

**VASIL LEVSKI NATIONAL SPORTS
ACADEMY SOFIA**

DEPARTMENT OF "SPORTS MEDICINE"

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ABSTRACT

of a dissertation on:

MORPHOLOGICAL CHARACTERISTICS OF ELITE

FOOTBALL PLAYERS FROM THE REPUBLIC OF SUDAN

**for awarding the educational and scientific degree "Doctor" in
a professional field 7.5. Health care. Doctoral program
Wellness - health promotion**

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The dissertation has been discussed and aimed at an official defense by the Department of Sports Medicine

The dissertation has a volume of 150 standard pages and includes 40 tables and 17 figures. The bibliographic list consists of 177 titles, of which 40 are in Cyrillic and 137 are in Latin.

The defense of the dissertation will take place on 27.09.2022 at 2:00 p.m. in Hall A-3 of the National Sports Academy "V. Levski", Students' Town, Sofia. The scientific jury is composed of:

Internal Members:

1. Prof. Dr. Diana Dimitrovi, Ph.D
2. Associate Professor Evelina Miloshova, Ph.D. External members:

1. Prof. Kiril Aladzhov, d.n
2. Associate Professor Diana Popova, doctor
3. Associate Professor David Kanchev, doctor

The defense materials are available to those interested in the library of the NSA "V. Levski"

TABLE OF ABBREVIATIONS

AKMM	- Absolute amount of muscle mass
ACTM	- Absolute amount of body fat
ATM	- Active body mass
CAF	- Confederation of African Football
KG	- Skin folds
MOB	- Muscle girth of thigh
MOM	- Muscle circumference of the arm
MOP	- Lower leg muscle circumference
PMT	- Subcutaneous adipose tissue
SE	- Somatotype units
VMI	- Body mass index

INTRODUCTION

Soccer is a sport practiced by millions of people around the world. It is equally suitable for persons from childhood to old age, both virtuoso competitors and persons with various health problems.

Over the years, competitions increase their dynamism and attractiveness, with which exciting spectacles are created for the spectators.

The sport is highly technical, related to the all-round development of the main physical qualities – speed, endurance, strength, explosive power, flexibility, agility. In addition, perfect coordination, quick reaction, perfect strategy and tactics, high functional work capacity are needed for successful implementation. The specified characteristics have their progressive

improvement in the different levels of sports training in order to reach optimal development in high-class competitors. Their morphological and functional features combined with technical, tactical and psychological preparation can serve as a model in football training work.

With the present scientific study of Sudanese high-class football players, we would like to be helpful and contribute to the development of this very popular sport in all the main stages of the training process - sports selection, selection, planning and implementation of the educational and training work, in the strategy and the tactics of the races.

Working hypothesis

The morphological characteristics of high-class competitors are a basis for selection and a model for building a similar body structure in athletes with lower qualifications.

The review of literature sources and information on the state of football in the Republic of Sudan finds a lack of scientific research on the structural features of the competitors of this sport.

This gave us a reason to direct our scientific and practical interests in studying the anthropometric characteristics of the players football in the A-professional division.

We hope to contribute to the development of a suitable program for the selection, selection and qualification of Sudanese football players.

II. PURPOSE, OBJECTIVES, ORGANIZATION AND METHODS OF THE RESEARCH

II. 1. Purpose and tasks of the study

The aim of the dissertation is to investigate the morphological status of elite Sudanese football players with a view to optimizing the learning and training process in this sport.

To achieve our goal, we set the following main **tasks**:

1. To study literary sources on the problem and analyze the concepts related to the morphological features of football players.

2. To investigate basic anthropometric characteristics of Sudanese football players playing in the National Championship of the country.

3. To determine the somatotype and composition of their body mass.

4. To carry out a comparative characterization of the contestants in depending on their playing position.

5. To create a database for evaluating the morphological status of football players with a view to optimizing the training process.

II.2. The subject of the study is anthropometric signs, body composition and somatotype characterizing the peculiarities in the morphological structure of elite football players from different game posts.

II.3. Object of the study The total number of persons included in the study is 202 football players. Their distribution is presented in separate research programs. The contingent

covers players forming Sudan's representative football teams.

II.3.1. Organization of the scientific experiment. He conducted in three stages.

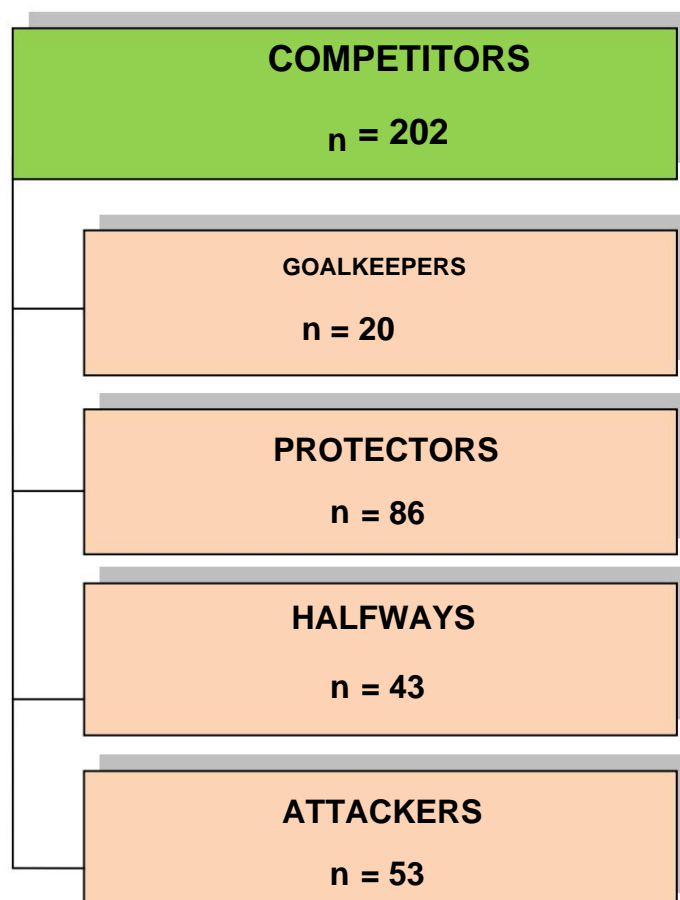
In the first stage (2016) an analysis of the literature was carried out sources and shaping of the literature review and hypothesis.

The main ones are the second two stages (2017-2018), during which football players from the A professional football league were tested according to the established methodology, i.e. 202 leading competitors.

In the last stage (2019-2020) the results were processed, some of them published and an appropriate layout of the doctoral work.

II.4. Study contingent

Football players - participants in the National Championship of the Republic of Sudan.



RESEARCH METHODS

Study of body structure

Anthropometry

Anthropometric studies were conducted according to the method of Martin, R, Saller, K. (1957) on the following indicators:

Table 1

I. Anthropometric indicators	Measurements units	Accuracy of measurement
1. Growth	cm	0.1 0.5 0.1
2. Weight	kg	0.1 0.1 0.1
3. Chest circumference	cm	0.1 0.1 0.1
4. Waist circumference	cm	0.1 0.1 0.1
5. Hip Tour	cm	0.1 0.1 0.1
6. Circumference of right arm flexed 7.	cm	0.1 0 ,1 0.5
Circumference of right arm relaxed 8. Circumference of	cm	
right forearm 9. Circumference of right thigh 10.	cm	
Circumference of right lower leg 11. Skinfold of m.biceps	cm	
brachii 12. Skinfold of m.triceps brachii 13. Skinfold	mm	
below scapula 14. Skinfold above flank 15. Skinfold on	mm	
thigh 16. Skinfold on lower leg 17. Skinfold on abdomen	mm	
18. Biepicondylar diameter of os	mm	
	mm	
	mm	
	mm	
	mm	
humeri	mm	
19. Biepicondylar diameter of os femuri 20. BMI-body	cm	0.5
mass index	$\frac{\text{тегло}(kg)}{\text{рѣст} (m^2)}$	0.1
21. Stretch	cm	0.1

Determination of body mass composition

1. Percentage of adipose tissue according to Jackson & Pollock (1985)

2. Absolute body fat (ABF)

3. Active body mass

- 4. Absolute amount of muscle mass (ACMM)**
- 5. Arm muscle circumference (AMC)**
- 6. Thigh Muscle Circumference (TMC)**
- 7. Lower leg muscle circumference (LMC)**

Determination of the somatotype by the Heath-Carter method

Mathematical statistical methods

- Variance analysis -
- Correlation analysis -
- Student's t-test for dependent samples and determination of Cohen's coefficient - Martin's method

Comparative analysis.

Frequency analysis.

The obtained data were processed on SPSS 25 and Excel.

III. RESULTS, ANALYSIS AND DISCUSSION

MORPHOLOGICAL CHARACTERISTICS OF SUDAN FOOTBALL PLAYERS

The results of the mathematical-statistical processing of the data allow them to be discussed in a morphological aspect, with a view to determining the specific characteristics in the physique of Sudanese football players. A comparative discussion with reference values of other authors has been carried out.

Height straight

The values of growth and its changes in the different age periods are a major indicator of physical development.

The average height of Sudanese football players is 177.5 cm, i.e. they are above average values according to accepted anthropological norms. Comparison with literature data (Fig.4) shows that there is a significant difference between 169.8 cm and 181.3 in different nationalities cm. There is a clear trend towards attracting taller players, which is reflected in their selection.

Although the "model" of the optimal physique of the football player is sought, practice shows that players of different heights and weight have high sports results, as a result of a number of other specific factors.

Height values are important when selecting players for individual positions. There is not much variability in our contingent, with the goalkeepers being the tallest (179.3 cm \pm 8.1 cm); after them are the midfielders (178.8 cm \pm 8.7 cm); defenders (177.3 cm \pm 6.59 cm) and forwards (176.3 cm \pm 5.7 cm) are the shortest. However, a relatively large range of height is found, which is most significant (49 cm) in midfielders. This fact has a bearing on the coaching decisions when determining the composition of the teams and planning game tactics.

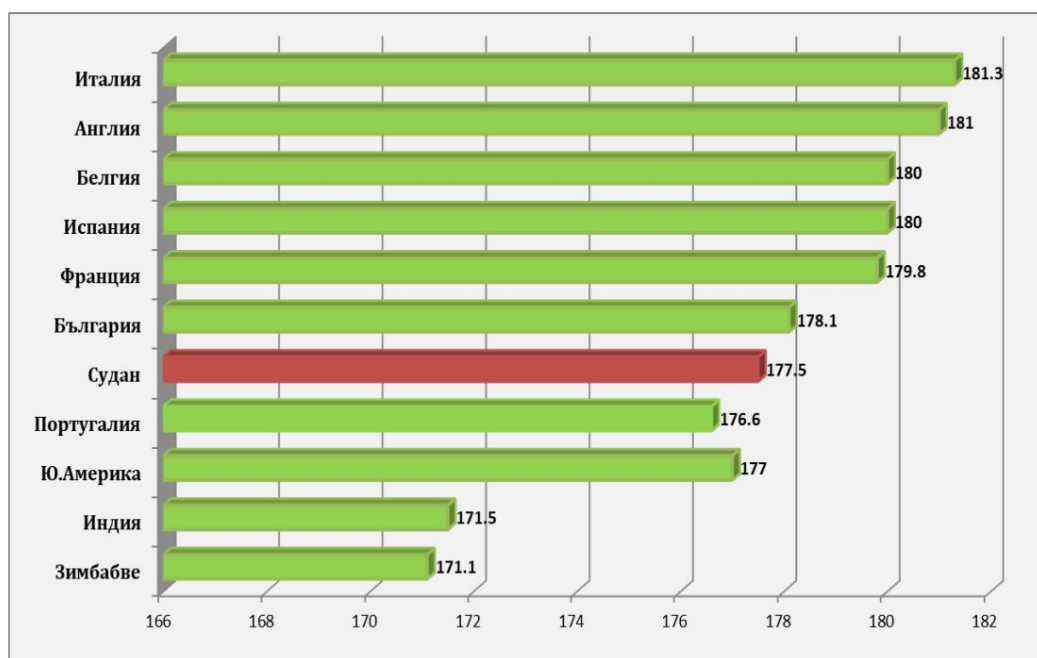


Fig. 4. Height of first-class footballers (cm)

The selection of football players is purposeful, but not strictly fixed. A major role is played by the coach, who, according to his tactics, seeks success in the game through taller, physically fit players or shorter and faster competitors.

It should not be forgotten that height indicators are not only a basic anthropological sign, but an essential factor in the relationships with the individual components of physical capacity. The information in this direction is extremely rich.

Analyzes related to the attribute "Growth"

The growth of football players is generally a prerequisite for professional efficiency, and for specific positions such as goalkeepers central defenders and central forwards it is undoubtedly superiority. The height values of the footballers we studied are listed in table 2.

Table 2**Statistics on the height of Sudanese footballers**

	Goalkeepers	Defenders	Midfielders	Strikers
Arithmetic average	179.3	177.27	178.00	176.26
Standard error	1.822519944 0.71		1.67	0.79
Median	177.5	177.00	179.00	177.00
Fashion	175	171.00	180.00	177.00
Standard deviation	8.150556972 6.59		8.66	5.76
Dispersion	66.43157895 43.49		74.92	33.17
Excess	1.670006524 -0.22		5.12	1.36
Asymmetry	1.148032139 0.19		-1.31	-0.39
I waved	32	34.00	49.00	176.3
Min.	167	163.00	148.00	160.00
Max.	199	197.00	197.00	190.00
Amount	3586	15245.00	4806.00	9342.00
Number	20	86	43	53

The analyzes give reasons to indicate that the average height varies from 179.3 cm for goalkeepers to 175.30 cm for forwards.

Regarding the reliability of the observed differences in the established quantitative values, attention should be paid to the data systematized in Table 3.

Table 3

indicator	Goalkeepers			Midfielders			Difference Statistical				rbs
	n1	\bar{y}_1	S1	n2	\bar{y}_2	S2	d	Cohen d	significance	P(t)	
indicator 20	179.3	8.2	43	178.0	8.7	1.300	0.16		0.52	39.56	0.078

Their analyzes lead to the conclusions that the observed differences between the height of goalkeepers and midfielders are not reliable. IN the same direction is also the comparative analyzes between the quantitative ones

values of the sign in the goalkeepers and another in those studied by us groups of football players strikers (table No. 4). However, the observed differences in this case are credible.

Table 4

indicator	Goalkeepers			Strikers			Difference		Statistical		rbs
	n1	\bar{y}_1	S1	n2	\bar{y}_2	S2	d	Cohen d	significance	P(t)	
indicator 20	179.3	8.2	69	176.3	5.4	3.2	13	0.51	2.06	95.80	0.216

The continuation of the comparative analyzes regarding "height" show that between defenders and forwards the observed quantitative differences are not reliable (values of P (t) - 76.65 i.e. < 95% and Sohen's coefficient is 0.19, i.e. < of 0.2). They are also not reliable in comparisons between defenders and midfielders (values p P (t) -35.76, i.e. < 95% and Sohen's coefficient is 0.10, i.e. < of 0.2), and also between the studied midfielders and forwards (values of P (t) -80.29 i.e. < 95%

The established facts lead to the conclusion that taller athletes are selected as goalkeepers in the football system in Sudan. For all other groups of football players, "height" is not a feature that is taken into account when choosing their playing position.

Weight

Along with height, body mass is the main indicator for evaluating a person's morphological features. In sports the significance of this sign is great given the dependences with physical capacity and the influence of weight on sports the technical results.

Weight information is multifaceted and related to the specificity of strategy and tactics, specifically in the soccer game (Fig. 5).

The average weight of Sudanese football players is 69.7 kg, which values are "below average" for the found height of 177.5 cm.

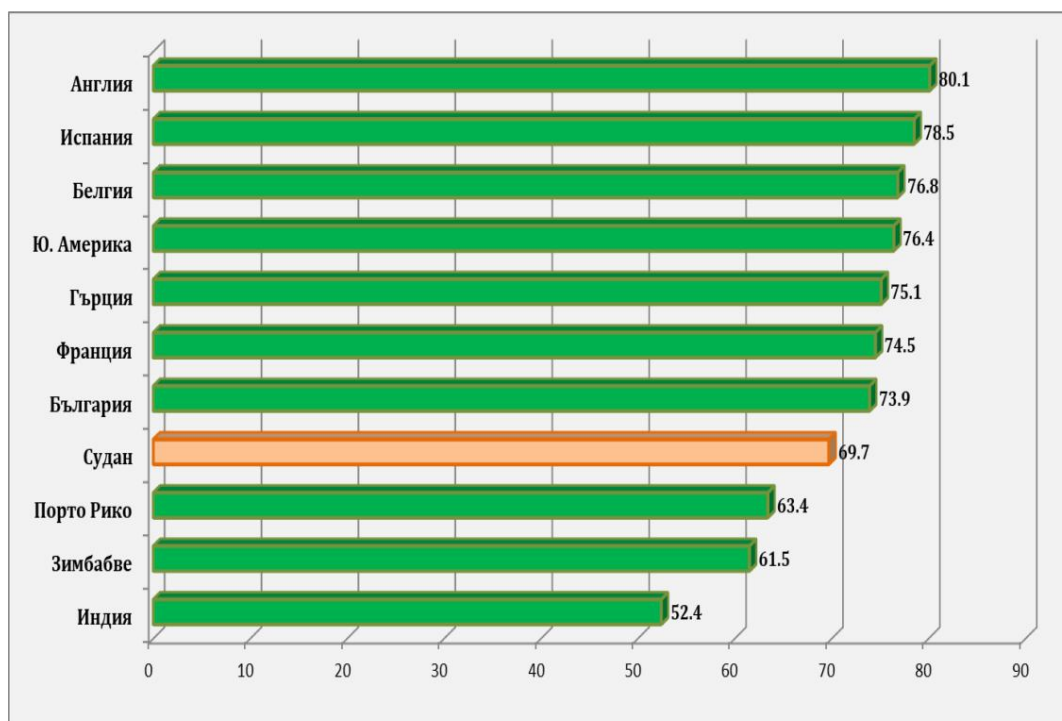


Fig. 5. Weight of first class football players (kg)

The studied Sudanese footballers (by posts) weighed – goalkeepers 72.13 kg; defenders – 69.4 kg; midfielders 69.1 kg; strikers 68.2 kg. The stated uniformity of the players would make it difficult for any coach, since only the goalkeepers have a larger mass, while for the players from the other positions there is no significant difference.

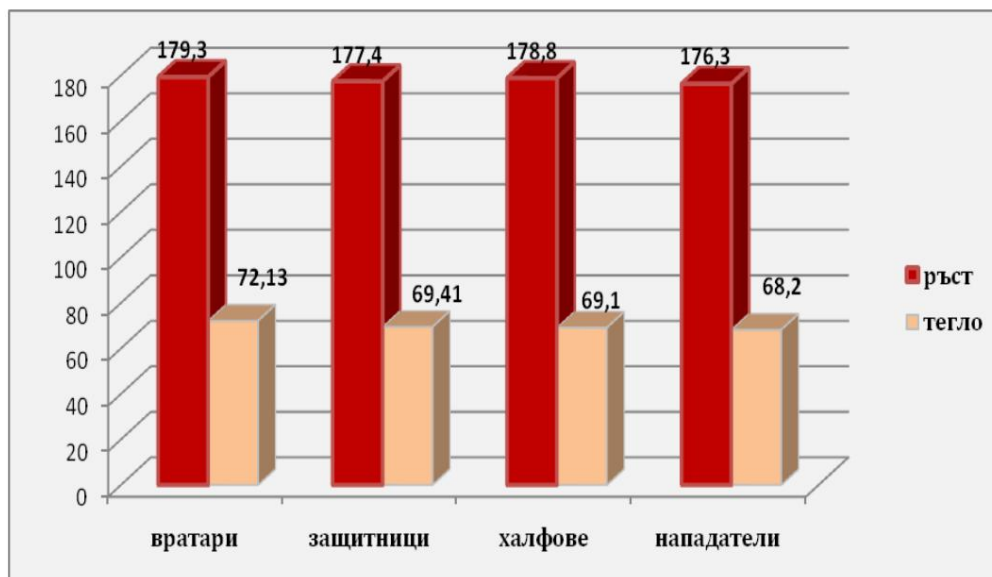


Fig. 6. Height and weight of Sudanese football players by playing positions

In view of the complex perception of the two main signs of the body structure - height and weight on the table. 5 and fig. 6 we present the results obtained by us for the investigated football players.

Table 5

Height and weight of Sudanese football players

Post	Height (cm)		Weight (kg)	
	\bar{y}	SD	\bar{y}	SD
Goalkeepers	179.3	± 8.1	72.13	± 7.5
Defenders	177.4	± 6.59	69.41	± 6.1
Midfielders	178.8	± 8.7	69.1	± 4.9
Strikers	176.3	± 5.7	68.2	± 6.1
Average values	177.5	± 7.1	69.7	± 5.3

We accept that for the better visualization of the data we have also made a graphic image (Fig. 6).

Analyzes related to the attribute "Body weight"

Body weight is the second major trait, the characteristics of which are determined by a variety of factors such as heredity, nutrition, physical activity, eco-sensitivity and

so called its changes in the studied Sudanese football players are summarized in Table 19. It can be seen that the values change in a small range - from 68.20 kg to 69.41 kg in all studied groups except for the "goalkeepers", where the average values are more tall -72.125 kg.

Table 6**Weight statistics of Sudanese football players**

	Goalkeepers	Defenders	Midfielders	Strikers
Arithmetic average	72,125	69.41	69.06	68.20
Standard error	1.692816	0.66	0.94	0.85
Median	69.5	68.00	69.00	67.00
Fashion	68	63.00	65.00	65.00
Standard deviation 7.570502		6,10	4.89	6.16
Dispersion	57.3125	37.25	23.93	37.94
Excess	-0.72136	-0.82	-0.45	0.41
Asymmetry	0.437128	0.38	0.65	0.67
I waved	28	27.00	16.50	28.00
Min.	60	57.00	62.50	56.00
Max.	88	84.00	79	84
Amount	1442.5	5969.50	1864.50	3614.50
Number	20	86	43	5

The reliability of the observed differences is confirmed only in a comparative analysis of the already mentioned group of footballers. The proof is the values of $P(t) > 95\%$ and the Sohen coefficient is 0.10, i.e. $>$ from 0.5.

In the comparative analyzes with another of the groups of football players studied - midfielders. The differences found are not reliable (values of $P(t) - 90.15$ i.e. $< 95\%$ and Sohen's coefficient is 0.49 i.e. $<$ of 0.5).

The following comparative analyzes carried out by us, but regarding the attribute "body weight" also do not form statistically reliable differences. Between football players

"defenders" and football players "forwards" the observed quantitative differences are respectively values of $P(t) - 83.60$ i.e. $< 95\%$ and Sohen's coefficient is 0.23 , i.e. < 0.5 . They are also not reliable in the comparisons between "defenders" and "midfielders" - the values of $P(t) - 21.78$ i.e. $< 95\%$ and the Sohen coefficient is 0.06 i.e. < 0.2 , and also and between the investigated "xalphas" and "attackers" (values of $P(t) - 56.50$ i.e. $< 95\%$ and Sohen coefficient 0.18 i.e. < 0.2).

We accept the observed results of the comparisons as logically explainable facts, arising to a large extent from the dependencies established in the previous section in relation to the attribute "height". Footballers "goalkeepers" have a pronounced advantage in height, and that's it conserves in terms of their overall body structure.

In the auto-reference, we do not comment on the differences with the other morphological signs, analyzing those related to the football game.

Body tours

Chest

The main body circumference is the chest circumference, which along with height and weight gives a general idea of a person's physical development. It is determined by the circumference of the chest, the muscles of the back and chest, as well as the subcutaneous fat in this area. With a fam a stipulation can be assumed that the position during inhalation and exhalation informs about some functional characteristics.

The average values of this feature in Sudanese football players is $92.3 \text{ cm} \pm 4.95 \text{ cm}$ (table 7). The largest chest circumference is for goalkeepers ($94.13 \text{ cm} \pm 5.2 \text{ cm}$) and the smallest for midfielders ($90.3 \text{ cm} \pm 3.13 \text{ cm}$), which represent too compact a group. We

measured the circumferences of the waist and hips with a view to following orientation for fat deposition in the abdominal area.

Table 7

Post	Corpse tours					
	Chest Circumference		Waist (cm)		Hip Circumference	
	ȳ	SD	ȳ	SD	ȳ	SD
Goalkeepers	94.13	5.2	82.4	5.9	96.4	4.5
Defenders	92.8	5.8	78.5	5.1	94.6	4.8
Midfielders	90.3	3.13	77.5	4.8	91.0	4.9
Forwards	91.9	4.8	78.6	4.7	92.5	5.6
Average values	92.3	4.32	79.2	5.2	93.6	4.5

In general, we can assume that Sudanese football players are characterized by an elongated body shape.

Rounds of the upper limbs

Soccer is a lower extremity loading sport, but the characteristics of the upper extremity shape the morphological human status and deserve comment.

Arm circumference bent

Its characteristic is particularly significant not only in absolute terms, but also as part of the somatotypological examination and determination of body mass composition.

The average feature is 30.2 cm. (Table 8) The comparison with the Bulgarian population (32.9 cm) shows lower values, especially for midfielders (28.7 cm), forwards (29.9 cm) and defenders (30.1 cm). Only goalkeepers are distinguished by higher indicators (32.1 cm) - almost identical to the literature data.

Arm circumference relaxed

We found a circumference of 27.4 cm for the entire contingent, which is about 2 cm smaller than the standard data for Bulgarians (29.7 cm).

The analysis by playing positions is of the same nature as the information discussed above.

Forearm circumference

The measurements of the indicated circumference are 24.8 cm and we found no information on other populations to use for comparative analysis. It shows a similar trend by positions, namely goalkeepers (26.2 cm) have the largest circumferences (table 8).

Table 8

Rounds of the upper limbs

Post	Tour of arm bent (cm)		Tour of arm relaxed (cm)		Tour of forearm (cm)	
	\bar{y}	SD	\bar{y}	SD	\bar{y}	SD
Goalkeepers	32.1	1.8	28.9	1.9	26.2	1.7
Defenders	30.1	2,3	27.4	1.8	24.7	1.8
Midfielders	28.7	1.7	25.8	1,2	23.9	1.5
Strikers	29.9	2,3	27.3	2,3	24.8	1.4
Average values	30.2	2.0	27.4	1.8	24.8	1.8

Tours of the lower limbs

Circumferences of the lower limbs characterize the development of musculature that plays a major role in the game of football. Numerous studies prove its role in the strength and explosiveness of movements, speed of movements, coordination of physical efforts, etc.

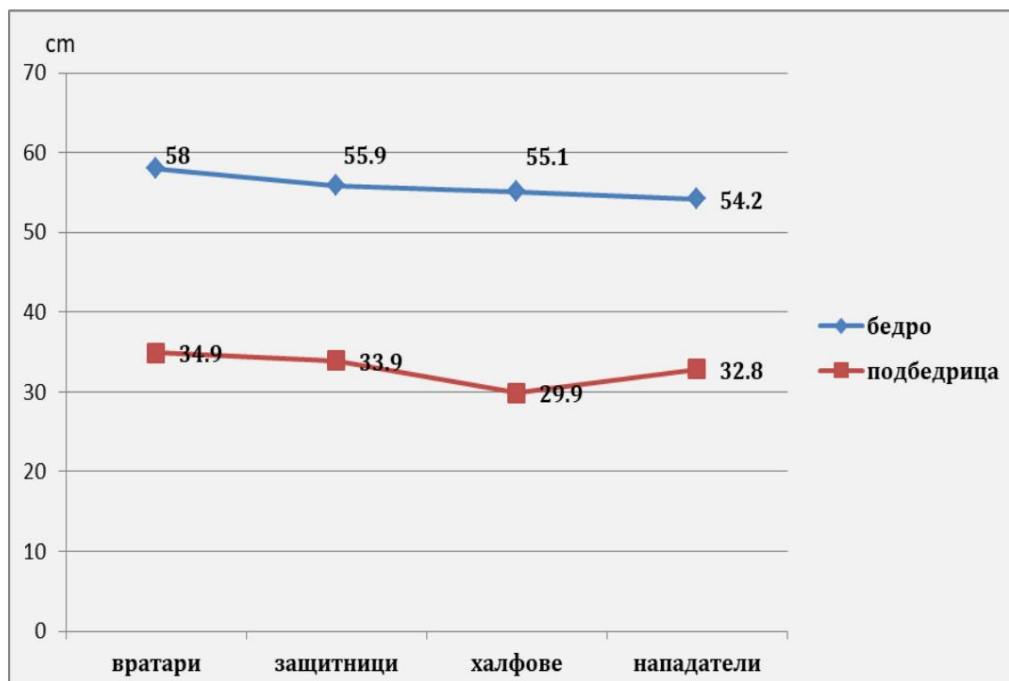


Fig. 7. Circumferences of the lower limbs (cm) of Sudanese football players by playing positions

Hip circumference

The analysis of the results found average values of 56.3 cm in the subjects we examined (table 9). They are higher than those of the Bulgarian population, which are 53.8 cm. Goalkeepers (58 cm) have the largest dimensions, with a significant difference from forwards (56.2 cm), defenders (55.9 cm) and midfielders (55.1 cm).

Table 9

Tours of the lower limbs				
Post	Hip circumference (cm)		Tour of lower leg (cm)	
	\bar{y}	SD	\bar{y}	SD
Goalkeepers	58.0	2.6	34.9	3.2
Defenders	55.9	3.1	33.9	3.0
Midfielders	55.1	4.1	29.8	2.9
Forwards	56.2	5.2	32.8	3.1
Average values	56.3	3.8	32.4	3.0

It is necessary to note that the measurements of the standard circumferences of the lower limbs give an indirect idea of the development of the musculature. The information largely is relative, given the deposition of adipose tissue in these topical areas.

Table 10**Thigh Circumference Statistics of Sudanese Football Players**

	Goalkeepers	Defenders	Midfielders	Strikers
Arithmetic average	58	55.98	56.53703704	56.24
Standard error	0.599342	0.33	0.456767665	0.72
Median	58	56.00	57	57.00
Fashion	57	55.00	57	57.00
Standard deviation	2.680338	3.09	2.373434407	5.22
Dispersion	7.184211	9.58	5.633190883	27.22
Excess	0.253982	1.49	4.92360356	18.94
Asymmetry	0.473762	0.31	0.150603899	-3.28
I waved	10.5	18.00	14	41.00
Min.	54	48.00	50	27.00
Max.	64.5	66.00	64	68.00
Amount	1160	4814.65	1526.5	2980.50
Number	20	86	43	53

Table 10 summarizes data on the quantitative values of hip circumference in the Sudanese football players we studied.

It can be seen that the values vary from 55.98 \pm 0.33 cm for the defenders to 58.00 \pm 0.59 cm for the goalkeepers, which compared to those published for the Bulgarian people – 53.8 cm are higher, which is an expression of motor activity in football.

Normative data for the assessment of hip circumference have been developed (Table 10-A).

Table 10-A

Normative chart for hip assessment

Rating	Limits %	
Very high	Over 62.35	2.28
High	From 59.4 to 62.35	13.59
Above Average	From 57.92 to 59.39	14.99
Average Below	From 54.96 to 57.91	38,29
Average Low	From 53.48 to 54.95	14.99
	From 50.51 to 53.47	13.59
Very low	Under 50.51	2.28

Analyzes related to the feature "thigh circumference"

The morphological and functional status of the lower limbs is logically one of the priority indicators, the condition of which should always be characterized, since they are leading factors in relation to the sports and competitive performance of every football player.

As for the statistical reliability of the established differences in the quantitative values of hip circumferences in different groups of football players, there are reasons to indicate that only in one of the cases - in comparisons between "goalkeepers" and "midfielders" they are reliable. The values of Sohen's coefficient are 0.57, and of P(t) 94.59. When comparing all other groups of football players, no such differences are found.

Lower leg circumference

Numerous studies show that the structure and qualities of the lower leg in football skills play a very large role in the successful performance of the game (Fig.7).

Our results found mean values of 32.4 cm. They range from 34.9 cm for goalkeepers, followed by defenders 33.9 cm, forwards 32.8 cm and midfielders 29.9 cm.

Analyzes related to the trait "lower leg circumference"

The table shows systematized data on the status of the symptom "Circumference of the lower leg" in the different groups of studied Sudanese football players. Varying from 29.91 \pm 0.56 cm for "midfielders" to 34.92 \pm 0.71 cm for "goalkeepers", this circumference is also a function of active and specific motor activity in football and should be expected to be of high values.

Table 11

Lower leg circumference statistics of Sudanese football players

	Goalkeepers	Defenders	Midfielders	Strikers
Arithmetic average	34.925	33.88	29.91	32.82
Standard error	0.712921	0.32	0.56	0.43
Median	35.5	34.00	29.00	33.00
Fashion	37	34.00	29.00	30.00
Standard deviation	3.18828	3.01	2.89	3.13
Dispersion	10.16513	9.07	8.35	9.82
Excess	-0.62073	1.45	1.61	-1.02
Asymmetry	-0.3729	-0.51	1.07	0.17
I waved	11	17.00	13.00	13.00
Min.	29	24.00	25.00	27.00
Max.	40	41.00	38.00	40.00
Amount	698.5	2914.00	807.50	1739.50
Number	20	86	43	53

Diameters of limbs

Determination of body bone diameters is essential for practice in order to draw conclusions about features

of the structure of the individual. In sports practice, the bone mass is rarely differentiated, although there are methods by measuring the diameters of the limbs. During routine activity

use some basic signs related to shoulder width

girdle, thorax, pelvic girdle, limb bones that allow conclusions about the "frame of the body".

In our study, we measure biepicondylar knee and elbow diameters in order to determine the somatotype.

Table 12

Biepicondylar diameter of os humeri and os femuri				
Post	os humeri		os femoris	
	ȳ	SD	ȳ	SD
Goalkeepers	6.63	0.93	7.25	0.95
Defenders	6.41	0.73	7.58	0.75
Midfielders	6.44	0.60	7.56	0.54
Strikers	6.48	0.58	7.64	0.53
Average values	6.50	0.71	7.50	0.69

The dimensions of the bone diameters of the limbs (Table 12) are small bones, which indicates that it is a gracile bone structure that does not show significant variability in football players from different game positions.

Analyzes related to the feature "biepicondylar diameter of the femur"

The biepicondylar diameters of the lower limbs, together with those of the upper ones, carry information about the massiveness of the bony skeleton. Since the biepicondylar diameter values of the os femuri are of priority importance for soccer players, we provide

the same in a table. The dimensions change from 7.79 \pm 0.09 cm for midfielders to 7.25 \pm 0.21 cm for goalkeepers.

Table 12-A

**Biepicondylar femur diameter statistics
of Sudanese footballers**

	Goalkeepers	Defenders	Midfielders	Strikers
Arithmetic average	7.25	7.58	7.79	7.64
Standard error	0.214660074	0.08	0.09250138	0.07
Median	7.5	7.70	7,8	7.70
Fashion	7.5	7.50	7,8	7.80
Standard deviation	0.959989035	0.75	0.480651268	0.53
Dispersion	0.921578947	0.56	0.231025641	0.28
Excess	-0.64723044	1.23	5.60491283	0.43
Asymmetry	-0.257990446	-0.68	-1.284106771	-0.22
I waved	3,4	4.00	2.7	2.20
Min.	5.5	5.40	6.1	6.50
Max.	8,9	9.40	8.8	8.70
Amount	145	652.10	210.3	405.00
Number	20	86	43	53.00

Summarizing the results related to the signs "thigh circumference", "lower leg circumference" and "biepicondylar diameter of os femuri", we logically come to the conclusion that the population of studied Sudanese football players can be characterized as homogeneous in terms of the morpho-functional status of the musculoskeletal system of the lower limbs.

Skin folds

The measurement of skin folds provides a variety of anthropological information about the total amount of subcutaneous fat tissue, its topical distribution in certain areas, their

symmetry, active body mass, etc. These indicators are basic for somatotypical diagnosis.

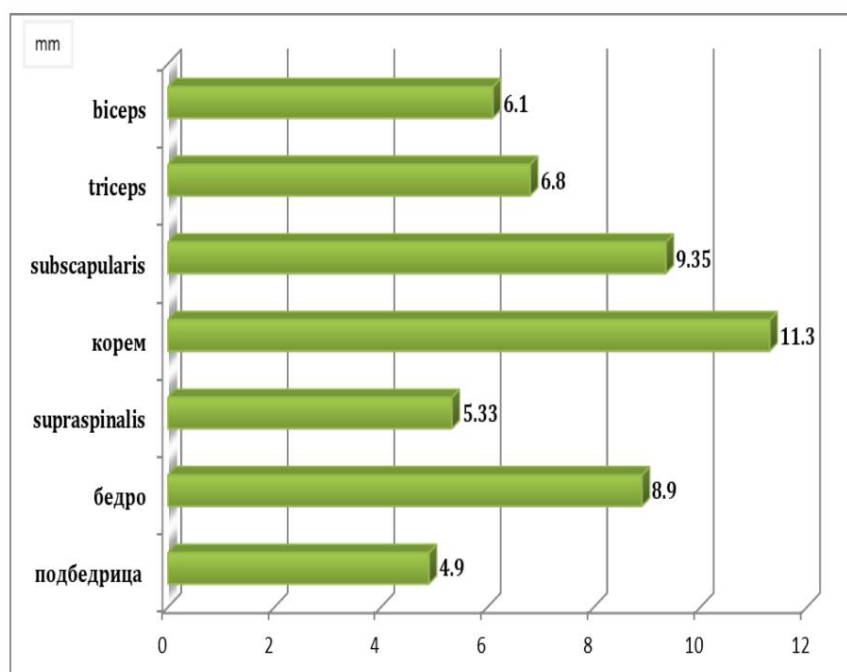


Fig. 8. Skin folds of Sudanese goalkeepers (mm)

Their total sum was calculated, with the highest values for goalkeepers (46.7 mm), with a small difference between defenders (38.1 mm), forwards (41.7 mm) and the smallest for midfielders (37.9 mm). The information obtained is largely indicative, but however, subcutaneous fat can be assumed to have low values. It is most pronounced in goalkeepers and weakest in midfielders (Fig. 8).

Topical distribution of subcutaneous fat

Issues related to the distribution of subcutaneous adipose tissue (SAT) on the body and limbs of athletes are rarely discussed in the literature. From a clinical point of view, the topical deposition of PMT has been extensively studied in the sense that its increase in the upper body and especially the abdomen is associated with a number of cardiovascular diseases.

Our results show that the skin folds of the lower extremities are relatively small in size. This gives us reason to assume that the preferential loading of the lower limbs of football players is the main factor for the specific distribution of subcutaneous fat.

BODY COMPOSITION

Body fat percentage

Calculating your body fat percentage is the first step in determining body composition. This sign is the widest used, taking into account possibilities for comparison on an individual level and with different population groups (Fig. 10).

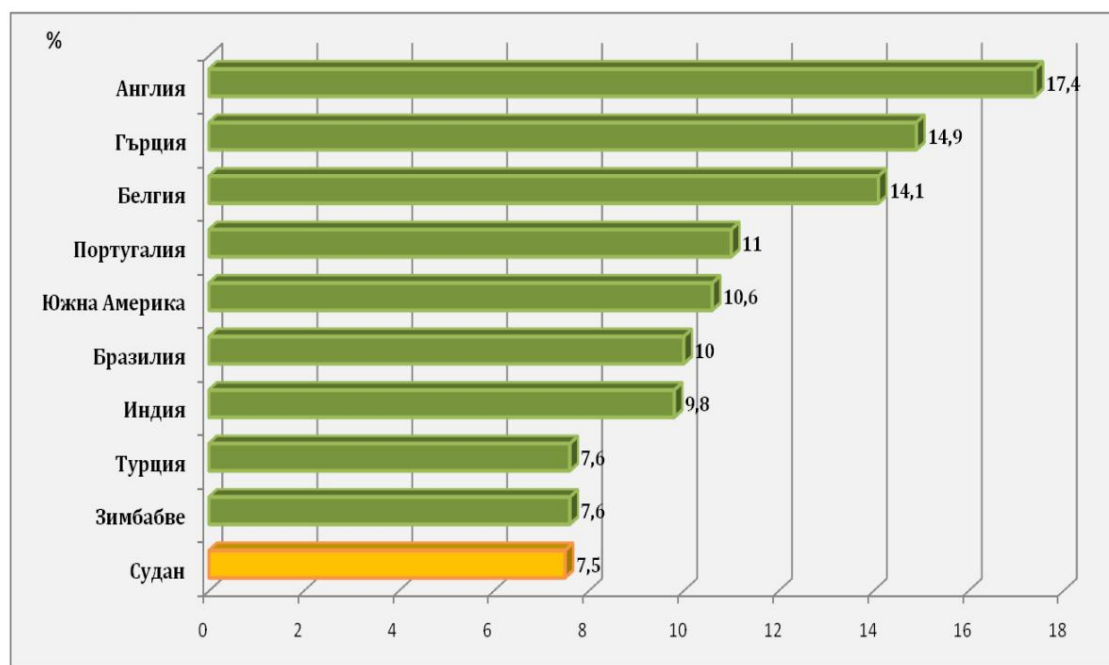


Fig. 10. Percentage of adipose tissue of first-class football players (kg)

It is accepted that the normative values for non-sporting men is 10-20%. In athletes, these values are too variable (5-13%).

Muscle mass

Body composition information necessarily includes an analysis of the total amount of muscle mass and the components that make it up characterize.

Absolute amount of muscle mass (ACMM)

This indicator is particularly important, informing about the development of the muscles in the human body. In non-sporting men there are average values of about 35% of body mass, and in athletes they reach 50-55%. The results obtained by us are presented in the table. 13. They found a relatively normal amount of muscle mass.

According to data of Butts, NK (1985) the characteristics of mm vastus lateralis and gastrocnemius have significantly higher values than those in non-athletes.

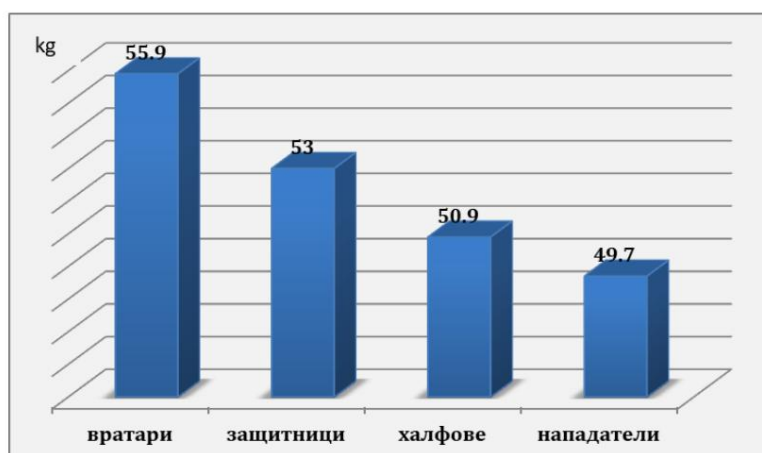


Fig. 13. Absolute amount of muscle mass (kg)

Our results for the competitors of the different games pots are presented both tabularly (Table 13) and by figure 13, because of their biological significance.

Table 13**Muscle mass and its components**

Post	MOP (cm)	MOB (cm)	ACMM (kg)
	34.9	55.2	55.9
Goalkeepers	33.9	54.6	53.0
Defenders	29.8	53.5	50.9
Midfielders	32.8	53.4	49.7
Forwards Average values	32.9	54.1	52.4

Arm circumference (AM) and thigh (AM)

IOM represents the relaxed arm without the subcutaneous tissue adipose tissue, which is 28.6 cm. It is the largest among goalkeepers.

Thigh muscle circumference (TMC) does not show significant differences between Sudanese players from different positions (Fig. 11). However, the sizes are most pronounced in the goalkeepers - 55.2 cm for the muscle thigh circumference (Table 13).

**Fig. 11. Thigh muscle circumference of Sudanese football players (cm)**

Bell, W. (1985) presents highest values in goalkeepers and defenders.

Lower leg muscle circumference (CLC) shows the highest values in goalkeepers, with midfielders having the smallest dimensions (Fig. 12).

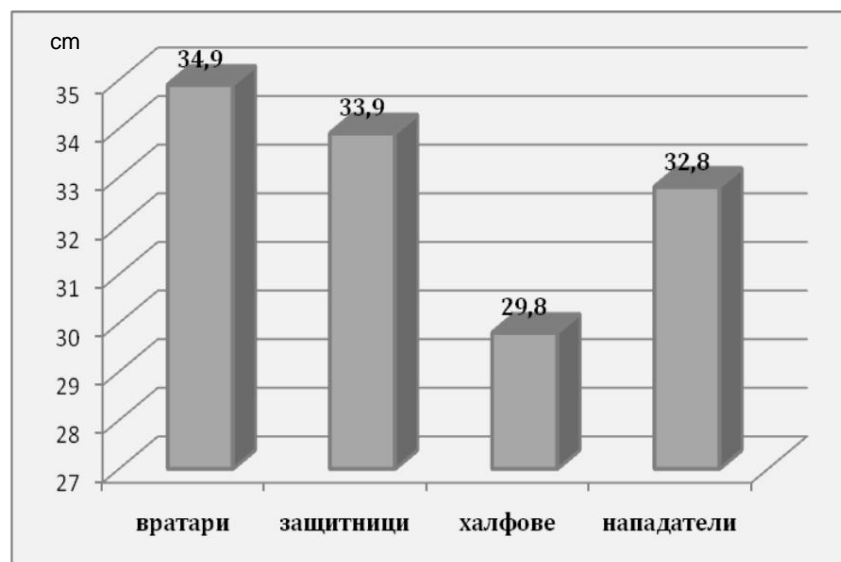


Fig. 12. Lower leg muscle circumference of Sudanese soccer players (cm)

DETERMINATION OF THE SOMATOTYPE

The somatotype gives a complex characteristic of the form and body structure, while body composition data can provide differentiated estimates for the different tissues of the human organism.

The **analysis** of our results shows that the endomorphic component has low values (2.0 CE), i.e. low fat is present postponement, which from the point of view of the game is a relatively positive sign, since the greater amount of fat tissue has a negative effect on the physical performance of the athlete.

The mesomorphic component characterizing the relative musculoskeletal development is too small – 2.63 CE. Its specificity is determined by the development of the muscle mass and the features of the bone structure. Most likely the ethnic characteristics of the Sudanese players regarding the skeletal system

are the ones that have a determining influence with their low values for this essential morphological feature.

The ectomorphic component is significantly larger - 3.3 CE, which is an expression of well-expressed relative linearity of the body and its segments. This feature is observed in the representatives of the black race. It should not be forgotten that for the formation of the final

assessment plays a role and attitude growth $\sqrt[3]{\text{weight.}}$

The obtained results for the Sudanese athletes are presented in table 14 and fig. 14.

Table 14

Somatotype of Sudanese football players by playing positions

Posts	Endomorphy	Mesomorphy	Ectomorphy
Goalkeepers	2.24	2.49	2.95
Defenders	1.88	2.48	3.01
Midfielders	2.08	3.25	3.19
Strikers	1.83	2.33	2.98
Average	2.0	2.63	3.03

The results found similar endomorphism with low values for all competitors, which is conditionally accepted as positive result.

The mesomorphic component is an expression of relative muscularity skeletal development and shows reliably higher data only in midfielders, i.e. 3.25 CE. For the rest of the players, the results are uniform and with low values.

Ectomorphy in the whole contingent is well expressed, as no significant differences are found between players from different posts.

The total somatotype can be differentiated as mesomorph-ectomorph, in which the ectomorphic component is strongest

expressed in contrast to the second and first. In fig. 14 shows the summary somatography.

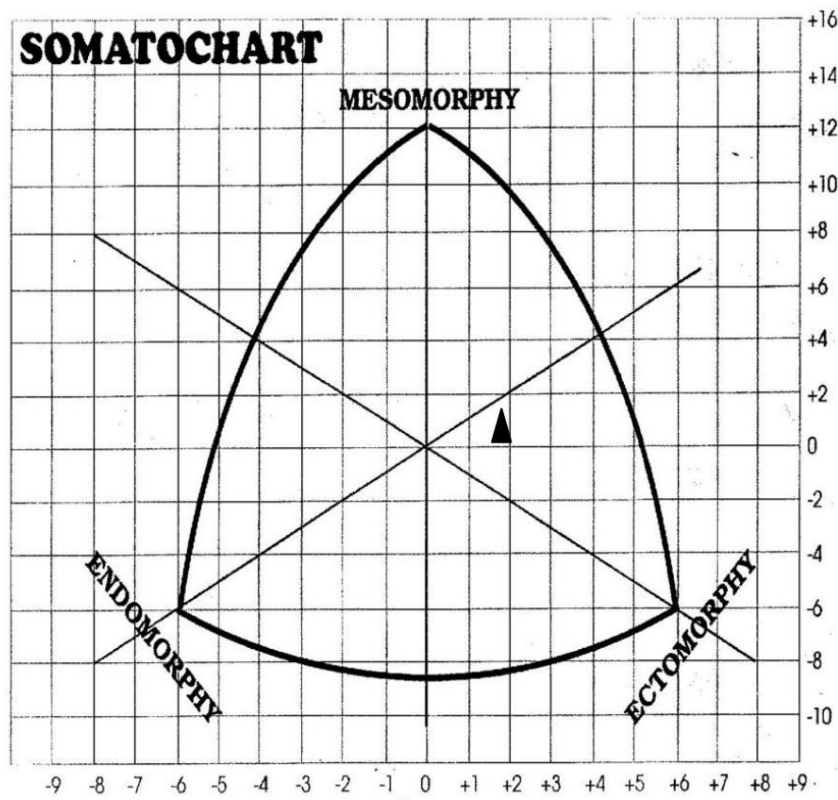


Fig. 14

It does not reflect the graphic images of the individual posts, which almost overlap. The final conclusion is that the somatotype of Sudanese football players characterizes a physique with a weak development of subcutaneous adipose tissue, low musculoskeletal development and marked elongation of body segments.

Comparison with other authors' publications shows significant differences mainly between goalkeepers and other players, given the the significant mesomorphy in the former.

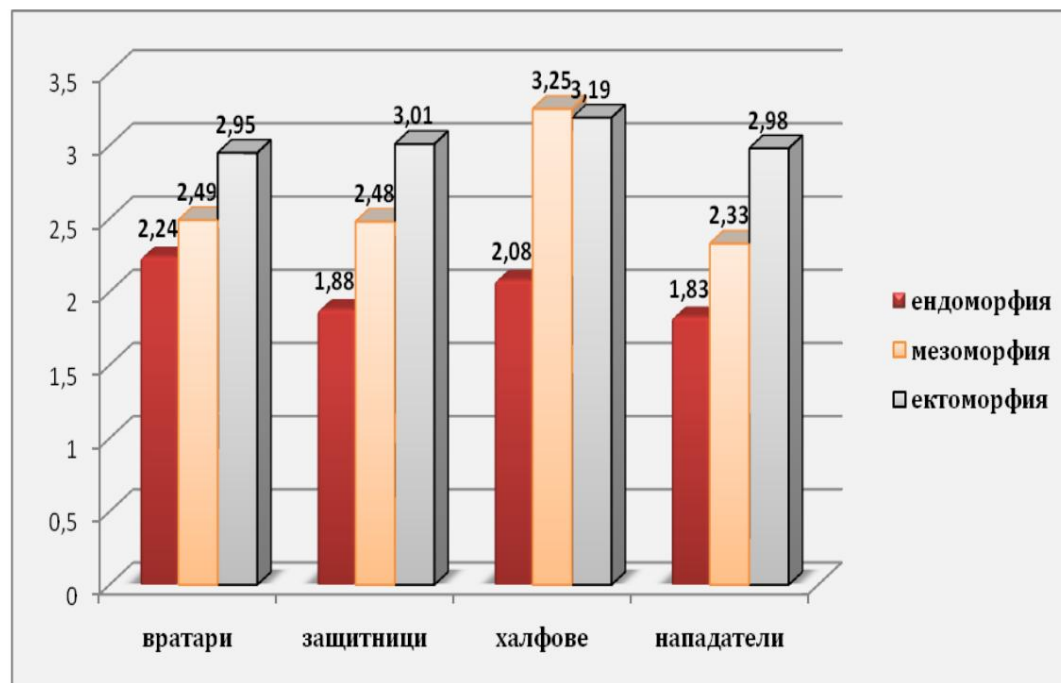


Fig. 15. Somatotype of Sudanese football players by playing positions

Our conclusion regarding the somatotype of the Sudanese football players we studied is that their model does not correspond to the trends of the modern game, which requires an adequate concept in this regard.

The present comparative analysis is a necessary continuation of the discussions made in the previous section, since the established differences in the quantitative values of the morphological signs of the different groups of studied Sudanese football players are formed over time based on the influence of

a number of genetic, social, environmental, behavioral, etc.

factors. Last but not least, in the process of sports-training and competitive activity, unintentional or purposeful selection takes place, which also affects the presentation of the morphological

status with a specific group of athletes.

It is relevant to establish to what extent the observed **differences** between the quantitative values of differentiated main signs are reliable and characterize individual characteristics of the individual group of football players - goalkeepers, defenders,

midfielders, forwards, or are these random differences that really don't exist throughout the general population.

RELATIONSHIP BETWEEN THE STUDYING MORPHOLOGICAL INDICATORS

The established condition, variability and reliability of the differences in basic morphofunctional indicators are supplemented by analysis of the interrelationships between them.

We dwell first on the interdependencies between the **8** main indicators presented.

The values of the indicators are significant at $\alpha = 0.05$ and give reasons to indicate that "Height", as the main feature, has an explainable high correlation only with the indicator "Weight" ($r = 0.62$).

Table 15
Correlation coefficients of basic anthropometric indicators

	Height	Weight	Circumference	Vol.m.freedom	City of Ob.	Love. thigh	Rev. subb.	Beep. diam.	Beep. diam.os femuri
	1.	2.	5.2.	5.1.	3.	4.	6.	7.	8.
1.	1								
2.	0.62	1							
5.2.	0.20	0.47	1						
5.1.	0.10	0.31	0.86	1					
3.	0.20	0.33	0.56	0.54	1				
4.	0.22	0.41	0.51	0.43	0.57	1			
6.	0.17	0.37	0.49	0.37	0.41	0.36	1		
7.	0.06	0.13	0.57	0.53	0.45	0.44	0.03	1	
8.	0.21	0.26	0.06	0.03	0.15	0.04	0.35	-0.14	1

In relation to "Weight", in addition to the above mentioned characteristics, not high ($r > 0.3$), but significant

correlation dependences with 5 more signs - chest circumference, waist circumference, arm circumference and hip circumference. We find it illogical that there is no dependence with the "lower leg circumference" indicator when proven in the literature

multiple presence of positive correlations as well.

"Chest girth" is the third indicator, the changes of which were characterized above by us. In the present analysis it can be pointed out that this trait related to total body dimensions and high level of functional fitness significantly and reliably correlates not only with the trait "weight".

All such established dependencies are logically explainable and give reasons again for the conclusion that the studied Sudanese football players actually have a homogeneous morphological status. This peculiar community of body structures is also an objective prerequisite for a successful sports-competitive performance in football, where universality is no less significant than specific performance in different playing positions.

"Thigh circumference" and "biepicondylar diameter of os femuri" are indicators of particular importance for football, since the ratio of work between upper and lower limbs is emphasized as a priority for the latter. In our case, significant correlations were also identified, as between the two indicators ($r = 0.35$) and all others (without height) with "Thigh Circumference". "Lower Leg Circumference" was significantly associated with four "Circumferences of indicators - "chest circumference", "waist circumference", arm relaxed", "arm circumference bent".

The expansion of our research activity regarding the interrelationships between the studied morphological indicators is substantially complemented by the complete characterization of the separate correlation coefficients between the quantitative values of all **indicators**. The systematization of the data is done and presented in Table 16.

Table 16

Correlational dependences between the studied anthropometric indicators

[illegible]

Lower leg circumference	0.06	0.26	0.15	0.57	0.53	0.37	0.45	0.44	0.31	0.03			1							
Bicep skinfold	0.02	0.12	0.13	0.16	0.13	0.11	0.09	0.16	0.08	0.03	0.16			1						
Skin fold triceps	0.03	0.16	0.10	0.37	0.31	0.29	0.23	0.34	0.14	0.15	0.34	0.37			1					
Subscapular skin fold	-0.03	0.08	0.11	0.35	0.41	0.27	0.19	0.19	-0.03	0.09	0.30	0.19	0.50			1				
Skin fold – abdominal	0.00	0.15	0.10	0.31	0.39	0.27	0.37	0.25	0.14	0.18	0.38	0.11	0.38	0.60			1			
Skin fold supraspinal	0.02	0.07	-0.07	0.26	0.26	0.23	0.02	0.16	0.02	-0.04	0.24	0.18	0.42	0.33			0.13	1		
Skin fold – thigh	-0.14	-0.15	-0.17	0.03	0.14	-0.01	0.23	0.05	0.08	0.06	0.22	0.05	0.30	0.36			0.52	0.11	1	
Skin fold – lower leg	0.02	0.19	-0.04	0.05	0.04	0.10	0.05	0.11			-0.02	-0.02	-0.10	0.18	0.23	0.27	0.24	0.13	0.16	1
Biepicondylar diameter of the humerus bone	0.31	0.13	-0.03	-0.01	-0.07	0.11	0.03	0.00	-0.01	-0.08	-0.22	0.06	-0.09	-0.14	-0.13	-0.06	0.14	0.09		1
Biepicondylar femoral diameter bone	0.21	0.26	0.09	0.06	0.03	0.10	0.15	0.04	0.15	0.35	-0.14	-0.06	-0.16	-0.12	-0.01	-0.18	-0.03	0.14	0.28	1

CONCLUSION

The applied research program brings together methods for characterization of physical development, body mass composition and somatotype, allowing for more detailed information on the physique of Sudanese football players.

The theoretical essence of the mentioned problem is a priori known, but the lack of anthropological research on athletes in the Republic of Sudan necessitate the creation of model characteristics adequate to their ethnic characteristics.

From the positions of the applied value for the dependence between bodybuilding and sports realization these indicators are established of physical development, which are essential for good physical fitness of the tested athletes.

We are confident that our results will be appreciated by dignity in the Republic of Sudan given their scientific practical significance.

Based on the conducted morphological study of sudanese footballers and intermediate grades can be done the following main integral conclusions and recommendations:

CONCLUSIONS

1. The analysis of the bibliographic material establishes that the structural features of football players show a large diversity, determined by their belonging to different ethnicities, natural-geographical conditions and specific way of life.

2. Sudanese footballers are above average height, average weight, moderate development of body circumferences, with low values for the bone diameters of the limbs informing about gracile bone structure.

3. Body mass composition analysis found an average level of muscle mass development and very low values for the level of adipose tissue (7.5%) and its derivative components.

4. The studied somatotype has the characteristics of a mesomorph ectomorph (2.0 – 2.63 – 3.03) i.e. low endomorphy, too weak pronounced mesomorphy and relatively high ectomorphy. The comparison with the literature data shows significant differences with the somatotype evaluations of leading soccer players from other countries of the world.

5. The comparative analysis of the morphological signs of the Sudanese footballers from different playing positions establishes statistically significant differences mainly between goalkeepers and the rest of the contestants, which necessitates the conclusion of a heterogeneous group individuals in terms of body structure.

6. The conducted correlation analysis reveals the specific interrelationships between individual indicators and confirm

the characteristics related to the morphological status of the contestants.

7. The results show the need for a high level of competence of the coaches for appropriate selection and training programs to form competitors with morphological indicators adequate for football in Sudan.

RECOMMENDATIONS

1. It is necessary for the institutions responsible for sports in Sudan to turn their attention to building a system for the selection of soccer players according to appropriate anthropometric indicators.

2. A group of national and international specialists is needed to develop a program to increase the qualification of sports the pedagogical staff regarding the implementation of adequate primary recruitment and selection of young Sudanese footballers.

3. We recommend to the Football Association of Sudan the establishment of complex methodology for targeted impact on the morphological status of football players as a base for good game qualities.

S P I S K

with the scientific publications in connection with the dissertation work

Muhammad Ali, W. Ya. Development of football in the Republic of Sudan. Sports and Science, 1, 2016.

Toteva, M., Mohamed Ali, W. Ya. Somatotypological characterization of Sudanese soccer players. Medicine and Sports, 3-4, 2019.

Doychev, B., Mohamed Ali, U. Ya. Influence of environmental factors on the body structures of Sudanese football players. Sports and Science, 5-6, 2019.

SCIENTIFIC CONTRIBUTIONS

1. For the first time in the Republic of Sudan, a complex morphological study of a differentiated population group was carried out.
2. For the first time, the body structure of high-class Sudanese football players was characterized and a comparison was made analysis with world leading competitors.
3. The applied research and statistical program is informative and guarantees the reliability of the results at competitors from the individual game positions.
4. The created model anthropometric characteristics for the selection and control of football players playing in different positions optimize the sports performance.
6. The approved practical methodology could be implemented and multiplied for competitors from other sports in the Republic of Sudan, as well as for selected groups of the population.