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Correlations between amplitude rheovasographic indicators of the crus and anthropometric dimensions in volleyball players women of different somatotypes

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Somatotypological features of the body can be considered as a lever of sports achievements, because they have an effect on the efficiency of the energy supply system, physical capacity, ability to adapt, and the state of the cardiovascular system. The purpose of our work is to reveal the correlations between the amplitude parameters of the crus rheovasogram and anthropometric indices in young volleyball players women of different somatotypes. A comprehensive clinical and laboratory study of the state of health and physical development of 108 volleyball players women aged 16-20 years (youth period of ontogenesis) of high sports ranks (from II adult to masters of sports) was conducted. Rheovasographic parameters of the crus in volleyball players women were determined by the method of tetrapolar rheocardiography on a certified computer diagnostic multifunctional complex. Anthropometric determination of the total dimensions of the body and chest, pelvis, limbs, and head was performed according to the recommendations of Shaparenko P. P. (2000), somatotypological - according to the Heath-Carter calculation method (1990). After somatotyping, it was established that 28 women volleyball players belonged to the mesomorphic type of constitution, 27 women athletes were assigned to the ectomorphic and ecto-mesomorphic somatotypes each, and 26 women volleyball players belonged to the medium intermediate type. The analysis of the obtained results was carried out in the license program "Statistica 5.5" using correlation analysis according to Spearman. We found that highly professional women volleyball players, who have different body types, differ in the strength and number of significant correlations between the amplitude rheovasographic parameters of the crus and anthropometric dimensions. The most numerous (18.64 % of the possible correlations, of which 6.82 % are reliable) and the strongest (3 strong with a correlation coefficient from -0.64 to -0.73) correlations between the amplitude indicators of the crus rheovasogram and parameters of the external body structure were recorded in volleyball players women of the middle intermediate somatotype. Ectomorphs had the lowest number and strength of relationships (3.18% of possible correlations, only 1 reliable). Individual longitudinal dimensions of the body, chest girths and its diameters, transverse dimensions of the pelvis, and skinfold thickness were most often correlated with the amplitude indicators of the crus rheovasogram in women volleyball players of various constitutional types. Determining the features of the correlations is the basis for assessing the harmony of the physical development of women volleyball players and conducting further statistical modeling to determine their appropriate crus rheovasographic indicators.

Keywords: correlations, peripheral hemodynamics, crus, anthropometry, somatotype, volleyball players women.

Introduction

Features of the body structure, which are strongly influenced by genetic factors, are an important basis for

sports results [11, 15]. Constitutional characteristics have an impact on the efficiency of the energy supply system, on

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the manifestation and development of physical qualities, the maximum consumption of oxygen, and, therefore, on physical performance, the course of recovery processes, the ability to adapt to various exogenous factors. In particular, Summer L. C. and co-authors [25] note that the change in body weight composition during the competitive season in athletes is accompanied by a change in sports results. The constitutional approach makes it possible to study the organism at different levels, starting from the organ and ending with the system [8]. The most recent is the use of the factor of constitutional belonging as a basis for accentuating personality characteristics [3], in particular, the determination of such indicators in persons of different somatotypes as: the indicator according to the scale of insincerity according to Eysenck, extraversion-introversion according to Eysenck, personal anxiety according to Spielberger, character accentuation of different types, etc. [1, 2].

D. Berhtraum with co-authors [4] proved the importance of the state of the cardiovascular system for diagnosing the adaptation capabilities of the body, this hypothesis is also confirmed by other scientists [17, 18], this question acquires special importance in youth, because at this time it increases the importance of the respiratory and cardiovascular systems for the proper physical development of a young organism against the background of significant changes in living conditions [27]. The functional state of an athlete's cardiovascular system is an undeniable factor in sports performance [5, 12, 19, 22]. Many scientific studies have proven the importance of indicators of central [13, 18, 23, 30] and peripheral hemodynamics [26] in increasing the level of fitness of athletes and forming their high potential for adaptation to intensive physical exertion of various directions. In particular, Usova O. V. with co-authors [26] notes that as a result of a decrease in the functional capabilities of the body, a decrease in the speed of blood vessel filling will be observed. According to many scientists, the parameters of regional blood circulation are significantly influenced by the features of the external structure of the body [20, 28]. In particular, a change in the dynamics of venous blood flow in the elderly was established in the context of the peculiarities of the composition of the tissues of the lower extremities [24]. Significant differences were found in the value of regional blood circulation indicators, in particular on the crus, in representatives of different constitutional types of adolescence, the most pronounced differences were between girls of ectomorphic and mesomorphic somatotypes [7, 9]. A correlational analysis was conducted between body composition components and indicators of the cardiovascular system in young women [16]. But, unfortunately, there is a lack of works that would relate to the relationships between indicators of the external structure of the body and regional features of blood circulation in athletes.

The purpose of our work is to reveal the correlations between the amplitude parameters of the crus

rheovasogram and anthropometric indices in young volleyball players women of different somatotypes.

Materials and methods

During 2017-2023, in the research center of National Pirogov Memorial Medical University, Vinnytsya, a comprehensive clinical and laboratory study of the state of health and physical development of 108 volleyball players women aged 16-20 years (youth period of ontogenesis) of high sports ranks (from II adult to masters of sports) was held. The average sports experience of volleyball players women was 6.361±2.865 years. Volleyball players women played as part of the teams: "Bilozgar - Medical University", "Dobrodiy - Medical University - ShVSM", student volleyball teams of Vinnytsia institutions of higher education, children's and youth sports schools of Vinnytsia and Kalynyvka. Each female athlete who had a sports experience of at least 3 years and the appropriate rank and age (inclusion criteria) gave informed consent to participate in such a study. All examinations were carried out at least 12 hours after training. Examination of volleyball players women was carried out in the period from day 5 to day 12 of their ovulatory-menstrual cycle. Eligibility for participation in further studies was a preliminary electrocardiographic and echocardiographic examination. Exclusion criteria were hypertension, pathological hypotension, arrhythmias, II-III degree mitral valve prolapse, pathological myocardial hypertrophy.

The research was carried out within the framework of the university-wide topic "Somato-viscerometric features of the human body in different periods of ontogenesis" (state registration number 0121U113772). The work was approved at the meeting of the Bioethics Committee of the National Pirogov Memorial Medical University, Vinnytsya (protocol No. 2) dated January 31, 2024.

The rheovasographic parameters of the crus in volleyball players women were determined by the method of tetrapolar rheocardiography on a certified computer diagnostic multifunctional complex (developers by scientists of National Pirogov Memorial Medical University, Vinnytsya and Vinnytsia National Technical University) and the amplitude, time and indicators of the ratio of amplitude and time rheovasographic parameters were evaluated (integral). An anthropometric study of the total dimensions of the body and chest, pelvis, limbs, and head was conducted according to the recommendations of Shaparenko P. P. [21]. All measurements were carried out with certified equipment with determination of the following dimensions: Martin's anthropometer was used to determine longitudinal dimensions, in particular body height and anthropometric points (cm); with a centimeter tape - girth measurements (cm), with a large thick compass - transverse and sagittal diameters of the body (cm), with a caliper - the width of the distal epiphyses of long tubular bones (cm), with a caliper - skinfold thickness (mm), on medical scales - body weight (kg). Body surface area (m²)

was calculated using the Dubois formula [21]. The somatotypological study was carried out according to the Heath-Carter calculation method [6], which was based on anthropometric measurements, the value of the components of the somatotype (ectomorphic, mesomorphic, endomorphic) was determined in points (from 1 to 7). After somatotyping, it was established that 28 women volleyball players belonged to the mesomorphic type of constitution, 27 women athletes were assigned to the ectomorphic and ecto-mesomorphic somatotypes, and 26 women volleyball players belonged to the medium intermediate type.

The analysis of the obtained results was carried out in the licensed program "Statistica 5.5" using Spearman's non-parametric correlation analysis.

Results

After conducting a correlation analysis of the amplitude rheovasographic parameters of the crus with anthropometric dimensions in volleyball players women with a mesomorphic somatotype, we found few reliable correlations of average strength, therefore we also analyzed average connections that were unreliable (Table 1). In particular, baseline impedance had reliable direct correlations only with the height of the suprasternal point and the width of the distal femoral epiphysis. But unreliable straight correlations of the average strength were found between this indicator and body length, heights of 2 more anthropometric points (shoulder and finger), width of the distal epiphysis of the crus, transverse lower thoracic diameter, skinfold thickness on the side and thigh; and with skinfold thickness on the forearm, the correlation was inversely proportional. The amplitude of the systolic wave was reliably correlated in volleyball players women mesomorphs with 7 anthropometric dimensions: the width of the distal epiphyses of the thigh and crus, with the girth dimensions of the forearm in the upper part, the chest during inhalation, exhalation and at rest, skinfold thickness on the side. Unreliable average strength direct correlations were found between this indicator and the height of the suprasternal point, the circumference of the forearm in the lower part, intercristal distance and external conjugate. It should be noted that all connections were only direct. We determined that the amplitude of the incisura had only 1 reliable inverse relationship of average strength - with skinfold thickness on the chest; and with skinfold thickness on the front surface of the shoulder and forearm, the correlations were unreliable, medium, and inverse; with intercristal distance, the relationship was direct. The amplitude of the diastolic wave on the crus was statistically significantly correlated with the skinfold thickness on the side, still direct but unreliable connections were found with the width of the distal epiphysis of the crus, the circumference of the forearm in the upper part, the chest during inspiration and at rest, the size of the external conjugate. With crus circumference at the bottom, the

Table 1. Correlations of the amplitude indicators of the crus
rheovasogram with anthropometric dimensions in mesomorph
volleyball players women.

	Rheovasogra		graphic	graphic indicators		
Anthropometric dimensions	Z	h1	h2	h3	h4	
body weight	0.15	0.17	-0.10	0.09	0.13	
body length	0.33	0.23	-0.09	0.06	0.05	
body surface area	0.20	0.18	-0.13	0.07	0.10	
the height of the suprasternal point	0.47	0.33	0.05	0.20	0.21	
the height of the pubic point	0.29	0.08	-0.11	-0.05	-0.06	
the height of the shoulder point	0.38	0.25	0.01	0.10	0.17	
fingertip height	0.35	0.20	-0.02	-0.03	0.12	
the height of the trochanteric point	0.13	-0.01	-0.21	-0.09	-0.20	
width of the distal epiphysis of the shoulder	0.07	0.26	-0.10	0.21	-0.10	
width of the epiphysis of the distal forearm	0.11	0.18	-0.10	0.13	-0.09	
width of the distal femoral epiphysis	0.39	0.39	0.16	0.29	0.27	
width of the distal epiphysis of the crus	0.35	0.46	0.22	0.36	0.21	
shoulder girth in a tense state	0.12	0.22	0.04	0.14	0.22	
shoulder circumference in a relaxed state	0.26	0.29	0.13	0.22	0.32	
forearm circumference at the top	0.25	0.44	0.15	0.37	0.22	
the circumference of the forearm in the lower part	0.22	0.37	0.03	0.28	0.05	
hip circumference	0.08	0.18	-0.02	0.13	0.15	
the circumference of the crus at the top	-0.10	-0.08	-0.10	-0.09	-0.27	
the circumference of the crus at the bottom	-0.20	-0.23	-0.10	-0.31	-0.31	
neck circumference	0.05	0.28	-0.08	0.21	0.02	
waist circumference	-0.01	-0.11	-0.28	-0.11	0.01	
hips circumference	-0.05	-0.06	-0.16	-0.11	0.06	
circumference of the hand	0.01	0.25	0.02	0.16	0.13	
foot circumference	-0.10	-0.01	-0.19	-0.01	-0.20	
chest circumference on inhalation	0.29	0.47	0.24	0.36	0.4 1	
chest circumference on exhalation	0.17	0.40	0.21	0.29	0.32	
chest circumference at rest	0.22	0.44	0.29	0.33	0.38	
transverse mean thoracic diameter	-0.01	0.10	-0.13	-0.01	0.12	
transverse lower thoracic diameter	0.33	0.25	0.04	0.18	0.23	
sagittal mean thoracic diameter	0.03	0.12	0.20	0.08	0.26	
acromial diameter	-0.24	-0.10	-0.26	-0.21	-0.27	
interspinous distance	-0.01	0.07	0.12	0.05	-0.03	
intercristal distance	0.27	0.32	0.31	0.20	0.22	

Anthronomotria dimonoiono	Rheovasographic indicators				
Anthropometric dimensions	Z	h1	h2	h3	h4
intertrochanteric distance	0.17	0.22	0.03	0.25	0.08
external conjugate	0.23	0.32	0.14	0.33	0.27
skinfold thickness on the back surface of the shoulder	-0.07	0.05	-0.02	-0.07	-0.06
skinfold thickness on the front surface of the shoulder	-0.22	-0.16	-0.33	-0.25	-0.19
skinfold thickness on the forearm	-0.35	-0.24	-0.35	-0.24	-0.38
skinfold thickness under the scapula	-0.10	0.10	-0.19	0.16	0.06
skinfold thickness on the chest	-0.25	-0.17	-0.39	-0.11	-0.27
skinfold thickness on the abdomen	0.28	0.25	-0.13	0.22	0.34
skinfold thickness on the side	0.37	0.48	0.19	0.5 1	0.20
skinfold thickness on the thigh	0.31	0.24	0.01	0.28	0.06
skinfold thickness on crus	0.22	0.16	-0.14	0.22	0.08

Continuation of table 1.

Notes: here and in the following, unreliable correlations of the average force are highlighted in red, reliable correlations of the average force are highlighted in blue, Z - basic impedance, h1 - amplitude of the systolic wave, h2 - amplitude of the notch; h3 - diastolic wave amplitude, h4 - rapid blood filling amplitude.

correlation was inverse. It was established that the *amplitude of rapid blood filling* had a reliable direct correlation only with the circumference of the chest during inspiration; with girth measurements of the shoulder in a relaxed state, chest on exhalation and at rest, skinfold thickness on the abdomen, the correlations were direct of medium strength, but unreliable; with skinfold thickness on the forearm and crus circumference in the lower part - reverse, average, unreliable (see Table 1).

In volleyball players women of ectomorphic somatotype, the amplitude parameters of the rheovasogram on the crus had only a few correlations of the average strength with indicators of the external structure of the body, so the basic impedance was correlated only with the girths of the crus in the lower part and the hand; these correlations were inverse, of medium strength, but unreliable (Table 2). The amplitude of the systolic wave did not correlate with any anthropometric measure. We determined that the amplitude of the incisura had only inverse relationships, reliable with skinfold thickness under the scapula, unreliable - with the width of the distal femoral epiphysis. The amplitude of the diastolic wave at the crus had no correlations with mean force. It was established that the amplitude of rapid blood filling had only 3 unreliable mean correlations, direct - with transverse lower thoracic diameter, inverse - with skinfold thickness on the chest and sagittal mid-thoracic diameter (see Table 2).

In the group of women volleyball players with an ectomesomorphic somatotype (Table 3), reliable direct correlations were found between the *basic impedance* on the crus and the heights of 3 anthropometric points **Table 2.** Correlations of the amplitude indicators of the crus rheovasogram with anthropometric dimensions in volleyball players women ectomorphs.

	Rh	indicate	cators		
Anthropometric dimensions	Z	h1	h2	h3	h4
body weight	-0.03	0.02	-0.08	-0.06	-0.06
body length	0.01	-0.07	-0.18	-0.22	-0.19
body surface area	-0.01	-0.02	-0.09	-0.11	-0.13
the height of the suprasternal point	0.19	0.09	-0.07	-0.11	-0.04
the height of the pubic point	0.07	0.19	0.01	0.02	0.06
the height of the shoulder point	0.11	0.04	-0.13	-0.22	-0.12
fingertip height	0.28	0.11	-0.02	-0.09	-0.07
the height of the trochanteric point	-0.04	0.11	-0.14	-0.11	-0.07
width of the distal epiphysis of the shoulder	0.21	0.08	-0.05	-0.01	-0.04
width of the epiphysis of the distal forearm	0.15	0.04	-0.15	-0.12	-0.08
width of the distal femoral epiphysis	0.07	-0.09	-0.33	-0.30	-0.15
width of the distal epiphysis of the crus	0.11	-0.01	0.01	-0.05	0.08
shoulder girth in a tense state	0.04	0.15	0.10	0.09	0.14
shoulder circumference in a relaxed state	0.07	0.20	0.09	0.11	0.18
forearm circumference at the top	-0.09	0.19	-0.01	0.01	0.15
the circumference of the forearm in the lower part	-0.08	-0.07	-0.13	-0.14	-0.19
hip circumference	0.05	0.10	-0.13	-0.08	0.01
the circumference of the crus at the top	-0.26	-0.04	-0.05	0.01	-0.02
the circumference of the crus at the bottom	-0.37	-0.10	-0.09	-0.02	-0.15
neck circumference	-0.17	-0.02	-0.21	-0.19	-0.01
waist circumference	0.09	0.24	0.12	0.08	0.12
hips circumference	0.06	0.14	0.05	0.08	0.01
circumference of the hand	-0.31	-0.23	-0.10	-0.07	-0.22
foot circumference	-0.02	0.01	0.01	-0.05	-0.07
chest circumference on inhalation	-0.17	-0.01	0.01	-0.11	-0.03
chest circumference on exhalation	-0.15	-0.03	0.10	-0.02	-0.07
chest circumference at rest	-0.23	-0.03	0.05	-0.04	-0.03
transverse mean thoracic diameter	0.04	0.15	0.25	0.20	0.22
transverse lower thoracic diameter	0.23	0.25	0.18	0.22	0.36
sagittal mean thoracic diameter	-0.28	-0.29	-0.25	-0.29	-0.33
acromial diameter	-0.22	-0.08	0.11	0.04	-0.22
interspinous distance	-0.03	-0.07	-0.03	-0.11	-0.17
intercristal distance	-0.01	-0.01	-0.11	-0.14	-0.12

body weight

body length body surface area

fingertip height

the shoulder

distal forearm

epiphysis

the crus

relaxed state

in the lower part

the top

the bottom neck circumference

hip circumference

waist circumference

hips circumference

foot circumference

exhalation

diameter

diameter

circumference of the hand

chest circumference on

chest circumference at rest

transverse mean thoracic

transverse lower thoracic

acromial diameter

interspinous distance

intercristal distance

sagittal mean thoracic diameter

chest circumference on inhalation

point

point

Anthropometric dimensions

the height of the suprasternal

the height of the pubic point

the height of the shoulder point

the height of the trochanteric

width of the distal epiphysis of

width of the epiphysis of the

width of the distal femoral

width of the distal epiphysis of

shoulder girth in a tense state

shoulder circumference in a

forearm circumference at the top

the circumference of the forearm

the circumference of the crus at

the circumference of the crus at

Anthronomotric dimonsions	Rheovasographic indicators				
Animopometric dimensions	Z	h1	h2	h3	h4
intertrochanteric distance	-0.01	-0.04	0.02	-0.01	-0.14
external conjugate	0.21	0.27	-0.03	0.04	0.21
skinfold thickness on the back surface of the shoulder	0.10	-0.08	-0.01	-0.06	-0.21
skinfold thickness on the front surface of the shoulder	-0.01	-0.10	0.03	0.06	-0.15
skinfold thickness on the forearm	-0.11	-0.11	-0.21	-0.22	-0.23
skinfold thickness under the scapula	0.20	-0.02	-0. 41	-0.28	-0.05
skinfold thickness on the chest	-0.30	-0.30	-0.10	-0.10	-0.35
skinfold thickness on the abdomen	-0.02	-0.17	-0.12	-0.12	-0.17
skinfold thickness on the side	0.05	-0.14	-0.14	-0.17	-0.12
skinfold thickness on the thigh	-0.13	-0.21	-0.23	-0.24	-0.11
skinfold thickness on crus	0.07	-0.03	-0.26	-0.20	-0.08

Continuation of table 2.

Table 3. Correlations of the amplitude indicators of the crus

 rheovasogram with anthropometric dimensions in volleyball players

 women ecto-mesomorphs.

7

0.27

0.36

0.32

0.37

0.11

0.39

0.48

0.15

-0.17

-0.14

-0.16

-0.11

0.28

0.34

0.11

-0.12

0.27

0.12

0.03

0.04

0.24

0.17

0.05

-0.19

0.30

0.21

0.20

0.07

0.06

0.08

-0.03

0.30

0.38

h1

0.23

0.30

0.28

0.32

0.26

0.34

0.35

0.28

-0.11

0.03

-0.26

-0.01

0.18

0.11

0.08

-0.24

0.26

0.30

0.14

-0.14

0.02

0.12

0.04

-0.03

0.20

0.09

0.12

-0.03

-0.11

0.16

-0.04

0.22

0.16

Rheovasographic indicators

h2

0.05

0.13

0.11

0.21

-0.04

0.17

0.20

0.02

-0.03

-0.02

-0.09

0.06

0.07

0.01

0.11

-0.06

0.16

0.14

0.10

-0.09

-0.11

-0.04

0.01

-0.18

0.18

-0.02

0.01

-0.12

0.06

0.23

-0.01

0.20

0.13

h3

0.14

0.19

0.17

0.18

0.07

0.21

0.28

0.16

0.05

0.13

-0.20

-0.04

0.10

0.02

0.09

-0.11

0.23

0.32

0.18

-0.05

-0.01

0.08

0.08

-0.06

0.19

-0.01

0.07

0.01

0.10

0.36

0.03

0.20

0.02

h4

0.32

0.36

0.37

0.37

0.21

0.39

0.44

0.25

-0.15

0.11

0.32

0.09

0.21

0.10

0.20

-0.07

0.31

0.37

0.19

-0.08

0.10

0.26

0.11

0.03

0.30

0.19

0.19

0.05

-0.04

0.17

0.09

0.42

SKILIOID LIICKIESS OIT CIUS	0.07	-0.05	-0.20	-0.20	-0.00
(suprasternal, brachial, digi	tal), i	ntercri	stal di	stance	e and
intertrochanteric distance;	direc	t, unr	eliable	e, me	dium-
strength correlations - with the	he ler	igth ar	nd surf	ace a	rea of
the body, the circumference	of th	e sho	ulder i	n a re	laxed
state; reverse, unreliable, m	ediun	n-stren	igth co	orrelat	ions -
with skinfold thickness on th	ne for	earm.	The a	mplitu	ide of
<i>the systolic wave</i> does not h	ave a	reliabl	e corre	elation	s with
anthropometric dimensions,	but ι	Inrelia	ble av	erage	force
direct correlations with the	heig	ht of	the su	prast	ernal,
brachial, and digital anthro	opom	etric p	oints	have	been
established. <i>Incisura amp</i>	olitud	e in v	olleyb	all pl	ayers
women ecto-mesomorphs h	ad on	ly one	reliab	le fee	dback
with skinfold thickness on th	ne for	earm.	The a	mplitu	ide of
the diastolic wave on the cr	us ha	d unre	eliable	correl	ations
of average strength: direct -	with 1	he ciro	cumfer	ence	of the
crus in the upper part and the	e sagit	tal mid	-thorac	cic dia	meter,
inverse - with the skinfold t	hickne	ess on	the f	orearn	n and
abdomen. Amplitude of rapid	l bloo	d filling	had r	eliable	small
direct correlations with the le	ength	and s	urface	area	of the
body, the height of the supi	asteri	hal, sh	oulder	and	digital
anthropometric points, the cil	rcumfe	erence	of the	crus	in the
upper part, interspinous di	stanc	e and	intert	rocha	nteric
distance, inverse - skinfold	thick	ness	on the	abdo	omen,
unreliable direct correlations	- WIT	n boay	/ weigi	nt and	i girtn
tnigns, unreliable reverse -	with	the w	lath o	t the	distai
epipnysis of the thigh and s	KINTOI	a thick	cness	on the	e siae
(see lable 3).					

We established that in volleyball players women of the average intermediate somatotype, the *basic impedance* had a reliable direct correlation only with the transverse lower thoracic diameter, unreliable direct correlations of average strength - with the transverse average thoracic diameter and interspinous distance and intercristal distance, inversely reliable - with skinfold thickness on the front surface of the shoulder (r=-0.73), on the chest

0	.2	7
	1	7
	1	7

Anthronomotric dimonsions	Rheovasographic indicators				
	Z	h1	h2	h3	h4
intertrochanteric distance	0.42	0.30	0.11	0.18	0.43
external conjugate	0.08	-0.08	-0.05	0.10	0.03
skinfold thickness on the back surface of the shoulder	-0.24	-0.14	-0.02	-0.10	-0.23
skinfold thickness on the front surface of the shoulder	-0.17	-0.07	-0.13	-0.19	-0.19
skinfold thickness on the forearm	-0.35	-0.17	-0.40	-0.32	-0.26
skinfold thickness under the scapula	0.06	-0.20	0.30	-0.01	-0.04
skinfold thickness on the chest	-0.11	-0.07	-0.22	-0.24	-0.21
skinfold thickness on the abdomen	-0.23	-0.27	-0.25	-0.35	-0.44
skinfold thickness on the side	-0.16	-0.19	-0.21	-0.21	-0.33
skinfold thickness on the thigh	0.13	0.07	-0.07	-0.03	-0.09
skinfold thickness on crus	-0.13	-0.18	-0.10	-0.18	-0.26

Continuation of table 3.

(r=-0.49) and forearm (r=-0.41), unreliable inverse of medium strength - with acromial diameter (Table 4). The amplitude of the systolic wave had reliable direct correlations with the transverse lower thoracic diameter and intercristal distance, unreliable direct correlations of medium strength with interspinous distance and skinfold thickness on the side, reliable inverse correlations with skinfold thickness on the front surface of the shoulder, forearm, chest and crus. The amplitude of the incisura was reliably correlated only with the skinfold thickness on the front surface of the shoulder (r=-0.42), with the skinfold thickness on the forearm, a feedback of medium strength was also found, but it was unreliable; direct non-reliable mean correlations were with chest circumference on inhalation and at rest, sagittal mean thoracic diameter, skinfold thickness on the thigh. The amplitude of the diastolic wave on the crus in volleyball players women of the average intermediate somatotype had reliable correlations of the average force only inversely proportional: with skinfold thickness on the chest and front surface of the shoulder, with skinfold thickness on the crus (r=-0.40) and forearm (r=-0.41) and forearm circumference in the lower part (r=-0.31) revealed unreliable inverse correlations. Unreliable average strength direct correlations are established between this amplitude parameter of the rheovasogram and the circumference of the chest during inhalation and at rest, the width of the distal epiphysis of the shoulder, and the transverse lower thoracic diameter.

Amplitude of rapid blood filling had inverse reliable correlations with skinfold thickness on the front surface of the shoulder and forearm; reverse unreliable of medium strength - with forearm circumference in the upper part, acromial diameter and skinfold thickness on the chest and crus; straight lines of medium strength - with transverse lower thoracic diameter, interspinous distance and intercristal distance (see Table 4). **Table 4.** Correlations of the amplitude indicators of the crus rheovasogram with anthropometric dimensions in volleyball players women of the average intermediate somatotype.

Apthropomotrio dimonsions Rheovasographic indi					ors
Anthropometric dimensions	Z	h1	h2	h3	h4
body weight	0.12	0.13	0.01	0.16	-0.01
body length	0.10	0.15	-0.03	0.10	0.04
body surface area	0.09	0.15	0.01	0.14	0.01
the height of the suprasternal point	0.22	0.26	0.09	0.21	0.13
the height of the pubic point	-0.04	-0.01	-0.08	0.02	-0.19
the height of the shoulder point	0.22	0.25	0.13	0.22	0.12
fingertip height	0.13	0.12	0.13	0.13	0.05
the height of the trochanteric point	0.24	0.22	0.21	0.23	0.10
width of the distal epiphysis of the shoulder	0.32	0.24	0.21	0.36	0.21
width of the epiphysis of the distal forearm	-0.07	-0.05	-0.20	-0.09	-0.09
width of the distal femoral epiphysis	0.18	0.11	0.04	0.16	0.03
width of the distal epiphysis of the crus	0.28	0.22	0.17	0.17	0.20
shoulder girth in a tense state	-0.07	-0.14	-0.15	-0.08	-0.20
shoulder circumference in a relaxed state	-0.03	-0.16	-0.17	-0.09	-0.25
forearm circumference at the top	-0.23	-0.23	-0.08	-0.09	-0.32
the circumference of the forearm in the lower part	-0.10	-0.13	-0.28	-0.31	-0.20
hip circumference	0.13	0.09	0.15	0.23	0.04
the circumference of the crus at the top	-0.14	-0.21	-0.30	-0.29	-0.26
the circumference of the crus at the bottom	-0.21	-0.06	-0.21	-0.17	-0.14
neck circumference	0.03	0.05	-0.07	0.02	-0.04
waist circumference	-0.01	0.17	0.06	0.16	0.02
hips circumference	-0.03	-0.08	0.04	0.06	-0.08
circumference of the hand	-0.16	-0.09	-0.28	-0.21	-0.18
foot circumference	-0.14	0.01	-0.14	-0.11	-0.18
chest circumference on inhalation	0.11	0.23	0.33	0.40	0.07
chest circumference on exhalation	0.01	0.08	0.29	0.30	-0.04
chest circumference at rest	0.09	0.15	0.37	0.40	0.02
transverse mean thoracic diameter	0.38	0.27	0.04	0.17	0.20
transverse lower thoracic diameter	0.43	0.49	0.11	0.31	0.38
sagittal mean thoracic diameter	-0.16	0.01	0.33	0.28	-0.10
acromial diameter	-0.33	-0.14	-0.12	-0.02	-0.35
interspinous distance	0.38	0.40	0.09	0.21	0.37
intercristal distance	0.36	0.41	0.08	0.20	0.34

Anthropometric dimensions	Rh	eovaso	graphic	indicate	ors
Anthropometric dimensions	Z	h1	h2	h3	h4
intertrochanteric distance	0.03	0.29	0.01	0.17	0.16
external conjugate	0.22	0.17	0.17	0.25	0.09
skinfold thickness on the back surface of the shoulder	0.14	-0.08	-0.01	0.01	0.01
skinfold thickness on the front surface of the shoulder	-0.73	-0.71	-0.42	-0.57	-0.64
skinfold thickness on the forearm	-0.41	-0.54	-0.37	-0.41	-0.50
skinfold thickness under the scapula	0.01	-0.13	-0.20	-0.09	-0.15
skinfold thickness on the chest	-0.49	-0.44	-0.29	-0.43	-0.41
skinfold thickness on the abdomen	0.05	0.13	0.10	0.10	0.09
skinfold thickness on the side	0.24	0.33	0.01	0.17	0.17
skinfold thickness on the thigh	0.11	0.01	0.31	0.15	0.02
skinfold thickness on crus	0.12	-0.47	-0.25	-0.40	-0.40

Continuation of table 4.

Notes: reliable strong correlations are highlighted in green.

Discussion

In the body of highly professional athletes, under the influence of systematic practice of volleyball, adaptive or maladaptive changes occur in various organs, in particular, in the organs of the cardiovascular system. Moreover, representatives of different somatotypes within the same sport (with typical training and competitive activity) have significant differences. In particular, it was proven that volleyball players of young age, representatives of certain constitutional types, differ not only in anthropometric parameters, in particular, girth, transverse and sagittal dimensions of the chest [19], but also in morphological and functional indicators of the cardiovascular system [10, 29]. Thus, the integrative-anthropological approach has a clear practical direction when establishing relationships between indicators of the external structure of the organism and parameters of regional hemodynamics [29, 28].

According to the results of our study, it can be concluded that highly professional women volleyball players, who have different body types, differ in the strength and number of significant relationships between the amplitude rheovasographic parameters of the crus and anthropometric dimensions. In particular, in volleyball players women of the mesomorphic somatotype, it was found that the amplitude indicators of the crus rheovasogram with constitutional parameters had not very numerically significant correlations of average strength (a total of 39 connections, which is 17.73 % of 220 possible correlations in this group), of which reliable was only 5.45 %. Representatives of the mesomorphic constitutional type are characterized by the predominant development of skeletal muscles against the background of massive bones, therefore, most often, of all the body sizes that we studied, the significant correlations with the amplitude

parameters of the crus rheovasogram were precisely those that determine constitutional belonging to the mesomorphic type (Fig. 1). Basic impedance, the value of which is determined by the resistance of body tissues to alternating current, which arises as a result of tissue resistance to current and reactive capacitive resistance [15], in volleyball players women of the mesomorphic somatotype, was correlated with the longitudinal dimensions of the body, the width of the epiphyses of the lower limb, and the indicators of subcutaneous fat deposition, so as the connections were direct. With an increase in body elongation, massiveness of the crus and thigh bones, skinfold thickness on the side and thigh of volleyball players women mesomorphs, the value of the basic impedance will increase. The amplitude of the systolic wave, which reflects the relative value of pulse blood filling in the studied section of the vascular bed, had the largest number of correlations (10 of average strength, 7 of which were reliable) with anthropometric dimensions. The revealed relationships indicate that with an increase in the width of the distal epiphyses of the lower limb, the girth of the forearm and chest, the skinfold thickness on the side of the systolic wave amplitude will also increase, and, therefore, the volumetric blood flow in the crus will increase. Incisura amplitude, which reflects peripheral resistance in arteries and arterioles of the smallest diameter [28], in the group of mesomorph volleyball players women had the least number of significant relationships (4 average strength, 1 of them reliable) with indicators of external body structure. The amplitude of the diastolic wave on the crus, which reflects the ratio of arterial and venous components of blood flow [20], was correlated with 6 anthropometric measurements, of which only the skinfold thickness on the side was reliably correlated. Rapid blood filling amplitude had only 1 significant direct relationship with inspiratory chest circumference. It should be noted that in volleyball players women mesomorphs with amplitude rheovasographic parameters of crus, the most numerous connections were established with the width of the distal epiphyses of the thigh and crus, the circumference of the forearm and chest, skinfold



Fig. 1. Peculiarities of correlations of the amplitude indicators of the crus rheovasogram with parameters of the external body structure in volleyball players women of the mesomorphic somatotype.



Fig. 2. Peculiarities of correlations of the amplitude indicators of the crus rheovasogram with the parameters of the external body structure in volleyball players women of the ectomorphic somatotype.



Fig. 3. Peculiarities of correlations of the amplitude indicators of the crus rheovasogram with the parameters of the external body structure in women volleyball players of the ecto-mesomorphic somatotype.



Fig. 4. Peculiarities of correlations of the amplitude indicators of the crus rheovasogram with parameters of the external body structure in volleyball players women of the average intermediate somatotype.

thickness on the side (see Fig. 1).

Only 7 (3.18 % of all possible correlations in this group) correlations of medium strength, of which only 1 is reliable, between amplitude indicators of regional blood circulation on the crus and constitutional characteristics were found in female volleyball players of ectomorphs (Fig. 2). Amplitudes of the incisura and diastolic wave had no significant correlations at all, only the amplitude of the systolic wave had the only inverse correlation with the skinfold thickness

under the scapula. In volleyball players women ectomorphs, which are characterized by insignificant fat deposition, an increase in skinfolds under the scapula may indicate a decrease in pulse blood supply to the crus.

In volleyball players women of the ecto-mesomorphic somatotype, it was found that the amplitude indicators of the crus rheovasogram with constitutional parameters had 30 connections of medium strength (13.63 % of the possible correlations in this group), half of them were reliable (15 correlations - 6.82 %). In sportswomen of this somatotype, when the fold on the forearm is reduced and the longitudinal dimensions of the body, shoulder girth, and pelvis width are increased, the value of the basic impedance will increase. The amplitudes of the incisura and the diastolic wave did not have reliable correlations, but the detected unreliable average forces nevertheless indicate that the amplitude of the incisura will increase with the increase in the longitudinal body dimensions of women volleyball players of ecto-mesomorphs. And this may indicate an increase in peripheral resistance in small arteries and a decrease in their elasticity. In women volleyball players of the ecto-mesomorphic somatotype, the amplitude of the systolic wave had the only inverse reliable correlation with the skinfold thickness on the forearm. Amplitude of rapid blood filling had the most numerous relationships with indicators of the external structure of the body - 13 of medium strength, of which 9 were reliable. It should be noted that this rheovasographic indicator is determined by the tone and elasticity of the vascular wall [28]. In female ecto-mesomorph athletes, the amplitude of rapid blood filling will increase with an increase in all total body dimensions, most longitudinal dimensions, hip and crus girths, pelvic width and a simultaneous decrease in fat deposits on the abdomen and sides (Fig. 3).

The most numerous (18.64 % of the possible correlations, of which 6.82 % are reliable) and the strongest (3 strong with a correlation coefficient from -0.64 to -0.73) relationships between the amplitude indicators of the crus rheovasogram and parameters of the external body structure were recorded in volleyball players women of the middle intermediate somatotype Attention is drawn to the fact that in athletes of this somatotype, the amplitude indicators do not correlate with the total, longitudinal dimensions of the body, instead, skinfold thickness and the diameters of the pelvis and chest have multiple connections with the amplitude characteristics of the crus rheovasogram (Fig. 4).

It was established that with an increase in the width of the distal epiphysis of the shoulder and transverse diameters of the chest, and with a decrease in the width of the shoulders and indicators of subcutaneous fat deposition, the value of the basic impedance will increase, which was correlated with 20.45 % of all anthropometric measurements that we determined. The amplitude of the systolic wave was correlated with 18.18 % of the anthropometric parameters, while it was established that an increase in body size and a

decrease in skinfold thickness will be accompanied by a better functional state of the crus vessels [28], and, therefore, a greater pulse blood flow in female volleyball players with an average intermediate somatotype. The amplitude of the incisor correlated with 13.64 % of the anthropometric parameters. It should be noted that only with skinfold thickness on the front surface of the shoulder, the relationship was reliable, inverse. Each of the amplitudes of the diastolic wave and rapid blood filling was correlated with 20.45 % of anthropometric dimensions. The amplitude of the diastolic wave - a reflection of the arterial-venous ratio of blood flow [20] - increases with an increase in the width of the distal epiphysis of the shoulder, the size of the chest, and a decrease in the indicators of subcutaneous fat deposition. The amplitude of rapid blood filling in volleyball players women with an average intermediate somatotype will increase with larger values of transverse inferothoracic size, interspinous distance and intercristal distance, and, simultaneously, with smaller values of forearm girth, shoulder width and skinfold thickness. It is noteworthy that skinfold thickness on the front surface of the shoulder had inverse correlations with all amplitude parameters, and most of them were strong.

M. Mirramezani and co-authors [14] emphasize the need to find new methods for accurate assessment of peripheral hemodynamic indicators, in particular the possibility of accurate assessment of the functional significance of peripheral vascular damage, because there are no modern standardized methods or techniques for its assessment. Characterization of the relationship between the amplitude parameters of peripheral hemodynamics and the anthropometric body dimensions of volleyball players women of different body types will make it possible to predict the

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morphofunctional changes of the crus vessels based on changes in the body structure.

Conclusions

1. The most numerous and strongest correlations between the amplitude parameters of the regional blood circulation at the crus and indicators of the external structure of the body were established in women volleyball players of medium intermediate and mesomorphic somatotypes. Ectomorphs have the smallest number and strength of correlations.

2. In volleyball players women of the mesomorphic somatotype, the most numerous correlations with indicators of the external structure of the body were found for the amplitude of the systolic wave and the basic impedance; in ectomorphs - incisor amplitude; in ectomesomorphs - amplitudes of rapid blood filling and basic impedance; in sportswomen with an average intermediate somatotype - basic impedance, amplitude of rapid blood filling and diastolic wave.

3. In volleyball players women of the mesomorphic somatotype longitudinal dimensions, epiphyses of the thigh and crus, circumferences of the forearm and chest, diameters of the pelvis (only direct correlations), skinfolds (mostly direct); in ecto-mesomorphs - total and longitudinal dimensions of the body, circumferences of limb segments, dimensions of the pelvis (only direct correlations), skinfolds (only reverse); in the middle intermediate somatotype - the width of the distal epiphysis of the shoulder, the dimensions of the chest and pelvis (only direct correlations), skinfolds (mostly reverse) were most often correlated with rheovasographic indicators. Single correlations from different groups of anthropometric sizes were found in ectomorphs.

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ОСОБЛИВОСТІ ВЗАЄМОЗВ'ЯЗКІВ АМПЛІТУДНИХ РЕОВАЗОГРАФІЧНИХ ПОКАЗНИКІВ ГОМІЛКИ З АНТРОПОМЕТРИЧНИМИ РОЗМІРАМИ У ВОЛЕЙБОЛІСТОК РІЗНИХ СОМАТОТИПІВ

Сарафинюк Л. А., Степаненко І. О., Хапіцька О. П., Андрощук О. В., Борейко Т. І., Сарафинюк П. В., Нестерова С. О. Соматотипологічні особливості організму можна розглядати як важіль спортивних досягнень, тому що вони мають вплив

на ефективність системи енергозабезпечення, фізичну працездатність, здатність до адаптації, стан серцево-судинної системи. Мета нашої роботи - виявити взаємозв'язки між амплітудними параметрами реовазограми гомілки та антропометричними показниками у волейболісток юнацького віку різних соматотипів. Проведено комплексне клініколабораторне дослідження стану здоров'я та фізичного розвитку 108 волейболісток віком 16-20 років (юнацький період онтогенезу) високих спортивних розрядів (від ІІ дорослого до майстрів спорту). Реовазографічні параметри гомілки у волейболісток визначали методом тетраполярної реокардіографії на сертифікованому комп'ютерному діагностичному багатофункціональному комплексі. Виконано антропометричне визначення тотальних розмірів тіла та грудної клітки, таза, кінцівок, голови за рекомендаціями Шапаренка П. П. (2000), соматотипологічне - за розрахунковим методом Heath-Carter (1990). Після соматотипування встановили, що до мезоморфного типу конституції належали 28 волейболісток, до ектоморфного та екто-мезоморфного соматотипів були віднесені по 27 спортсменок, до середнього проміжного типу - 26 волейболісток. Аналіз отриманих результатів проведений у ліцензійній програмі "Statistica 5.5" з використанням кореляційного аналізу за Спірменом. Нами встановлено, що високопрофесійні волейболістки, які мають різний тип статури тіла, різняться за силою та кількістю значущих зв'язків між амплітудними реовазографічними параметрами гомілки й антропометричними розмірами. Найчисельніші (18,64 % із можливих кореляцій, із них 6,82 % достовірних) і найбільшої сили (3 сильних з коефіцієнтом кореляції від -0,64 до -0,73) взаємозв'язки між амплітудними показниками реовазограми гомілки та параметрами зовнішньої будови тіла зафіксовані у волейболісток середнього проміжного соматотипу. У ектоморфів була найменша кількість та сила взаємозв'язків (3,18 % із можливих кореляцій, лише 1 достовірна). З амплітудними показниками реовазограми гомілки у волейболісток різних конституціональних типів найчастіше корелювали окремі поздовжні розміри тіла, обхвати грудної клітки та її діаметри, поперечні розміри таза, товщина шкірно-жирових складок. Визначення особливостей кореляцій є підґрунтям для оцінки гармонійності фізичного розвитку волейболісток та проведення у подальшому статистичного моделювання для визначення у них належних реовазографічних показників гомілки.

Ключові слова: кореляції, периферична гемодинаміка, гомілка, антропометрія, соматотип, волейболістки.

Author's contribution

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