.88	75.05	75.31 [‡]	75.75 [‡]
CIRCUMFERENCES (mm)						
upper arm relaxed	267.64	277.56 [‡]	281.48 [‡]	282.41 [‡]	285.55 [‡]	286.57 [‡]
upper arm flexed	299.45	309.67	313.44	307.48	319.43 [‡]	318.36 [‡]
forearm	251.95	259.83 [‡]	262.33 [‡]	263.83 [‡]	266.75 ^{‡*}	265.97 ^{‡*}
thigh	550.16	564.6 [‡]	571.23 [‡]	569.54 [‡]	576.43 [‡]	577.57 [‡]
calf	367.60	372.11	376.40 [‡]	379.59 [‡]	381.36 [‡]	381.70 [‡]
SKINFOLDS (mm)						
biceps	4.49	3.88	4.01	4.19	6.6	4.29
triceps	8.08	7.34	8.03	8.27	7.67	7.92
forearm	4.98	4.54	4.68	4.75	4.92	4.93
subscapular	9.17	9.53	10.45	10.55	10.51 [‡]	10.84 [‡]
Front thigh	11.66	11.14	12.18	13.0	11.65	12.66 [‡]
Calf back	7.73	7.23	7.91	7.56	7.12	7.25
Supra-iliac	6.65	7.14	7.18	7.58	7.25	7.97 [‡]

[‡] Significantly higher than in the subgroup aged up to 20;

* significantly higher than in the subgroup aged up to 22

The analysis of the limb circumferences showed that there were significant differences in all measured circumferences between age-specific subgroups of football players. The youngest football players ("up to 20") showed significantly smaller upper arm circumference compared to players from other age-specific subgroups ($p < 0.001$). The differences of this parameter within the other subgroups were not significant ($p > 0.05$). The circumference of

flexed upper arm was significantly larger ($p = 0.002$) only in players from the "over 28" subgroup, compared to the players from the "up to 20" subgroup.

The forearm circumference was significantly smaller in the youngest subgroups ("up to 20" and "up to 22") compared to others ($p < 0.001$). There was no difference regarding this parameter among other age-specific subgroups.

The football players younger than 20 years had significantly smaller circumferences of thigh and calf compared to other age subgroups ($p < 0.001$). There were no differences regarding these parameters of the lower limb among the other five subgroups.

The analysis of the skinfolds measured at seven landmarks showed that there were significant differences between the six age-specific subgroups of football players in our participants regarding several parameters. The skinfold of the forearm (ANOVA: $F = 2.35$ $p = 0.04$), the subscapular skinfold ($F = 10.89$ $p < 0.001$), the thigh skinfold ($F = 2.60$ $p = 0.02$) and the suprailiac skinfold ($F = 2.58$ $p = 0.03$) were significantly different between the six subgroups. The other three parameters (skinfolds of biceps, triceps and the calf) were similar in all football players ($p > 0.05$).

Discussion

The studies published in the field of anthropometry including football players are very often conducted on elite level players, or they compare the results between elite and non-elite players. A valuable aspect of the present study is that the anthropometric investigation was performed on a very large group of non-elite but high level football clubs. The results of this study can serve as normative data for comparison of the anthropometric examination of adult football players in our country.

The age of the football players in the study covers a wide range (18–35 y). The mean age of players was similar to the studies from Turkey (24.1 years) and South America (24.2 years), but it was smaller than the mean age (26.4 years) of soccer players in four high level European Leagues (English, Italian, German and Spanish League) [5, 9, 10].

The comparison of the anthropometric features of footballers from different countries shows national variations, Table 5. The mean values of body height and body weight in Macedonian football players were higher than those in Asian counterparts, but were similar to the values of the European and the American teams [11]. The height and weight of Japanese national squad members were smaller (175.3 cm; 69.7 kg) [12] than the average height of the Macedonian adult football population. The footballers from the Indian national team were

shorter than their siblings from Europe, (171.6 cm; 64.4 kg) and from the footballers of the Australian National league (179.1 cm; 69.7 kg) [13]. There are inconsistent data on the physical characteristics of football players in the First English league. White et al. reported that the average height and weight of football players were 180.4 cm and 76.7 kg, respectively, while according to Williams et al. (1973) they were smaller and lighter (174.6 cm; 69.4 kg) [14, 15]. Italian professionals were 177.2 cm high and weighed 74.4 kg, and Hungarian footballers were 176.5 cm tall and weighed 70.5 kg [16, 17]. Footballers from the American National Team were 178 cm tall and 77 kg heavy [18]. The stature and body mass of players at the Copa America, Championships in Uruguay reported by Rienzi were 1.77 m and 76.4 kg, respectively [5]. Elite adult soccer players have an average height of 182–186 cm and a weight of 75–80 kg; these findings have been made in Danish, Italian and German players [1]. The comparison of morphological properties between Macedonian footballers and footballers from neighboring countries (Croatia and Serbia) shows that Macedonian footballers are 2 cm shorter on average than Croatian and Serbian footballers, while the body weight is almost identical (77.6 kg and 77.4 kg) [19, 20].

The Macedonian adult footballers showed particularly similar morphological characteristics with their Croatian counterparts. Their body mass (77.6 kg), lean body mass (66.3 kg) fat tissue (14.7% vs. 14.9%), knee diameter (100.9 vs. 100 mm) and elbow diameter (78 vs. 72 mm) were almost identical. The Macedonian and Croatian football players showed small differences between the upper and lower parts of the upper limb: upper arm circumferences (285 mm vs. 292 mm) regarding forearm (264 mm vs. 264 mm). The circumferences of legs were significantly higher in the upper part, thigh (577 mm vs. 577 mm), than calves (381 mm vs. 389 mm) [20].

The anthropometric characteristics were compared between six (6) age categories in our study. The average body height of footballers from different age-specific subgroups was similar. The footballers from the three oldest age subgroups had the same average body height, which confirms the completion of the growing process by reaching the final body

height at the age of 26 years. The footballers from the youngest subgroup (up to 20) were significantly lighter than the footballers from

other age sub-groups, but their lean body mass, muscle mass and fat mass were insignificantly lower than those in the other subgroups.

Table 5

Comparison of general anthropometric parameters of Macedonian National League club footballers and football players from other countries

References	Nationality	Age	Height (cm)	Weight (kg)	Body fat percent
9	Turkish	24.01	178.4	76.1	-
5	South American	26.1	177	76.4	10.6
5	English	24.7	179	77.6	16.2
10	Germany	25.8	183	77.5	13.7
12	Japanese	-	175.3	69.7	-
13	Indian	-	171.6	64.4	-
13	Australian	24.8	179.1	69.7	-
14, 15	English	25.1	180.4	74.4	-
16, 17	Hungarian	-	176.5	70.5	-
18	American	-	178	77	-
1	Danish	-	179	72.1	-
19	Croatian	23.2	180.6	77.6	14.9
20	Serbian	23.8	181.9	77.4	10.8

The comparison of diameters of the four ankles in different age-specific subgroups showed that only the oldest subgroup ("over 28") had larger diameters of the wrist and the ankle than the youngest subgroup ("up to 20"). Although the relative bone component (expressed in%) was significantly higher in the youngest subgroup ("up to 20") compared to the oldest subgroup ("over 28"), the absolute bone component (expressed in kg) was higher in the oldest subgroup.

The youngest subgroup had smaller limb circumferences compared to all other age groups. Although the difference between the circumferences of various parts of the limbs were insignificantly different in the subgroups aged "up to 22", "up to 24", "up to 26", "up to 28", and "over 28", there was an obvious trend of increment of volume of limbs with age, especially up to the age of 28 years. The muscle mass, which was derived from the measured circumferences, was also insignificantly smaller in the youngest footballers compared to all other subgroups.

The thickness of the skinfolds is important for the assessment of the size of body fat mass. The thickest skinfolds, which represent the largest amount of subcutaneous adipose tissue in all age-specific subgroups, were found in

the front thigh and on the subscapular measuring point. The thinnest amount of subcutaneous adipose tissue was measured on the biceps measuring point (on the front side of the upper arm). If we compare the distribution of adipose tissue regarding the body and limbs in our football players, it could be inferred that the skinfolds were thickest on the lower limbs and thinnest on the arms. The percentage participation of adipose tissue in the body mass of footballers in different age-specific subgroups was similar, although a slight increase of the percentage related to age was obvious.

Reports regarding certain anthropometric parameters (diameters, circumferences and skinfolds) in adult footballers are rare in the literature. The comparison of our results with the data of Gil et al. regarding anthropometric parameters of young adult Spanish footballers showed that young Spanish footballers had larger upper arm (30.57 cm), larger thigh (56.6 cm) and larger calf (37.7 cm) circumferences than our footballers at the same age up to 20 years [21]. The data on the diameters of the joints was not substantially different from our data for the same age, except for the diameter of the elbow which was 10 mm smaller in Spanish footballers than that in our participants. The thickness of the skinfolds showed similar values, with the thickest skinfolds on the thigh

and the subscapular measuring point in both compared samples.

The comparison of the anthropometric data of all the participants in our study with the Turkish national football players showed that football players from Turkey had bigger upper arm girth (31 cm) and almost the same calf girth (37.58 cm). They also had very similar mean values of triceps (7.88 mm) and subscapular (10.65 mm) skinfolds, but significantly thinner suprailiac skinfold (5.34 vs 7.33 mm) [9]. German amateur soccer players also had bigger arm, calf and thigh girth than Macedonian sub-elite players [22]. Brazilian professional soccer players, aged 22.7 years, showed the thickest skinfold at the horizontal abdominal and suprailiac sites (13.5 mm), subscapular (11.5 mm) and thigh (10.1 mm) versus data of the thickest skinfold at thigh and subscapular point in our study [23].

The intergroup variability of anthropometric measures regarding football players' age showed that only young adult players (up to 20) differ in some parameters from other players. The differences among other age subgroups were so insignificant that it could be concluded that footballers older than 20 years of age are a homogenous group regarding the majority of anthropometric parameters (diameters, circumferences, and skinfolds). The obtained average values for the cohort (18–35y) could be used as normative data for adult male footballers in our country.

Conclusions:

Anthropometric characteristics of footballers may be indicators of the level of physical fitness of an athlete and therefore anthropometric examination is an important segment of the athlete's physical examination. The youngest subgroup of footballers (aged up to 20 years) showed significantly different values for the majority of the parameters compared to older footballers. The differences in anthropometric parameters were insignificant among other age-specific subgroup, which showed the homogeneity of the football players' population older than 20 years regarding these parameters. The results obtained could serve as normative anthropometric values for regular sport medical examinations of footballers in our country. These results could also be used as a

template for the purpose of comparison of anthropometric and functional features between adult footballers of similar level from different countries.

Key points:

- The adult football players in the Republic of Macedonia were insignificantly variable in height and body mass compared with their counter parts from European and American teams.
- The football players up to 20 years old who played in senior national football league were lighter and smaller than their older colleagues.
- The football players aged from 20 to 35 years were less variable in height, body mass, and various anthropometric dimensions of limbs and trunk.
- The distribution of adipose tissue regarding the body and limbs showed that the skinfolds were thickest on the lower limbs and thinnest on the arms.

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Резиме

АНТРОПОМЕТРИСКИ ПАРАМЕТРИ КАЈ ФУДБАЛЕРИ НА СЕНИОРСКА ЛИГА ВО РЕПУБЛИКА МАКЕДОНИЈА

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Цели: Успехот во спортската изведба е тесно поврзан со физичката состојба на спортистите. Во процена на физичкиот статус освен физиолошките и фитнес-параметрите значајно влијание имаат и антропометриските параметри. Целта на студијата е да се установаат нормативни вредности за одредени антропометриски параметри за фудбалери од Република Македонија, кои се мерат и анализираат во рутинска практика при процена на нивниот антропометриски статус.

Материјал и метод: Анализирани се мерењата на осумстотини (800) мажи, фудбалери кои играат во тимовите на Првата државна лига, со просечна возраст $24,06 \pm 4,8$ години. Фудбалерите беа поделени на шест подгрупи, на возрастна разлика од 2 години. Применето е антропометриско мерење по Матиегка.

Резултати: Средна височина на фудбалерите изнесува $178,8 \pm 6,7$ см, средна тежина $77,72 \pm 7,9$ kg; релативна мускулна компонента (ММ%) = 53,04; коскена компонента (КМ%) = 17,15; и релативна масна компонента (МТ%) = 14,7%. Направена е дескриптивна статистика за 16 антропометриски параметри, 4 пречници, 5 обеми и седум ожни димпни, кои се користат за определување на телесни компоненти според протоколот по Матиегка.

Заклучок: Играчите на сениорската фудбалска лига на нашата земја не се разликуваат значително по височина и тежина од фудбалерите на повеќето европски земји. Најмладата подгрупа испитаници се пониски и полесни од своите повозрасни соиграчи. Играчите од 20 до 35 години покажаа хомогени својства во однос на мерените антропометриски параметри. Добиените вредности може да се користат како стандардни вредности за фудбалери од сениорска категорија во Република Македонија.

Клучни зборови: фудбалери, сениори, антропометрија, телесен состав.