

Anthropometric features of limbs in volleyball players of different somatotypes

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Abstract. The relevance of determining the anthropometric dimensions of the limbs, which determine the external structure of the human body and have close relationships with the technical and tactical activities of volleyball players, is that morphological characteristics can be the basis for qualified sports selection. The purpose of this study was to determine the differences in the value of anthropometric limb dimensions between volleyball players and girls who did not play sports within the general group and a separate constitutional type. A study was conducted of 108 volleyball players with an average sports experience of 6.361 ± 2.866 years of youthful age (mean age – 18.05 ± 1.39 years). 130 practically healthy girls who did not play sports, of adolescent age (mean age – 17.91 ± 1.49 years) made up the control group. Anthropometry was carried out with certified equipment according to the recommendations of P.P. Shaparenko, somatotyping – by the Carter-Heath method. After determining the constitutional affiliation, volleyball players and non-athletes were divided into four groups: ectomorphic, mesomorphic, ecto-mesomorphic and middle intermediate somatotypes. It was found that all the girth dimensions of the upper and lower extremities and the width of the distal

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epiphyses of the thigh, lower leg, shoulder, and forearm were significantly larger in female athletes than in girls of the control group. The somatotypological approach modified the nature of the previous results: in volleyball players of all somatotypes compared to girls of control groups of the corresponding type of constitution only the widths of epiphyses of the shoulder and forearm were statistically significantly larger; the width of the distal epiphysis of the lower leg was bigger only in sportswomen of the average intermediate somatotype, and the width of the distal epiphysis of the thigh was bigger in sportswomen of the ecto-mesomorphic and average intermediate types; most of the girth dimensions of the limbs were bigger only in sportswomen of the ectomorphic and average intermediate somatotypes. Thus, volleyball players of each constitutional type have their peculiarities of the structure of limbs, which should be taken into account when creating a morphometric profile of volleyball players and taken into account in sports orientation and prognostication

Keywords: anthropometry; upper and lower limbs; constitutional types; volleyball

◆ INTRODUCTION

The level of sports performance in modern volleyball is so high that to achieve it, athletes must have a whole range of different data that must be at the highest level. In particular, B. Kazakhov & D. Allayarov [1] emphasise the importance of individual indicators of technical and tactical activity of volleyball players for the effectiveness of the competitive activity of the whole team. M.F.K. Hammoodi *et al.* [2] note that in addition to technical and tactical training of volleyball players, special physical fitness plays a leading role in their success, as Y. Yakusheva *et al.* [3] note in their work. The team of authors of Lviv State University of Physical Culture [4] do not deny the importance of the functional state of the athlete's body for the full implementation of his/her technical and tactical skills but emphasise that anthropometric parameters can be the basis for characterizing morphological and functional changes in the body of an athlete engaged in game sports. A comprehensive analysis and consideration of the anatomical and physiological features of the body ensures the training of highly qualified athletes because the peculiarities of the external structure of the athlete's body are a prerequisite for the realization of his/her physical capabilities [5]. And the results of the assessment of anthropometric characteristics will allow compiling profiles of elite athletes in certain sports, which can be used as a training bar for beginners. An analysis of the anthropometric profile and constitutional characteristics of female athletes of the Mexican Olympic team engaged in classical and beach volleyball was carried out [6]. To assess the anthropometric profile of volleyball players, a comprehensive study was conducted, which included the determination of total dimensions and individual partial dimensions, in particular the thickness of skin folds, longitudinal, girth and transverse body dimensions [4], and the authors propose to use the results obtained to monitor the level of training of volleyball players.

The markers of sports selection should include constitutional features of an athlete, which are formed under genetic influence and modified by exogenous factors, among which the specificity of sports activity can be the most significant because it polishes the physique of an individual athlete to its needs [7]. The majority of the analysed studies define the features of the somatotypic profile of volleyball players, in particular, S.K. Noutsos *et al.* [8] determined the value of the components of the somatotype according to the Heath-Carter in the adolescent elite of female volleyball players and noted that it is the specificity of the training activity of female athletes that leads to

changes in their body, which are provided by adaptation processes to specific physical activities. Using somatotyping by Heath-Carter C. Poveda-Loor *et al.* confirm [9] that in athletes, the value of somatotype components, especially muscle and fat, clearly demonstrate sexual dimorphism, therefore, to develop model anthropometric characteristics of athletes of a particular sport is necessary to take into account the factor of gender.

Thus, the work of many scientists has proven the fact that indicators of the external structure of the body affect sports performance and must be taken into account when conducting qualified both prognostic selection to select beginners who have the greatest chance of achieving outstanding results, and confirmatory selection – for intra-team specialization or team recruitment. In addition, the study of anthropometric features of female athletes is of theoretical importance for understanding the general human morphology. However, few studies examine this issue with regard to the ethno-territorial factor. In addition, there is no data on the peculiarities of the structure of the limbs in female athletes who play volleyball professionally but differ in somatotypic characteristics. The aim of the study was to identify the peculiarities of the girth and transverse dimensions of the upper and lower limbs in high-skilled youth volleyball players of different constitutional types.

◆ MATERIALS AND METHODS

From 2018 to 2023, a study was conducted of 147 youth volleyball players (16 to 20 years old) who had been playing the sport for at least 3 years and had achieved high sportsmanship. The athletes played in the following teams: “Bilozgar – Medical University”, “Dobrodiy – Medical University – School of Higher Sportsmanship (SHS)”, student volleyball teams of higher education institutions of Vinnytsia and children's and youth sports schools of Vinnytsia and Kalynivka. All the athletes underwent ultrasound examination of the heart and parenchymal organs, spirometry, electrocardiography and tetrapolar rheography of the chest and extremities. If hypertension, arrhythmias, regurgitation of II-III degrees, myocardial hypertrophy or pathology of parenchymal organs were detected, practically healthy volleyball players were excluded from the group. Thus, the total group of volleyball players who had no deviations in their health status was 108 athletes. The distribution of volleyball players by the level of sportsmanship in percentage terms is shown in Figure 1.

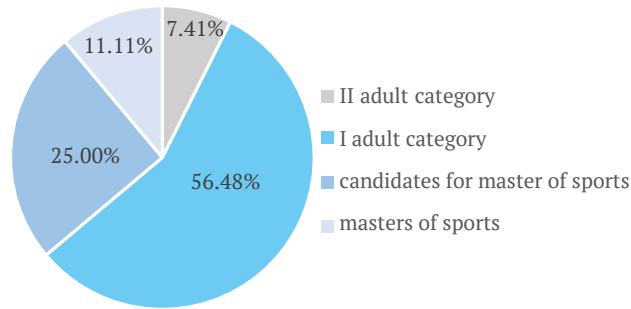


Figure 1. Distribution (%) of volleyball players by level of sportsmanship

Source: developed by the authors

The control group consisted of 130 practically healthy girls of the same age who did not go in for sports. The conclusion about the health status of the girls in this group was made after a comprehensive clinical and laboratory examination (ultrasound examination of the heart, thyroid gland, spleen, kidneys, liver, urinary and gallbladder, X-ray examination; spirometry, electrocardiography, tetrapolar

rheography). In cases of pathology detection, girls were excluded from further research and were not included in the main group of practically healthy. The age distribution of volleyball players and girls of the control group is shown in Table 1, it should be noted that the average age of volleyball players was 18.05 ± 1.39 years, and that of non-athletes – 17.91 ± 1.49 years.

Table 1. Age distribution in the observation groups

Volleyball players (n = 108)			Control group (n = 130)		
Age (years)	Number (n)	%	Age (years)	Number (n)	%
16	20	18.52	16	30	23.08
17	18	16.67	17	30	23.08
18	28	25.92	18	22	16.98
19	20	18.52	19	17	13.08
20	22	20.37	20	31	23.84

Source: developed by the authors

Anthropometry was performed with certified equipment: a caliper was used to determine the width of the distal epiphyses of the tubular bones, a Martin anthropometer – body length, a centimetre tape – girth of the torso and limbs, a caliper – thickness of skin and fat folds, and a medical scale – body weight. The anthropometric study was performed according to the recommendations of P.P. Shaparenko [10]. The somatotypic affiliation was determined by the calculated modification of the Carter-Heath method [11]. After somatotyping, it was found that 28 volleyball players and 33 girls of the control group belonged to the mesomorphic type of constitution. Ectomorphs included 27 volleyball players and 36 control group members; ecto-mesomorphs – 27 volleyball players and 24 control group members, and middle intermediate type – 26 volleyball players and 37 control group members. The results were analysed and graphs were drawn using the licensed software package “Statistica 5.5”. The statistical significance of the difference between the studied groups in the value of anthropometric sizes of extremities was determined by the non-parametric method using the Mann-Whitney U test (the level of statistical significance was estimated by 3 gradations: $p < 0.05$, $p < 0.01$, $p < 0.001$).

The work is a fragment of the planned research work of the Department of Sports Medicine, Physical Education and Rehabilitation of Vinnytsia National Medical University named after M.I. Pirogov “Somato-viscerometric features of the human body in different periods of ontogeny”, state registration number 0121U113772 (applied). The work was approved at the meeting of the Bioethics Committee of the Pirogov National Medical University (Minutes No. 2) on 31 January 2024. The approval process took into account the basic bioethical principles established, in particular, in the Declaration of Helsinki [12].

★ RESULTS

It was established that volleyball players had the widths of distal epiphyses of segments of the upper and lower extremities significantly larger (in all cases $p < 0.001$) than girls of the control group. In particular, the width of a distal epiphysis of a shoulder in volleyball players of mesomorphs is bigger, than in ectomorphs ($p < 0.01$) who had the value of the given size the smallest among all sportswomen, the significant differences ($p < 0.05$) were found at the comparison of volleyball players of ecto-mesomorphic and ectomorphic types (Fig. 2).

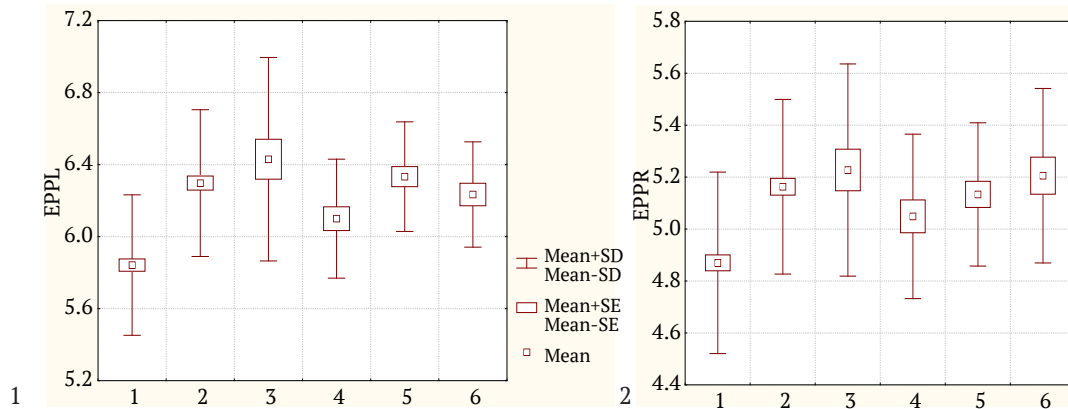


Figure 2. Features of the width of the distal epiphyses

of the shoulder (1) and forearm (2) (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

In order to find out the constitutional conditionality of anthropometric sizes of the upper and lower limb, their size between sportswomen and non-athletes within a separate somatotype was compared. It was found that in volleyball players of all somatotypes (Table 2) the width of the distal epiphysis of the shoulder was greater than in girls of control groups of corresponding constitutional types (in all cases $p < 0.001$). The width of a distal epiphysis

of a forearm had the smallest values in volleyball players of an ectomorphic somatotype, but significant differences between sportswomen of different constitutional types were not revealed (Fig. 2). In volleyball players of mesomorphic ($p < 0.01$), ectomorphic ($p < 0.01$), ecto-mesomorphic ($p < 0.001$) and average intermediate ($p < 0.01$) somatotypes the forearm epiphysis is wider than in control groups (Table 2).

Table 2. Width of the distal epiphyses of limb segments in individuals with different somatotypes ($M \pm \sigma$)

Indicators.	Control	Volleyball players	Control	Volleyball players
	Mesomorphic somatotype		Ectomorphic somatotype	
EPPL	5.765 \pm 0.388	6.430 \pm 0.565***	5.715 \pm 0.437	6.100 \pm 0.330***
EPPR	4.922 \pm 0.324	5.227 \pm 0.409**	4.775 \pm 0.379	5.049 \pm 0.317**
EPB	8.515 \pm 0.375	8.590 \pm 0.806	7.939 \pm 0.407	8.090 \pm 0.744
EPG	6.381 \pm 0.410	6.662 \pm 0.592	6.419 \pm 0.378	6.420 \pm 0.530
	Ecto-mesomorphic somatotype		Middle intermediate somatotype	
EPPL	5.778 \pm 0.254	6.333 \pm 0.304***	5.895 \pm 0.384	6.234 \pm 0.293***
EPPR	4.800 \pm 0.248	5.133 \pm 0.276***	4.899 \pm 0.285	5.206 \pm 0.336**
EPB	8.115 \pm 0.549	8.767 \pm 0.848**	8.102 \pm 0.449	9.136 \pm 0.913***
EPG	6.485 \pm 0.422	6.627 \pm 0.386	6.457 \pm 0.386	6.815 \pm 0.462**

Notes: EPPL – width of the distal epiphysis of the upper arm (cm); EPPR – width of the distal epiphysis of the forearm (cm); EPB – width of the distal epiphysis of the thigh (cm); EPG – width of the distal epiphysis of the lower leg (cm); * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$

Source: developed by the authors

In volleyball players of ectomorphic somatotype the width of the distal femoral epiphysis was less than in sportswomen of mesomorphic ($p < 0.05$), ecto-mesomorphic ($p < 0.01$) and average intermediate ($p < 0.001$) types (Fig. 3). It was found that in non-athletes and volleyball players of mesomorphic and ectomorphic types, there was

no significant difference ($p > 0.05$) in the width of the distal femur epiphysis; and in volleyball players of ecto-mesomorphic ($p < 0.01$) and average intermediate ($p < 0.001$) types of constitution this anthropometric size was larger compared to girls who did not engage in sports of the same constitution (Table. 2).

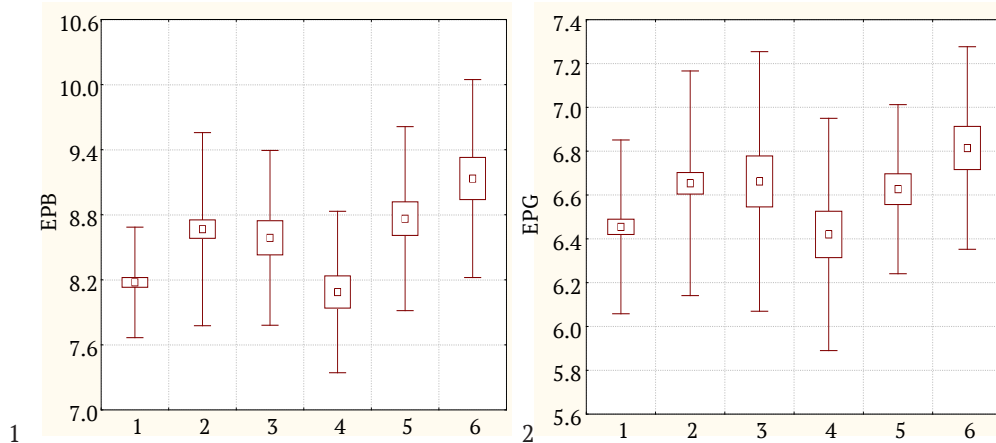


Figure 3. Features of the width of the distal epiphyses

of the thigh (1) and tibia (2) (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

It was established that the width of a distal epiphysis of a tibia had the greatest values in volleyball players of the average intermediate somatotype, and the smallest – in ectomorphs, only between these groups the significant difference ($p < 0.01$) was revealed by the value of this index (Fig. 3). In girls of mesomorphic, ectomorphic and ecto-mesomorphic somatotypes the width of the distal epiphysis of the tibia did not have significant differences depending on the level of motor activity, only in volleyball players of the average intermediate type it was greater ($p < 0.01$) compared to non-athletes of the same type of body constitution (Table 2).

Comparing the value of all girth sizes of segments of the lower and upper extremities between volleyball

players of the general group and non-athletes, we found significantly higher ($p < 0.01$) values in sportswomen. In particular, it concerns the value of shoulder girth in the relaxed and tense states. In addition, volleyball players of mesomorphic somatotype had girths of the tense and relaxed shoulder statistically significantly larger in comparison with ectomorphic volleyball players (in both cases $p < 0.001$) and ecto-mesomorphs ($p < 0.01$ and $p < 0.05$), volleyball players of the average intermediate somatotype had larger shoulder perimeters than ectomorphs (in both cases $p < 0.001$). It was found that volleyball players of ecto-mesomorphs in comparison with ectomorphs had bigger girths of the tense ($p < 0.01$) and relaxed shoulder ($p < 0.05$) (Fig. 4).

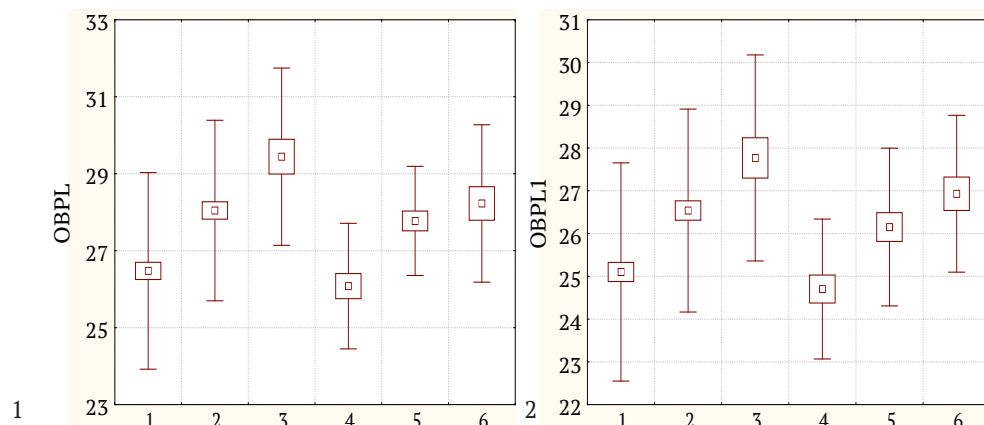


Figure 4. Features of the girth dimensions of the tense (1) and relaxed (2) shoulder (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

It has been established that in girls with good development of the mesomorphic component of somatotype

(mesomorphs and ecto-mesomorphs) the differences in the size of the girths of the tense and relaxed shoulder

between the groups of sportswomen and non-athletes are levelled. Only volleyball players of ectomorphic and average intermediate types of a body constitution had

bigger shoulder circumferences (in all cases $p < 0.001$) than girls of the control group of the same somatotype (Table 3).

Table 3. Limb circumferences in individuals with different somatotypes (cm, $M \pm \sigma$)

Showcasing. ki	Control	Volleyball players	Control	Volleyball players
	Mesomorphic somatotype		Ectomorphic somatotype	
OBPL	28.20 ± 2.14	29.44 ± 2.30	23.70 ± 1.73	26.08 ± 1.63***
OBPL1	26.97 ± 2.32	27.77 ± 2.41	22.42 ± 1.62	24.70 ± 1.64***
OBPR1	24.04 ± 1.93	24.65 ± 1.28	21.41 ± 1.17	22.86 ± 1.42***
OBPR2	15.88 ± 0.73	15.89 ± 0.93	14.79 ± 0.90	15.38 ± 0.71**
OBB	53.63 ± 4.01	56.02 ± 2.69*	47.84 ± 3.06	50.88 ± 3.19**
OBG1	35.82 ± 2.09	37.85 ± 2.73**	32.00 ± 1.83	34.04 ± 1.65***
OBG2	23.29 ± 1.52	23.39 ± 1.49	21.45 ± 1.08	21.84 ± 1.99
OBK	18.56 ± 1.29	19.14 ± 0.87**	17.85 ± 1.13	18.48 ± 0.80*
OBS	22.64 ± 1.21	23.23 ± 1.13	21.76 ± 1.21	22.73 ± 0.92***
	Ecto-mesomorphic somatotype		Middle intermediate somatotype	
OBPL	26.55 ± 2.12	27.77 ± 1.42	26.04 ± 1.51	28.23 ± 2.05***
OBPL1	25.02 ± 1.95	26.15 ± 1.84	24.50 ± 1.20	26.93 ± 1.83***
OBPR1	23.02 ± 1.28	23.87 ± 1.07	22.82 ± 0.98	24.46 ± 1.38***
OBPR2	15.44 ± 0.99	15.87 ± 0.79	15.68 ± 1.42	16.30 ± 1.05*
OBB	52.29 ± 3.65	54.70 ± 3.19*	51.83 ± 2.59	55.46 ± 3.45***
OBG1	34.47 ± 2.23	36.09 ± 1.65**	34.13 ± 1.72	36.34 ± 1.84***
OBG2	22.66 ± 1.87	22.52 ± 1.39	22.17 ± 1.29	22.68 ± 1.94
OBK	18.42 ± 1.24	18.85 ± 0.69	18.31 ± 0.82	19.23 ± 1.48**
OBS	22.73 ± 1.13	23.25 ± 0.88	22.32 ± 1.12	22.96 ± 1.27

Notes: OBPL: upper arm circumference at rest; OBPL1: upper arm circumference at rest; OBPR1: upper arm circumference at rest; OBPR2: lower arm circumference at rest; OBB – hip circumference; OBG1 – upper leg circumference; OBG2 – lower leg circumference; OBK – hand circumference; OBS – foot circumference; * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$

Source: developed by the authors

The forearm girth in the upper third (Fig. 5) of sportswomen of the general group and mesomorphic, ecto-mesomorphic and average intermediate somatotypes is significantly bigger in comparison with girls of the control group, besides, in volleyball players of mesomorphic and average intermediate somatotype this size is significantly bigger ($p < 0.001$), than in volleyball players of ectomorphs, in whom it is smaller in comparison with ecto-mesomorphs ($p < 0.01$). It was found that mesomorphic volleyball players had a larger ($p < 0.05$) forearm circumference in the upper third than sportswomen of ecto-mesomorphic somatotype. The forearm circumference in the lower third had the highest average values in volleyball players with an average intermediate somatotype, the lowest – in ectomorphs. Significant differences were found when comparing sportswomen of ectomorphs with volleyball players of average intermediate ($p < 0.01$) and

ecto-mesomorphic ($p < 0.05$) somatotypes (Fig. 5). It was established that between volleyball players and non-athletes of mesomorphic and ecto-mesomorphic somatotypes there is no significant difference in the size of the forearm circumference in the upper and lower thirds. Sportswomen of the ectomorphic somatotype had bigger values of forearm circumferences in the upper ($p < 0.001$) and lower ($p < 0.01$) parts than girls of control groups. In volleyball players with an average intermediate somatotype these anthropometric sizes were also significantly larger (Table 3).

It was found that in volleyball players of ectomorphs the hip circumference was significantly smaller (in all cases $p < 0.001$) compared to sportswomen of mesomorphic, ecto-mesomorphic and middle intermediate somatotypes; representatives of other somatotypes practically did not differ among themselves by the value of this indicator (Fig. 6).

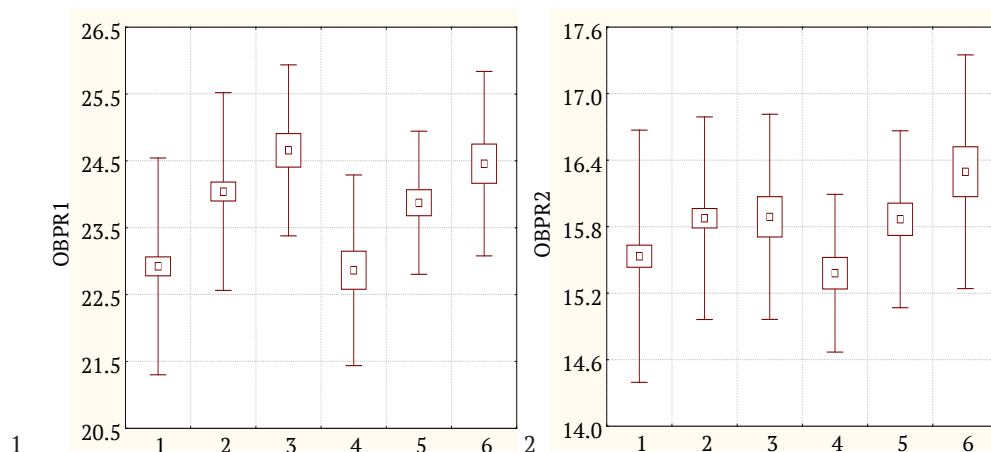


Figure 5. Features of forearm girth dimensions in the upper (1) and lower (2) thirds (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

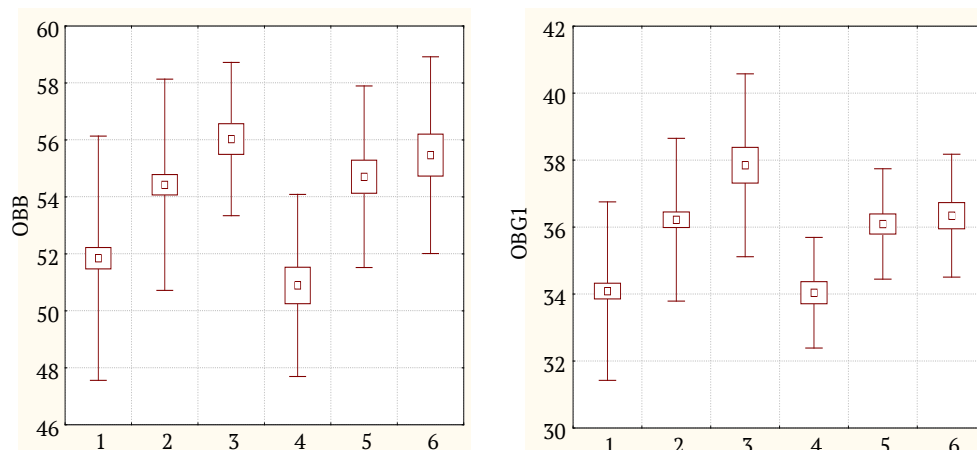


Figure 6. Features of the girth dimensions of the thigh (1) and lower leg in the upper (2) and lower (3) parts (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

The tibia girth in the upper third of volleyball players of mesomorphic somatotype was statistically significantly larger compared to representatives of ectomorphic ($p < 0.001$) and ecto-mesomorphic ($p < 0.05$) somatotypes. In volleyball players of ectomorphs this size was the smallest, therefore significant differences were found when comparing with sportswomen of ecto-mesomorphic and average intermediate somatotypes (in both cases $p < 0.001$) (Fig. 6). It was established that the girths of a thigh and a lower leg in the upper part of sportswomen of the general group (Fig. 6) and all constitutional types were statistically significantly bigger than in girls of control groups (Table 3).

The lower third tibia girth was the smallest in the group of sportswomen of ectomorphic type of a body structure, the significant difference ($p < 0.01$) was established between them and volleyball players of mesomorphic

somatotype in which the average value of this size was the largest among all comparison groups. In volleyball players of mesomorphic somatotype this index was bigger ($p < 0.05$) than in sportswomen of ecto-mesomorphic somatotype (Fig. 7); volleyball players of all constitutional types had this anthropometric size statistically significantly bigger in comparison with non-athletes of control groups of corresponding somatotypes (Table 3).

The girth dimensions of the hand and foot in general groups of volleyball players were significantly larger compared to girls who did not engage in sports (Fig. 8). In volleyball players of ectomorphic somatotype, the hand girth was smaller than in mesomorphic and average intermediate types (in both cases $p < 0.05$). The foot girth did not significantly differ between sportswomen of different constitutional types (Fig. 8).

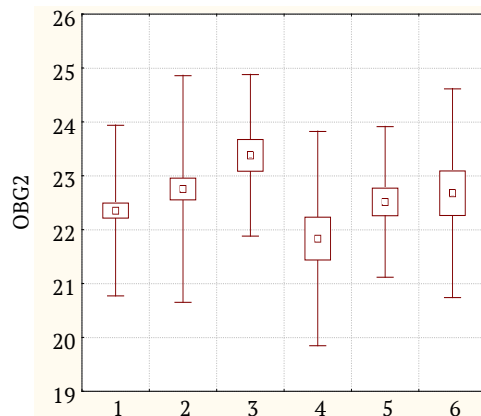


Figure 7. Peculiarities of lower leg girth in the lower part (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

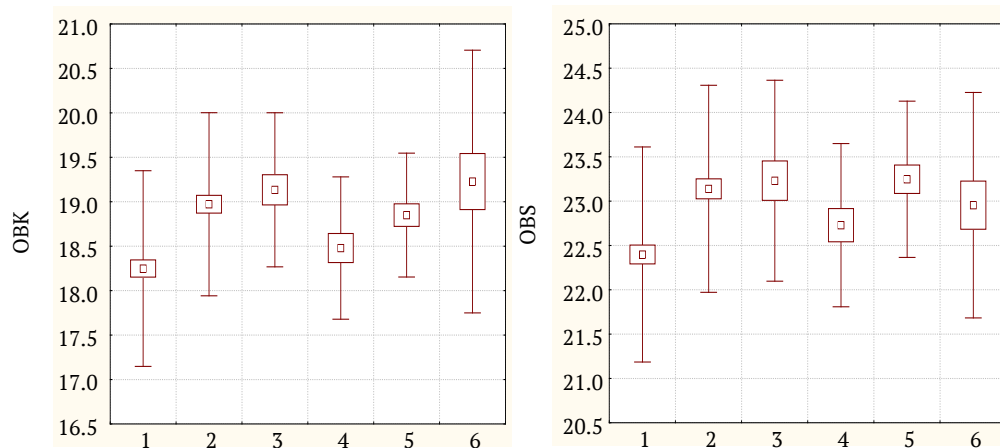


Figure 8. Features of the girth dimensions of the hand (1) and foot (2) (cm) in volleyball players of different somatotypes

Notes: Mean – sample mean; Mean \pm SE – \pm error of the mean; Mean \pm SD – \pm standard deviation; 1 – non-athletes (control group); 2 – general group of volleyball players; 3 – mesomorphic athletes; 4 – ectomorphic athletes; 5 – ecto-mesomorphic athletes; 6 – athletes of intermediate somatotype

Source: developed by the authors

The hand girths of volleyball players of mesomorphic ($p < 0.01$), ectomorphic ($p < 0.05$) and average intermediate ($p < 0.01$) somatotypes are bigger than those of non-athletes of the same somatotype, only representatives of ecto-mesomorphic type did not have significant differences. The average values of a foot girth in volleyball players of all somatotypes were bigger than in non-athletes, but only between sportswomen and girls of the control group of an ectomorphic somatotype the significant differences were revealed ($p < 0.001$) (Table 3). In general, volleyball increases the width of the limb epiphyses and arm and leg circumferences in women, and the effect depends on their body type.

DISCUSSION

In order to achieve a high result, athletes must have an appropriate level of motor skills' development, technical, tactical, game, functional, psychological, and integral

training, which must be at the highest level [1-3]. The combination of these qualities, even with the best planning of the training process in its various cycles at all stages of long-term training, compliance with all the principles of management and control is extremely rare. T. Kutseryb *et al.* [13] note that sports selection should be based on the correspondence of anatomical and physiological features of people to the professional demands of their sports activity. But P.D. Fabricant *et al.* [14] emphasize that early sports specialisation in children and adolescents trying to achieve elite status may be accompanied by an increased risk of injury. According to some scientists, when conducting sports selection, preference should be given to those athletes who have a set of morphological and functional characteristics that significantly affect performance and at the same time have a high degree of genetic determination [15]. Among such morphogenetic traits that affect sports abilities,

anthropometric indicators play an important role [16]. In particular, R. Pavlović [5] notes that such anthropometric parameters as length and body weight can be predictors of sports results in short-distance running, especially at 100 m and 200 m, because it is at these distances that the running performance will depend on the motor-functional ability of the sprinter. Scientists argue that even in team sports, performance may depend on the anthropometric dimensions of the players' bodies [17, 18]. M. Gusic *et al.* [19] argue that representatives of individual game sports differ significantly from each other, have specific anthropometric characteristics, and that football and handball players, in particular, differ significantly in length, body weight, shoulder, forearm and lower leg circumferences. There are few data on anthropometric features of volleyball players of high skill level of a separate period of ontogenesis. In particular, M. Joksimovic *et al.* [20] studied the morphological characteristics of elite volleyball players from 4 different national teams that competed in the European Championship qualifiers, and R. Pavlović *et al.* [21] emphasise the lack of information on the population of volleyball players who compete in top-level competitions. As a result of the present study, it was found that volleyball players had distal epiphysis widths of all segments of the upper and lower extremities significantly larger than girls of the control group. This corresponds to the data obtained by T. Kutseryb *et al.* [4] and S.K. Noutsos *et al.* [8].

The analysis of the literature data did not reveal any works that would study the issue of peculiarities of anthropometric parameters of the lower and upper limbs in volleyball players of different somatotypes. Some scientists [13] also note that there are very few modern works that study the structure of the body of athletes from the point of view of constitutional morphology, comparing somatotypes in athletes of different sports. The use of various methods of somatotyping complicates the analysis and comparison of the obtained somatotypic data in athletes. From our point of view, the use of the method of determination of constitutional types by Hit-Carter is the most objective, because it is based on a number of anthropometric measurements; it gives the chance of individual determination of components of a somatotype in points (digital expression) and due to the presence of intermediate types it is possible to assign each person to a specific constitutional type [11]. In addition, the analysis of modern literature shows that this method is the most common [4, 8, 9]. The use of the Heath-Carter methodology allowed the team of authors Z. Grgantov *et al.* [22] to recommend the use of somatotyping as a selection criterion for young volleyball players of different sports roles (connectors, attackers, libero), noting that most often a balanced ectomorphic somatotype was found in all positions of players.

In conformity with the results of this study, it was found that the somatotypic approach in comparing the transverse dimensions of the limbs confirmed the previously identified (between general groups of comparisons) tendency of a greater width of the distal epiphyses in volleyball players compared to non-athletes of the corresponding constitutional types. But reliable differences were established only for the width of the epiphyses of the shoulder and forearm – in volleyball players of all somatotypes they were statistically significantly larger.

The transverse dimensions of the thigh were significantly larger only in volleyball players of ecto-mesomorphic and middle intermediate somatotypes; in representatives of extreme somatotypes (mesomorphic and ectomorphic) the differences were insignificant. And the width of the distal tibia epiphysis only in volleyball players of the middle intermediate type was significantly larger, between the athletes and the control group of mesomorphic, ectomorphic and ecto-mesomorphic somatotypes the width of the tibia did not differ. Based on this, it can be assumed that belonging to one constitutional type reduces the difference in the size of the transverse dimensions of the lower limb and is a more significant determinant than the peculiarities of sports activity. In addition, the significance of constitutionality is indicated by the fact that significant differences in the size of the transverse dimensions of the limbs between volleyball players belonging to different somatotypes were found. Thus, in sportswomen of mesomorphic somatotype the width of distal epiphyses of a shoulder and forearm was the largest, in ectomorphs – the smallest. Volleyball players of the ectomorphic somatotype had the smallest sizes of diaphyses on the lower limb, and the greatest width of the thigh and tibia was in sportswomen of the middle intermediate somatotype. Earlier it was established [23] that volleyball players of all somatotypes in comparison with non-athletes of corresponding types of constitution had significantly larger almost all transverse sizes of a chest, only width of shoulders statistically did not differ between volleyball players and control groups.

S.S. Karatieieva *et al.* [24], studying the hip circumferences of students involved in sports, faced the problem of the lack of a methodology that would allow the use of circumferential partial parameters as criteria for sports selection in a particular sport. The analysis of scientific research revealed a number of studies that determined the girth dimensions of volleyball players. In particular, A. Pastuszek *et al.* [25] found that volleyball players had larger arm and lower leg circumferences, and J.B. Fields *et al.* [26] reiterate that successful volleyball, like other sports, requires a combination of anthropometric characteristics and technical and tactical indicators.

According to the results of this study, it was found that volleyball players of the general group compared to girls of the control group had larger girth sizes of the upper and lower limbs, which is confirmed by scientific observations on the importance of the development of the muscular system for the sports achievements of volleyball players, so the girth size of the body can be an indicator of a number of elements of motor fitness, as stated by A. Sieroń *et al.* [27].

The somatotypological approach in comparing the size of the circumferences of segments of the upper and lower limbs made it possible to assert that the belonging of adolescent girls to types of constitutions with good development of the mesomorphic component levelled the difference in the size of most of the girth dimensions of the limbs. The only exception was volleyball players of ectomorphic and average intermediate somatotypes, whose sizes were larger compared to girls who did not play sports of the corresponding constitutional types. Regarding somatotypic differences between volleyball players themselves, the prevalence of most girth dimensions, except for the hand and foot circumference, was determined in

sportswomen with mesomorphic somatotype. Volleyball players of ectomorphic somatotype had the smallest average values of these indicators.

Thus, the specificity of training and competitive activity in volleyball is reflected in changes in the external structure of the body, in particular in the anthropometric dimensions of the limbs. It is the transverse and girth parameters of the upper and lower limbs that should be included in the model characteristics of volleyball players, which is necessary for sports selection. Belonging to a certain constitutional type influences the features of girth and transverse dimensions of limbs in volleyball players of high level of sports skill, which also needs to be taken into account in sports specialization.

◆ CONCLUSIONS

The results of the study, which was conducted in volleyball players of different constitutional types and was based on the use of anthropometric and statistical research methods, ensured the fulfilment of the goal in full. Systematic volleyball training has a significant impact on the somatometric features of the upper and lower extremities, as evidenced by the presence of significant differences in the value of these indicators between groups of volleyball players and non-athletes. In addition, genetically determined constitutional features determine the size of the girth and transverse dimensions of the limbs in volleyball players of a high level of sportsmanship. It has been established that volleyball players of the general group in comparison with girls of the control group had larger ($p < 0.01-0.001$) all transverse and girth dimensions of the upper and lower limbs.

Analysing the features of anthropometric sizes within a separate somatotype between sportswomen and non-athletes, it was found that the width of distal epiphyses of the

shoulder and forearm in volleyball players of all somatotypes was larger compared to non-athletes of control groups. The transverse sizes of segments of the lower limb differed only in representatives of separate somatotypes: the width of the distal epiphysis of the lower leg was greater ($p < 0.01$) only in volleyball players of the middle intermediate somatotype, and the width of the distal epiphysis of the thigh was significantly greater in sportswomen of ecto-mesomorphic and middle intermediate types compared to girls of control groups of the same somatotype.

Most of the limb circumferences were larger only in sportswomen of ectomorphic and average intermediate somatotypes compared to girls who did not engage in the corresponding constitutional types. Belonging to constitutional types with good development of the mesomorphic component, levelled the difference between volleyball players and non-athletes in the size of the circumferences of individual segments of the lower and upper extremities.

Further study of the peculiarities of anthropometric dimensions of the lower and upper extremities in volleyball players will allow forming their morphological portrait, which can be the basis for qualified sports selection, taking into account not only intra-team specialization, but also the belonging of athletes to a certain constitutional type. In addition, the size of the limbs, along with other anthropometric indicators of the body, can be the basis for further mathematical modelling of the proper parameters of peripheral haemodynamics in volleyball players of a particular constitutional type.

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◆ CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Антропометричні особливості кінцівок у волейболісток різних соматотипів

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Анотація. Актуальність визначення антропометричних розмірів кінцівок, які визначають зовнішню будову тіла людини та мають тісні взаємозв'язки з техніко-тактичною діяльністю волейболістів, полягає у тому, що морфологічні ознаки можуть бути базисом для проведення кваліфікованого спортивного відбору. Мета даної роботи полягала у визначенні відмінностей величини антропометричних розмірів кінцівок між волейболістками та дівчатами, які не займалися спортом, в межах загальної групи і окремого конституціонального типу. Було проведено дослідження 108 волейболісток із середнім спортивним стажем $6,361 \pm 2,866$ років юнацького віку (середній вік – $18,05 \pm 1,39$ років). 130 практично здорових дівчат, які не займалися спортом, юнацького віку (середній вік – $17,91 \pm 1,49$ років) склали контрольну групу. Антропометрію проводили сертифікованим обладнанням за рекомендаціями П.П. Шапаренко, соматотипування – за методом Carter-Heath. Після визначення конституціональної приналежності волейболістки та неспортсменки були розділені на чотири групи: ектоморфного, мезоморфного, екто-мезоморфного та середнього проміжного соматотипів. Було встановлено, що у спортсменок усі обхватні розміри верхньої та нижньої кінцівок і ширина дистальних епіфізів стегна, гомілки, плеча та передпліччя достовірно більші, ніж у дівчат контрольної групи. Соматотипологічний підхід видозмінив характер попередніх результатів: у волейболісток всіх соматотипів порівняно з дівчатами контрольних груп відповідного типу конституції були статистично значуще більшими лише ширини епіфізів плеча та передпліччя; ширина дистального епіфізу гомілки була більшою лише у спортсменок середнього проміжного соматотипу, а ширина дистального епіфізу стегна була більшою у спортсменок екто-мезоморфного та середнього проміжного типів; більшість обхватних розмірів кінцівок були більшими лише у спортсменок ектоморфного та середнього проміжного соматотипів. Таким чином, волейболістки кожного конституціонального типу мають свої особливості будови кінцівок, які необхідно враховувати при створенні морфометричного профілю волейболісток і враховувати при спортивній орієнтації та прогнозуванні

Ключові слова: антропометрія; верхня та нижня кінцівки; конституціональні типи; волейбол