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ASSESSMENT OF CHANGES IN MORPHOLOGICAL STATUS AND PHYSICAL QUALITIES OF 4–17-YEAR-OLD GIRLS ENGAGED IN RHYTHMIC GYMNASTICS

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Abstract. Aim of the study: to evaluate dynamics of the morphological status and physical qualities of 4–17-year-old girls engaged in rhythmic gymnastics. Calculation of indices and their estimation were done with the hardware and software complex titled "Psychofunctional status control in rhythmic gymnastics classes". As a result, we have discovered that the age of 7, 11 and 13-14 years is a sensitive period of an increase in longitudinal body dimensions of gymnasts. Body mass increases simultaneously with body length. Body girth dimensions also significantly increase at 7, 11, 13-14 and 16 years. Physical qualities also have significant changes: strength and speed-strength indices increased at 7 and 13-15 years (puberty), flexibility – at 7 and 14 years, performance – at 8 and 12 years, vestibular stability (coordination) – at 10 and 14 years. The conducted study allowed us to receive substantial data on age-related differences of young gymnasts according to morphological and functional indices, on the development of physical qualities and performance.
Keywords: rhythmic gymnastics, sport girls, morphological status, vestibular stability, physical qualities.

Introduction. Modern rhythmic gymnastics are described with stressful competitive activity and training process, a constantly increasing difficulty in coordination of performed exercises, a need to form stable and reliable skills [1-2]. Researchers share an opinion of a significant role of discovering increase rates of special qualities and functional properties during training, which correlates with a need for not only initial, but also stage diagnosis with the standard specially developed testing technology. Stage-based control allows to assess stage development of an athlete, which is a cause of a prolonged training effect as a result of long-term training – during a phase (or period), macrocycle (year), over a number of years (Olympic cycle). Prompt data on changes in functional processes and state of a body plays a substantial role in both planning training loads during athlete preparation and in arranging restorative measures within the biomedical support system [3-8].

Aim of the study: to evaluate dynamics of the morphological status and physical qualities of 4–17-year-old girls engaged in rhythmic gymnastics.

Methods and organization. The study included 4–17-year-old girls engaged in rhythmic gymnastics, including members of the Russian national team (adult and junior athletes), Moscow team, Donetsk team, as well as pupils of the Pyatigorsk Sports School No. 1, the Zheleznovodsk Sports School, and the TANDEM club located in Moscow, 206 people total.

All participants gave their consent for participation in accordance with the WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects, (2013), as well as a permission to process personal data. For minor participants, such permission was given by their legal representatives. The study was also approved by the Bioethics Committee of the North-Caucasian Federal Research and Clinical Center (protocol No. 1 dated 20.01.2022).

Calculation and estimation of the indices were done with the "Psychofunctional status

control in rhythmic gymnastics classes" complex [9]. Standing and hand dynamometry parameters were identified with corresponding dynamometers DS 200 and EN 101. To assess physical development, we used standard anthropometric methods: identifying body length (height) and mass, chest girth on inhale, exhale and pause, wrist girth. Standard requirements were met during the anthropometric study [10-12].

According to the study's data, we also calculated and analyzed morphological and functional values and indices: body surface area, chest girth, chest excursion, Quetelet index I, Quetelet index II (BMI), Broca index, Erisman index, Levi chest-height index, Levi body mass-length index, Pignet index, vital index, muscular strength to mass ratio index, back strength to mass ratio index.

Physical performance was rated with the Harvard step test [10]. Speed-strength abilities were determined with the standing long jump test. The sit and reach test was applied to evaluate flexibility, the ability to move the joints of the spine and the hip joints. In order to estimate vestibular stability, which is one of the main components of coordination abilities of gymnasts, we applied stabilometry with the "Stabilotrenazher ST-150" force plate (LLC "Mera-TSP", Moscow)

The statistical data processing was carried out with the Statistica 13.0 software. We compared the parameters with the non-parametric Kruskal-Wallis and Dunn's tests. The data is presented in a form of medians and quartiles (Me (Q1; Q3)).

Results and discussion. The test parameters were included in the "Psychofunctional and morphological indices of rhythmic gymnasts of different age (4 to 20 years)" [13] and "Postural stability indices of rhythmic gymnasts" electronic databases [14].

Table 1

Morphological (physical development) status indices of female rhythmic gymnasts, Me (Q1; Q3)

№	Groups	Body mass*, kg	Body length*, cm	Leg length*, cm	Arm length*, cm	Foot length*, cm
1	4 years (n=14)	18 (15;18)	107 (105;110)	55 (54;55)	43 (42;45)	17 (16;18)
2	5 years (n=7)	18 (17;18)	116 (108;118)	57 (55;64)	47 (43;48)	17 (16;18)
3	6 years (n=10)	19 (18;20)	116 (112;118)	63 (61;64)	50 (47;50)	18 (17;19)
4	7 years (n=10)	24 (22;28)	127 (125;132)	69 (66;75)	54 (53;57)	20 (19;20)
5	8 years (n=12)	25 (23;27)	130 (127;134)	72 (71;76)	56 (54;58)	20 (20;21)
6	9 years (n=18)	28 (23;30)	134 (130;139)	73 (72;78)	57 (54;58)	21 (20;22)
7	10 years (n=17)	28 (26;32)	137 (134;144)	77 (75;79)	61 (59;63)	21 (20;23)
8	11 years (n=21)	33 (30;37)	148 (143;152)	84 (81;87)	64 (60;65)	23 (21;24)
9	12 years (n=16)	34 (33;37)	149 (146;154)	87 (83;89)	66 (64;68)	23 (22;24)
10	13 years (n=16)	39 (37;42)	159 (157;164)	88 (83;93)	70 (67;71)	24 (23;25)
11	14 years (n=14)	43 (39;49)	163 (160;165)	92 (85;93)	71 (70;72)	24 (23;25)
12	15 years (n=12)	50 (43;52)	169 (162;171)	101 (94;101)	75 (72;78)	25 (25;26)
13	16 years (n=11)	50 (48;56)	168 (166;169)	94 (92;101)	76 (73;77)	25 (24;27)
14	17 years and older (n=28)	53 (50;55)	172 (168;173)	101 (96;101)	73 (71;75)	25 (24;26)
15	Number of intergroup pairwise differences, Dunn's test	38	37	35	39	28

Note: significance of differences was calculated with the Kruskal-Wallis (* – $p<0.01$, differences between all groups are significant) and Dunn's ($p<0.05$) tests, the data are described with the median and quartiles

Table 2

Morphological (physical development) status indices of female rhythmic gymnasts, Me (Q1; Q3)

№	Groups	Chest girth*, cm	Chest girth (at rest)*, am	Body surface, the Mosteller formula*, cm^2
1	4 years (n=14)	12 (12;12)	56 (53;57)	7338 (6788;7504)
2	5 years (n=7)	12 (11;12)	55 (54;57)	7489 (7269;7640)
3	6 years (n=10)	12 (12;12)	58 (55;58)	7748 (7607;8123)
4	7 years (n=10)	13 (12;13)	61 (60;64)	9210 (8803;10345)
5	8 years (n=12)	12 (12;13)	62 (61;64)	9399 (9050;9926)
6	9 years (n=18)	13 (13;13)	64 (61;67)	10224 (9213;10797)
7	10 years (n=17)	13 (13;14)	64 (63;67)	10404 (9869;11350)
8	11 years (n=21)	14 (13;15)	69 (65;72)	11740 (10949;12373)
9	12 years (n=16)	14 (13;15)	70 (68;72)	11905 (11389;13024)
10	13 years (n=16)	15 (14;15)	74 (72;78)	12998 (12697;13802)
11	14 years (n=14)	15 (14;15)	76 (74;83)	13697 (13290;15170)
12	15 years (n=12)	15 (15;15)	81 (79;84)	15324 (14786;16041)
13	16 years (n=11)	16 (15;17)	83 (81;87)	15302 (14847;15995)
14	17 years and older (n=28)	15 (15;15)	84 (81;84)	15215 (15015;15964)
15	Number of intergroup pairwise differences, Dunn's test	30	34	40

Note: significance of differences was calculated with the Kruskal-Wallis (* – $p<0.01$, differences between all groups are significant) and Dunn's ($p<0.05$) tests, the data are described with the median and quartiles

A comparative study (tables 1, 2) revealed statistically significant differences between all age-related groups in almost all studied parameters: body length, body mass, arm length, leg length, foot length, wrist girth, body surface area, chest girth, BMI.

An analysis of age-related changes and separate rapid increases in morphological parameters of female gymnasts showed that the most substantial increase in body length was registered at 7, 11 and 14 years, body mass – at 7, 11 and 14 years, leg length – at 7, 11 and 13 years, arm length – at 7 and 11 years, foot length – 7, 11 and 14 years, wrist girth – 7, 11 and 16 years, chest girth – 7, 11, 13-14 and 16 years, BMI –14 and 16 years.

Therefore, the age of 7, 11 and 13-14 years is a sensitive period of an increase in longitudinal body dimensions of the gymnasts. Body mass increases simultaneously with body length. Body girth dimensions also significantly increase at 7, 11, 13-14 and 16 years. Body mass to length ratio indices and proportionality indices practically do not change with age, which reflects a sufficient proportionality of the body of the girls who passed the initial selection in rhythmic gymnastics.

The results revealed a great number of statistically significant differences in physical qualities of gymnasts at different ages. The greatest increase rates in hand strength were noted at 7, 13 and 15 years (fig. 1). Results of the standing long jump test that evaluates speed-strength qualities improved at 7, 10 and 14-15 years (fig. 2). The best flexibility values in the sit and reach test were registered at 7 and 14 years (fig. 3). Results of the Harvard step test that characterizes physical performance (endurance) showed a significant increase at 8 and 12 years (fig. 4).

Vestibular stability (movement coordination) according to the statokinesiongram area index (table 3) with eyes both opened and closed improved by the age of 10 years, in terms of the statokinesiogram area and simultaneously the velocity of the center of mass movement – by the age of 14 years.

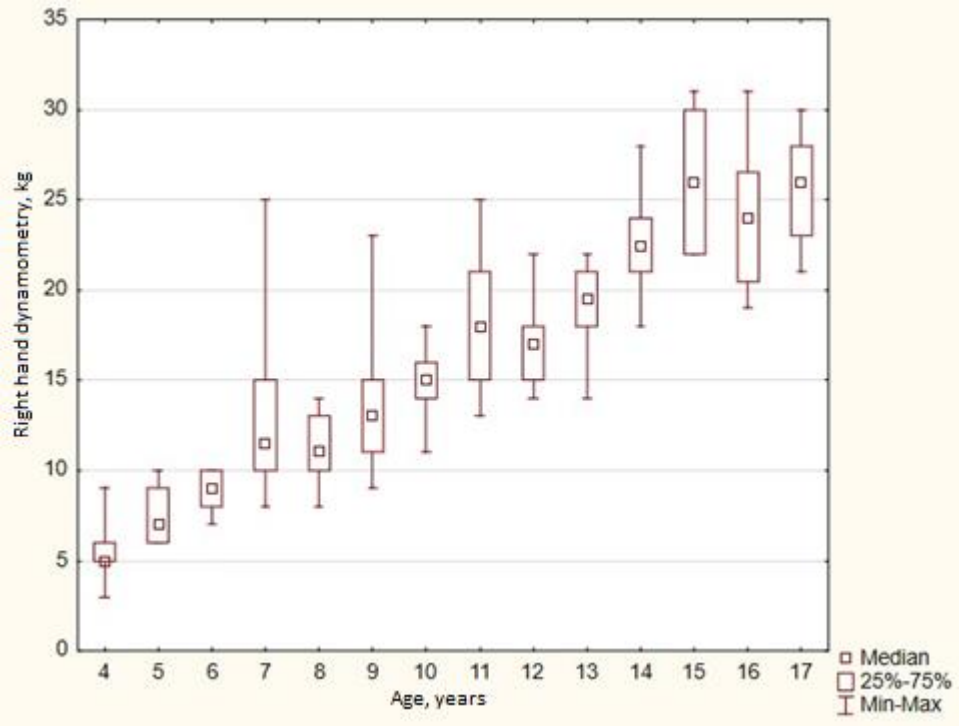

Fig. 1. Right hand dynamometry of 4–17-year-old rhythmic gymnasts, Me (Q1; Q3)

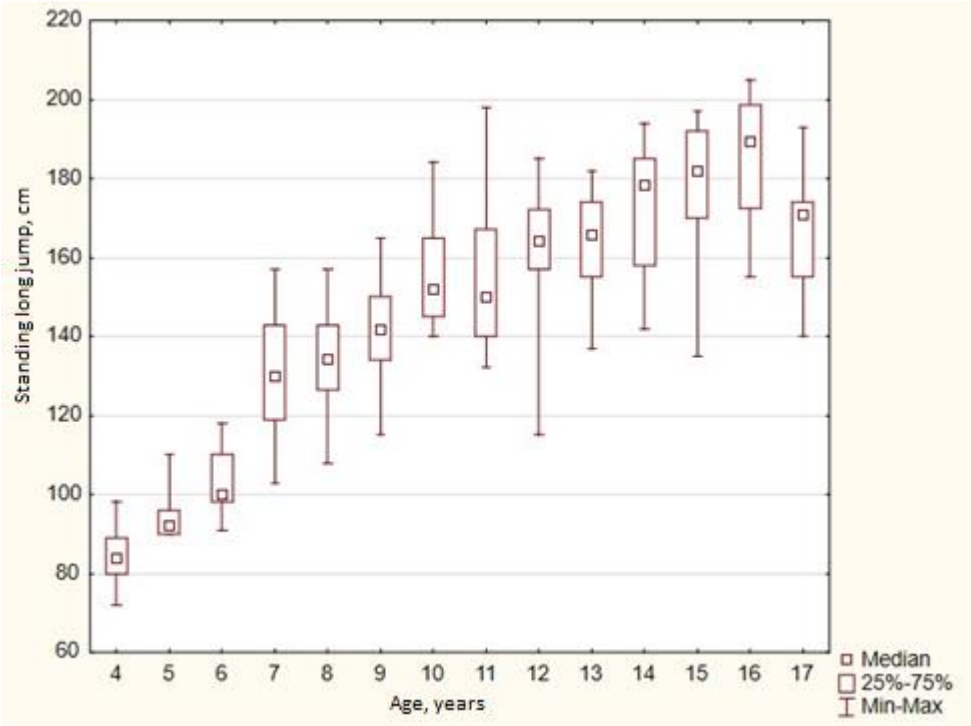

Fig. 2. Parameters of the standing long jump test among 4–17-year-old rhythmic gymnasts, Me (Q1; Q3)

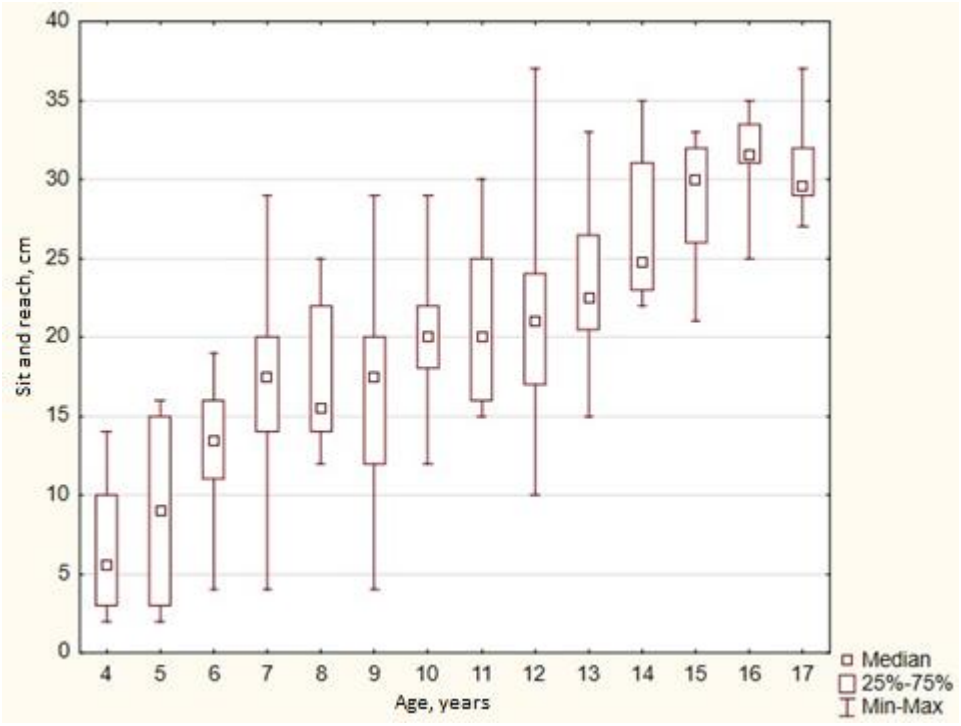

Fig. 3. Parameters of the sit and reach test among 4–17-year-old rhythmic gymnasts, Me (Q1; Q3)

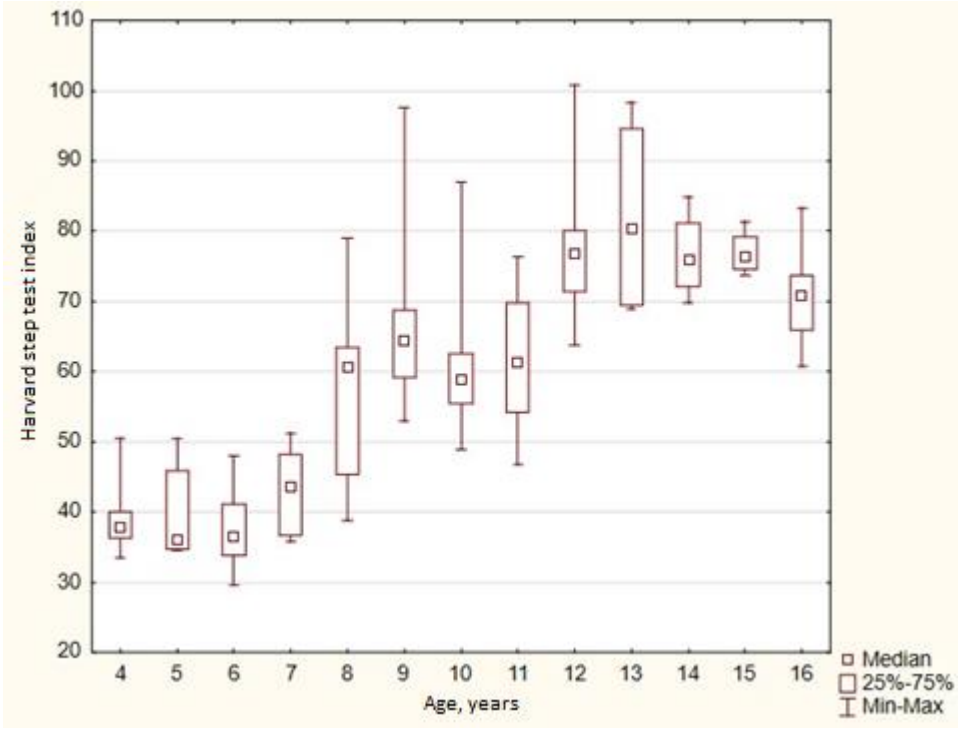

Fig. 4. Harvard step test index among 4–17-year-old rhythmic gymnasts, Me (Q1; Q3)

Table 3

Vestibular stability (Romberg test) parameters on a force plate among 4–17-year-old rhythmic gymnasts, Me (Q1; Q3)

№	Groups	S* (eyes open), mm^2	S* (eyes closed), mm^2	V* (eyes open), mm/s	V* (eyes closed), mm/s	P* (eyes open), mW	P*, (eyes closed), mW
1	4 years (n=14)	904 (741;1893)	978 (634;2048)	29 (26;37)	29 (27;49)	615 (466;1547)	717 (507;2014)
2	5 years (n=7)	1170 (762;1286)	943 (426;1096)	29 (22;39)	30 (22;36)	926 (427;1306)	665 (387;1106)
3	6 years (n=10)	393 (269;784)	432 (396;674)	18 (14;27)	23 (20;26)	253 (148;688)	449 (324;656)
4	7 years (n=10)	673 (380;728)	919 (581;1074)	19 (16;21)	28 (24;30)	271 (170;294)	499 (338;722)
5	8 years (n=12)	330 (196;735)	561 (322;675)	15 (12;18)	20 (16;28)	157 (102;273)	286 (193;728)
6	9 years (n=18)	429 (257;880)	391 (256;808)	15 (13;16)	17 (15;22)	139 (86;232)	230 (169;330)
7	10 years (n=17)	158 (109;329)	256 (212;337)	12 (10;14)	17 (13;20)	93 (68;133)	191 (160;279)
8	11 years (n=21)	189 (108;253)	235 (167;375)	10 (8;13)	15 (12;15)	55 (50;88)	120 (83;193)
9	12 years (n=16)	169 (114;413)	253 (190;396)	11 (11;14)	14 (13;20)	112 (97;149)	182 (125;275)
10	13 years (n=16)	200 (127;289)	292 (248;317)	12 (10;12)	16 (12;21)	110 (83;117)	218 (125;392)
11	14 years (n=14)	203 (113;374)	326 (278;418)	9 (7;14)	13 (10;20)	68 (42;145)	141 (67;389)
12	15 years (n=12)	302 (219;899)	12 (11;24)	210 (155;264)	10 (9;15)	185 (99;791)	93 (55;160)
13	16 years (n=11)	221 (151;572)	11 (9;16)	284 (140;423)	16 (10;21)	116 (85;222)	210 (81;327)
14	17 years and older (n=28)	200 (124;400)	9 (7;12)	178 (96;274)	8 (6;10)	85 (66;160)	62 (34;91)
15	Number of intergroup pairwise differences, Dunn’s test	7	12	13	14	11	14

Note: significance of differences was calculated with the Kruskal-Wallis (* – $p<0.01$, differences between all groups are significant) and Dunn’s ($p<0.05$) tests, the data are described with the median and quartiles; S – statokinesiogram area; V – mean velocity of the center of pressure; P – statokinesiogram power

Conclusion. Consequently, the conducted study allowed us to receive substantial data of scientific and practical interest on age-related differences of young gymnasts according to morphological and functional parameters, on the level of developing physical qualities and performance.

We have found that the age of 7, 11 and 13-14 years is a sensitive period of an increase in longitudinal body dimensions of gymnasts.

Body mass increases simultaneously with body length. Body girth dimensions also significantly increase at 7, 11, 13-14 and 16 years. Indices of body mass to length ratio and proportionality indices slightly changed, which shows a proper proportionality of the gymnasts' bodies. Physical qualities also underwent age-related changes: strength and strength-speed parameters improved at 7 and at 13-15 years, flexibility – at 7 and 14, total performance – at 8 and 12 years, vestibular stability (coordination) improved by the age of 10 and perfected by the age of 14. All physical qualities studied reached the adult level by puberty, which usually occurs somewhat later in gymnasts [15].

Conflict of interest. The authors declare no conflict of interest.

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COMPARATIVE AND STRUCTURAL ANALYSIS OF PHYSICAL DEVELOPMENT INDICES OF GIRLS OF THE FIRST AND SECOND CHILDHOOD

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Abstract. The aim of the study was a comparative and structural analysis of the physical development of girls during the first and second childhood. Anthropometric measurements were carried out using a sliding caliper, centimeter tape, spreading caliper, height chart and floor electronic scales. The obtained data were used to determine the body composition. According to the results, we obtained statistically significant data on age-related differences in physical development of 6-10-year-old girls. Analysis of anthropometric indices in dynamics by age demonstrated that the most substantial changes are noted in the increase in arm length at the age of 7, 9, 10 years, shoulder length – at 7, 9 years, length of the forearm, hand, leg, thigh, shin, foot – in all four studied age groups, chest girth – at 6, 7, 9 years, thigh girth – at 6, 7, 9 years, thickness of skin-fat folds on the abdomen – at 6 and 9 years, thickness of skin-fat folds on the thigh in front – at 6, 7 and 9 years. We also identified the structure of morphological parameters of girls at the age of 6, 7, 8, 9 and 10 years with factor analysis.

Keywords: physical development, anthropometry, body composition, morphological status, girls, first childhood, second childhood.

Introduction. Physical development is a natural process of change in the features of a body. This parameter is closely connected with human health, gender, age, living conditions and hereditary factor. A body acquires optimal morphological characteristics in favorable conditions. In unfavorable conditions, on the other hand, the human development potential is limited by the lower boundaries of the hereditary range.

The main parameters determining human physical development are body mass, longitudinal body dimensions (body length, length of upper and lower limbs), shoulder width and pelvic diameter [1].

Each stage of ontogenesis is characterized by its specific anatomical and physiological features. Differences between age groups are determined not only by quantitative but also by qualitative features of morphological structures [2].

The period of the first childhood is considered as the age of 4-7 years, which is characterized by the development of connective tissue and skeletal muscles, accompanied by an increase in body mass, chest girth and body length [3].

The age of 8-12 years (for girls) is the period of the second childhood, which is characterized by an annual gradual increase in body mass up to 2.5 kg, body length – by 4.5 cm and an increase in chest girth. All functions of a body reach their completion in development, individual and typological features of body constitution begin to appear [4].

The aim of the study is to conduct a comparative and structural analysis of the physical development of girls during the first and second childhood.

Methods and organization. The study involved 6-10-year-old girls from different regions of Russia: Stavropol Krai, Rostov, Moscow, Ivanovo, Tver, Vladimir, Astrakhan, Chelyabinsk Oblasts (210 people in total), who were undergoing treatment in children's sanatoriums of the Caucasian Mineral Waters.

When conducting the study, the child's legal representatives, parents have previously given an informed consent in accordance with Article 9 of the Federal Law dated July 27, 2006

No. 152-FZ "On personal data" [5]. Employees of the Center for Biomedical Technologies conducted anthropometric measurements of the participants using the following equipment: sliding caliper, centimeter tape, spreading caliper, height chart and floor electronic scales. The following parameters were identified: body length; body mass; longitudinal body dimensions of different body parts: arm, shoulder, leg, thigh, foot; girth of different body parts: hand, wrist, forearm, relaxed and tense shoulder, chest in a calm state; thickness of skin-fat folds: hand, forearm, abdomen, waist, thigh, shin using methodological recommendations titled "Method of complex anthropometry in sports and clinical practice" [6].

The indices were calculated and estimated with the "Human body mass composition" software. Thus, we registered the following parameters: body surface area, fat free body mass, absolute and relative masses of fat, bone and muscle components, specific body weight, Quetelet I, Quetelet II, Broca, Erisman and Pignet indices [7].

The statistical processing was made with the Statistica 12.0 software. The following statistical processing methods were used for the selected data: descriptive statistics presented as medians and quartiles (Me (Q1; Q3)), comparison of indices with the non-parametric Kruskal-Wallis test, and factor analysis.

Results and discussion. Modern anthropology considers human ontogenesis as a comprehensive process controlled by a single gene complex, with its own rates of growth and development [8]. A comparative analysis of body dimensions has shown that girls aged 6-10 years have an active development of skeletal muscles, manifested by an increase in body length and mass (table 1).

Table 1

Physical development parameters (body length and mass) of 6-10-year-old girls

№	Indices	6 years (n=50)	7 years (n=24)	8 years (n=46)	9 years (n=49)	10 years (n=41)	P
1	Body mass, kg	21.6	27.3	27.5	32.4	34.2	0.01
2	Body length, cm	117.8	126.3	131.6	137	141.8	0.01

Note: significance of differences was calculated with the Kruskal-Wallis test; differences between all the groups are significant

Analysis of length, girth parameters and thickness of skin-fat folds in dynamics by age revealed that the most significant increases are: arm length – at the age of 7, 9, 10 years, shoulder length – at 7, 9 years, length of forearm, hand, leg, thigh, shin, foot – in all four studied age groups, chest girth – at 6, 7, 9 years, thigh girth – at 6, 7, 9 years, thickness of skin-fat folds on the abdomen – at 6 and 9 years, thigh in front – at 6, 7 and 9 years (table. 2). Consequently, as a result of analyzing the physical development indices of 6-10-year-old girls, there is significant inter-age variability and insignificant inter-dimensional variability of girth and thickness of skin-fat folds.

Table 2

Physical development parameters of the girls during the first and second childhood, Me (Q1; Q3), cm

№	Indices	6 years (n=50)	7 years (n=24)	8 years (n=46)	9 years (n=49)	10 years (n=41)	P
1	2	3	4	5	6	7	8
2	Arm length	50 (48;52)	55 (52;56)	57 (55;59)	60 (57;62)	63 (59;64)	0.01
3	Shoulder length	19 (18;20)	22 (21;23)	22 (21;24)	24 (22;24)	25 (23;26)	0.01
4	Forearm length	19 (18;20)	20 (19;21)	21 (20;22)	22 (21;24)	23 (22;24)	0.01

Table 2 (continued)

5	Wrist length	12 (11;13)	13 (12;14)	14 (13;14)	14 (13;15)	14 (14;15)	0.01
6	Leg length	66 (64;69)	73 (70;77)	76 (73;79)	80 (76;83)	85 (81;88)	0,01
7	Thigh length	34 (32;35)	36 (33;39)	38 (36;39)	40 (38;42)	42 (40;45)	0.01
8	Shin length	32 (29;33)	35 (33;36)	36 (34;38)	38 (36;40)	40 (37;42)	0.01
9	Foot length	18 (17;18)	20 (19;21)	20 (19;21)	21 (20;22)	22 (21;23)	0,01
10	Chest girth at rest	56 (54;60)	62 (60;65)	63 (60;65)	65 (61;72)	67 (62;73)	0.01
11	Chest girth on inhale	61 (58;64)	67 (64;69)	67 (64;70)	70 (66;77)	72 (67;78)	0.01
12	Chest girth on exhale	56 (53;59)	61 (58;63)	61 (58;64)	63 (59;69)	65 (60;70)	0.01
13	Thighs' girth	63 (60;66)	68 (64;71)	68 (66;72)	72 (69;79)	75 (70;80)	0.01
14	Thigh girth	35 (33;38)	38 (35;41)	38 (36;42)	42 (38;46)	41 (39;47)	0.01
15	Skin-fat folds: the abdomen	7 (5;9)	8 (5;16)	8 (6;13)	13 (7;16)	10 (7;15)	0.01
16	Skin-fat folds: thigh in front	8 (7;12)	12 (8;17)	12 (8;15)	15 (12;17)	12 (8;16)	0.01

Note: significance of differences was calculated with the Kruskal-Wallis test; differences between all the groups are significant

Factor analysis was used to identify the structure of significant factors showing morphological differences separately for each age. The first significant factor for 6-year-old girls included characteristic changes in the body composition, including muscle, fat and bone body mass – changes in latitudinal indices with a total share of variance of 41.2%. The second significant factor for this age is connected with the development of longitudinal body characteristics with a total share of variance of 30.2% (table 3).

Table 3

Main factors reflecting the body composition of 6-year-old girls

Factors	Variables	Total share of variance
1	Fat free body mass – Behnke formula, kg	41.2%
	Body surface area – Isaksson formula, m^2	
	Absolute mass of fat component (D) – Ya. Matejko formula, kg	
	Absolute mass of muscle component (M), kg	
	Absolute mass of bone component (O), kg	
2	Quetelet index I, g/cm	30.2%
	Quetelet index II (body mass index (BMI)), kg/m^2	
	Erisman index, cm	
	Pignet index, c.u.	

The first significant factor for 7-year-old girls included the composition of body mass (muscle, fat and bone component) – changes in latitudinal indicators with a total share of variance of 42.4%. The second significant factor for this age is related to the development of longitudinal body characteristics and body mass with a total share of variance of 39.8% (table 4).

Table 4

Main factors reflecting the body composition of 7-year-old girls

Factors	Variables	Total share of variance
1	Fat free body mass – Behnke formula, kg	42.4%
	Body surface area – Isaksson formula, m^2	
	Absolute mass of fat component (D) – Ya. Matejko formula, kg	
	Relative mass of fat component (D1), %	
	Absolute mass of muscle component (M), kg	
	Relative mass of muscle component (M1), %	
	Absolute mass of bone component (O), kg	
2	Quetelet index I, g/cm	39.8%
	Quetelet index II (body mass index (BMI)), kg/m^2	
	Broca index, %	
	Erisman index, cm	
	Pignet index, c.u.	

The first significant factor for 8-year-old girls with a total share of dispersion of 36.9% characterized the development of longitudinal characteristics of a body and body mass. The second significant factor for this age characterized changes in the body composition, including muscle, fat and bone components – changes in latitudinal indices with a total share of dispersion of 36.5% (table 5).

The first significant factor of 9-year-old girls with a total share of dispersion of 44.2% combines longitudinal parameters and body mass. The second significant factor for this age – the body composition, including muscle, fat and bone component – changes in latitudinal indices with a total share of dispersion of 34.5% (table 6).

Table 5

Main factors reflecting the body composition of 8-year-old girls

Factors	Variables	Total share of variance
1	Fat free body mass – Behnke formula, kg	36.9%
	Body surface area – Isaksson formula, m^2	
	Relative mass of bone component (O1), kg	
	Absolute mass of muscle component (M), kg	
	Absolute mass of bone component (O), kg	
2	Absolute mass of fat component (D) – Ya. Matejko formula, kg	36.5%
	Quetelet index II (body mass index (BMI)), kg/m^2	
	Broca index, %	
	Erisman index, cm	
	Pignet index, c.u.	

Table 6

Main factors reflecting the body composition of 9-year-old girls

Factors	Variables	Total share of variance
1	Absolute mass of fat component (D) – Ya. Matejko formula, kg	44.2%
	Relative mass of bone component (O1), kg	
	Quetelet index I, g/cm	
	Quetelet index II (body mass index (BMI)), kg/m^2	
	Broca index, %	
	Erisman index, cm	
	Pignet index, c.u.	
2	Fat free body mass – Behnke formula, kg	34.5%
	Body surface area – Isaksson formula, m^2	
	Absolute mass of muscle component (M), kg	
	Absolute mass of bone component (O), kg	

The first significant factor for 10-year-old girls with a total share of dispersion of 47.3% characterizes the increase in length parameters and body mass. The second significant factor for this age is related to characteristic changes in the body composition, including muscle, fat and bone components – changes in latitudinal indices with a total share of dispersion of 31.3% (table 7).

According to the results of the factor analysis of the data assessing the priority of development of morphological features separately for each age, the main criteria characterizing the physical development of the studied girls were identified: latitudinal and longitudinal indices (table 8).

Table 7

Main factors reflecting the body composition of 10-year-old girls

Factors	Variables	Total share of variance
1	Absolute mass of fat component (D) – Ya. Matejko formula, kg	47.3%
	Relative mass of fat component (D1), %	
	Specific body mass	
	Quetelet index I, g/cm	
	Quetelet index II (body mass index (BMI)), kg/m^2	
	Broca index, %	
	Erisman index, cm	
	Pignet index, c.u.	
2	Fat free body mass – Behnke formula, kg	31.3%
	Body surface area – Isaksson formula, m^2	
	Absolute mass of muscle component (M), kg	

Table 8

Main indices characterizing morphological status of 6-10-year-old girls

Age	6 years	7 years	8 years	9 years	10 years
1 factor	latitudinal	latitudinal	longitudinal	longitudinal	longitudinal
2 factor	longitudinal	longitudinal	latitudinal	latitudinal	latitudinal

Conclusion. The conducted study allowed to obtain significant data making it possible to assess the physical development of 6-10-year-old girls. Significant inter-age variability and insignificant variability of girth and thickness of skin-fat folds were revealed. Analysis of morphological indices in dynamics by age demonstrated that the most significant changes were noted in the increase of following parameters: arm length – at the age of 7, 9, 10 years, shoulder length – at the age of 7, 9 years, length of the forearm, hand, leg, thigh, shin, foot – in all four studied age groups, chest girth – at 6, 7, 9 years, thigh girth – at 6, 7, 9 years, thickness of skin-fat folds on the abdomen – at 6 and 9 years, thickness of skin-fat folds on the thigh in front – at 6, 7 and 9 years. With the help of factor analysis the structure of morphological status in girls aged 6, 7, 8, 9 and 10 years was determined, showing morphological differences of the participants: latitudinal and longitudinal indices. The obtained data may be used as model characteristics for further assessment of physical development and health of girls of this age.

Conflict of interest. The authors declare no conflict of interest.

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METHOD OF TREATMENT AND RESTORATION MEASURES FOR INFANTS WITH TORTICOLLIS

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Abstract. The article presents the effectiveness of treatment and restoration measures for infants with torticollis. The course's duration was 5 weeks with gradual complication of the applied measures and forms of sessions. After the course, examination results according to the R. Bernbeck's method were improved: "Neck rotation" – by 59.63%, "Lateral neck flexion" – by 83.51%, "Point ratio according to the muscle function scale (affected/unaffected side)" – by 72.43%. The anthropometric results were also improved: passive head tilt to the affected muscle – by 25,30%, passive head tilt to the side opposite to the affected muscle – by 6.97%, distance from the mental protuberance (point 2) to the acromion (point 3) in passive head turn toward the affected muscle – by 37.2%, in passive head turn to the side opposite to the affected muscle – by 37.4%. Values of cervical spine goniometry in passive head tilt to the affected muscle improved by 76%, in passive head tilt to the side opposite to the affected muscle – by 56%. When parents of the patients subjectively assessed the course's effect, 60% of them reported high results, 40% of them reported good results. The data obtained in the course of the study convincingly demonstrate effectiveness of treatment and restoration measures for infants with torticollis.
Keywords: treatment and restoration measures, torticollis, children, infancy, hydrokinesiotherapy, therapeutic gymnastics, therapeutic massage, myofascial release.

Introduction. The problem of birth deformities remains as the most relevant and has serious social and medical significance. That having been said, torticollis is registered in 16% of newborns [1]. Torticollis is a congenital or acquired neck deformity that is characterized with an incorrect position of the head, i.e. lateral tilt and turning it [2-3]. Congenital torticollis is a pathology due to unilateral developmental disorder of the sternocleidomastoid muscle, characterized by shortening of one of these muscles. This pathology may also be caused by a deformity of the cervical vertebrae, in case of which the vertebra narrows or becomes wedge-shaped, resulting in an imbalance of the nearby muscle system. The progression of the deformity is expressed in facial asymmetry, asymmetry of nasolabial folds, atrophy of the cheek muscles, smaller lower jaw and a number of other diverse signs. Application of treatment and restoration measures, such as physical therapy and massage, with other methods at earlier stages of child's development leads to more effective corrective results, contributing to prevention of occurrence and progression of such complications.

Aim of this study: to evaluate effectiveness of treatment and recovery measures for children with torticollis.

Methods and organization. The study took place in the child swimming center "Bul'-Bul'" ("Gurgle-gurgle") located in Chelyabinsk. It included 15 4-5-month children, 9 boys and 6 girls. Main criteria for participant selection were: age – 4-5 months, congenital torticollis, absence of contraindications for the used methods.

Before and after the course, we carried out an external examination according to the R. Bernbeck's method [4-5]: neck rotation (degrees), lateral neck flexion (degrees), point ratio according to the muscle function scale

(affected/unaffected side). We also estimated anthropometric indices according to a distance (in cm) between points (fig. 1): head tilt to the affected muscle, point 1 to point 3 (cm); passive tilt to the side opposite to the affected muscle, point 1 to point 3 (cm); distance between point 2 and point 3 in passive head turn to the side of the affected muscle (cm); distance between point 2 and point 3 in passive head turn to the side opposite to the affected muscle (cm) (fig. 1).

Goniometry was also performed with the evaluation of the results (in degrees) for passive head tilt: passive head tilt to the affected muscle and passive head tilt to the side opposite to the affected muscle. The obtained data were statistically processed in Statistica 13. We calculated the arithmetic mean (X) and standard deviation (σ), the significance of the differences between the indices before and after the study was identified with the Wilcoxon's signed rank test at the level of $p<0,05$.

The course lasted 5 weeks and consisted of 3 periods: introductory (14 days), main (10-14 days), final (5-7 days), each of which was characterized by specific tasks and the choice of means and forms for their implementation (fig. 2).

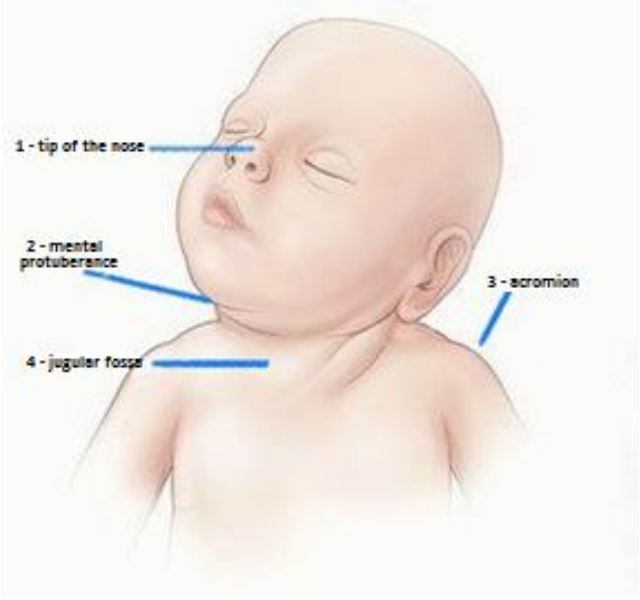

Fig 1. Location of measurement points in the anthropological study

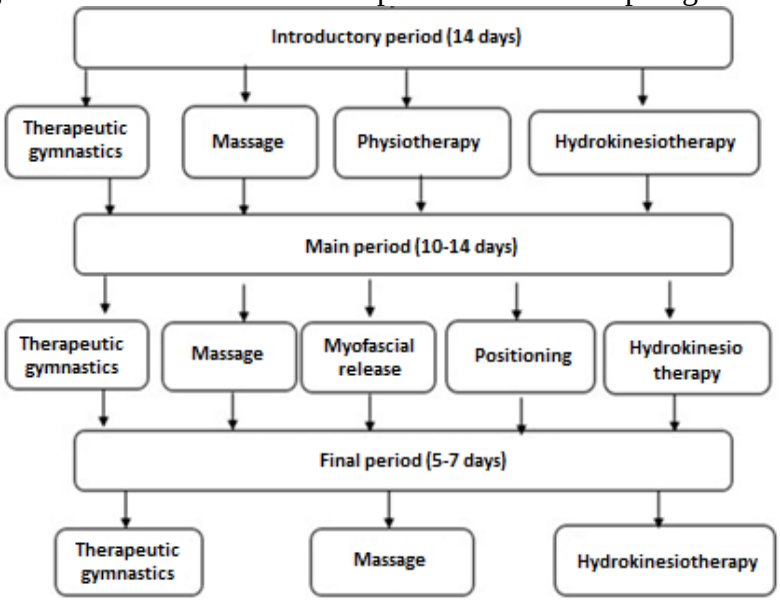

Fig. 2. General scheme of methodology of treatment and recovery measures for infants with torticollis

The introductory period of treatment and recovery measures included therapeutic gymnastics (passive alternating and simultaneous movements in the limbs) for 10-15 minutes every day, gentle rocking on an exercise ball, therapeutic massage (every other day), physiotherapy (wax therapy) was carried out 2-3 times a day, hydrokinesiotherapy – each day for 7-10 minutes (swimming on a stomach, side pulling) at a water temperature of 36-37°C.

The main period additionally used myofascial release conducted every other day for 5 minutes (relaxation of muscles and fasciae – connective tissue, pressure on the points was applied by hand or with a roller), positioning – daily 2-3 times a day (a child is laid down on a hard mattress without a pillow, the procedure was done during a nap); time of hydrokinesiotherapy session was increased to 7-12 minutes every other day at a water temperature of 34-35°C. The final period consisted of: therapeutic gymnastics, duration of a therapeutic massage session increased to 10-15 minutes, the time of hydrokinesiotherapy procedures (every other day) increased to 10-15 minutes with a decrease in water temperature to 33-34°C.

Effects of the suggested course were evaluated by the dynamics of the studied parameters (table 1, 2). Results of the R. Bernbeck examination revealed significant improvement in the following indices: "Neck rotation" – by 59.63%, "Lateral neck flexion" – by 83.51%, "Point ratio according to the muscle function scale (affected/unaffected side)" – by 72.43% (table 1).

Table 1

Changes in the results of the R. Bernbeck examination in infants with torticollis during the course, X±σ

Tests	Initial values	Final values	P<
Neck rotation, degrees	45±11.02	71±6.39	0.05
Lateral neck flexion, degrees	28±13.90	51±2.92	0.05
Point ratio according to the muscle function scale (affected/unaffected side), c.u.	1.85±0.23	0.51±0.01	0.05

Results and discussion. As a result of the course, the anthropometric indices improved: passive head tilt to the affected muscle – by 25,30%; passive head tilt to the side opposite to the affected muscle – by 6.97%; increase in the distance between point 2 and point 3 in passive turn to the affected muscle amounted to 37.2%; dynamics of the point 2 to point 3 distance in passive turn to the side opposite to the affected muscle improved by 37.4% (table 2).

Values of cervical spine goniometry in passive head tilt to the affected muscle improved by 76%, in passive head tilt to the side opposite to the affected muscle – by 56% (table 3).

Table 2

Changes in the results of the anthropometry test in infants with torticollis during the course, X±σ

Tests	Initial values	Final values	P<
Passive head tilt to the affected muscle, point 1 to point 3, cm	9.92±2.62	7.41±0.07	0.05
Passive head tilt to the side opposite to the affected muscle, point 1 to point 3, cm	6.31±0.28	5.87±0.32	0.05
Point 2 to point 3 distance in passive head turn to the affected muscle, cm	9.31±0.05	5.85±0.37	0.05
Point 2 to point 3 distance in passive head turn to side opposite to the affected muscle, cm	5.80±0.31	3.63±0.02	0.05

Table 3

Changes in the results of the goniometry test in infants with torticollis during the course, X±σ

Tests	Initial values	Final values	P<
Passive head tilt to the affected muscle, degrees	13±5.60	35±9.74	0.05
Passive head tilt to the side opposite to the affected muscle, degrees	25±4.10	39±7.64	0.05

In the survey of the patients' parents on the effectiveness of the course, 60% of the respondents reported high results, the rest (40%) reported good results.

Conclusion. Positive result dynamics of the R. Bernbeck examination, anthropometric indices, goniometry of the cervical spine and parental assessment convincingly demonstrate effectiveness the course that includes treatment and restoration measures for infants with torticollis.

Conflict of interest. The authors declare no conflict of interest.

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EFFECTS OF HYPEROXIC INHALATION IN ATHLETES WITH AEROBIC AND ANAEROBIC LACTATE MECHANISMS OF ENERGY SUPPLY OF MUSCLE ACTIVITY, WHO HAD COVID-19, DURING TRAINING IN MIDDLE ALTITUDE CONDITIONS

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Abstract. Aim of the study – to evaluate an effect of a hyperoxic inhalation course on the oxygen transport system of athletes with aerobic and anaerobic lactate mechanisms of energy supply of muscle activity, who previously had COVID-19, when performing intense training loads in middle altitude conditions. The study included 54 qualified athletes (Candidate for Master of Sports, Master of Sports of International Class), among which 24 male and 30 female athletes. 25 of them had COVID-19. The inhalation course that consisted of not less than 7 procedures, had a positive effect on the oxygen transport system of all athletes regardless of the predominant energy supply mechanism during training camps in middle altitude, including athletes, who had COVID-19. Athletes with the anaerobic lactate mechanism especially need additional support with hyperoxic mixture due to the specificity of their training and competitive activity.
Keywords: hyperoxic mixture, middle altitude, athletes, COVID-19, mechanisms of energy supply of muscle activity, oxygen transport system.

Introduction. Preparation of athletes in hypoxic conditions of middle altitude is widely practiced in elite sports. Most scientists consider middle altitude as a zone of 800-1000 to 2500 m above sea level, the main feature of which are functional changes in a body in case of moderate activity. Adaptation of a body to altitude hypoxia is a complicated process, which causes alterations from the cardiovascular, hematopoietic, external respiration and gas exchange systems. This is the reason why mountain training is practiced as a measure for improving functional capabilities of athletes and their performance in all sports [1-2]. In case of training athletes, who previously had COVID-19 and started training in middle altitude conditions, it is important to note that in intense activity they may have lowered parameters of blood oxygen saturation, even though the morphological nature of such signs is not identified. These signs may serve as consequence of both disturbed diffusion capacity of the lungs and increased bronchial reactivity [3]. Therefore, altitude hypoxia may be connected with a certain risk for athletes, who had COVID-19, so they need a special approach and additional ways to support the functional status of the cardiovascular system [4-5]. Mixtures with increased oxygen content that has been used widely in elite sports for several years to correct the functional status, improve functional capabilities of the respiratory system and performance of athletes may become one of these additional ways [6-9]. The literature sources contain research demonstrating that a combined effect of middle altitude hypoxia with controlled oxygen therapy positively influences the cardiorespiratory system of athletes, who had COVID-19. Moreover, a conclusion was made that middle altitude training for these athletes is effective and safe [10-12]. However, there are practically no data on the effect of hypeoxic gas mixtures on the functional status of athletes, who had COVID-19 and trained in middle altitude, taking into account specifics of different sports.

Aim of the study – to evaluate an effect of a hyperoxic inhalation course on the oxygen transport system of athletes with aerobic and

anaerobic lactate mechanisms of energy supply of muscle activity, who previously had COVID-19, during intense training in middle altitude conditions.

Methods and organization. The study took place in the Center of Biomedical Technologies of the North-Caucasian Federal Research and Clinical Center of the Federal Medical and Biological Agency (Maloe Sedlo Mountain, Kislovodsk) during training camps in the "Yug Sport" center at an altitude of 1240 m. It involved 54 qualified athletes (Candidate for Master of Sports, Master of Sports, Master of Sports of International Class), including 24 male and 30 female athletes. Average age of the participants – 18.7±5.6 years. Sports: boxing (13 people, women), underwater sports (7 people, men), figure skating (17 people, women), mountaineering (5 people, men), ski racing (5 people, men), ski mountaineering (7 people, men). Among 54 athletes 25 of them (20 female and 5 male athletes) previously had COVID-19. During the study, the athletes continued training intensively (2-3 times a day).

At the beginning and at the end of the training camps all athletes were monitored, including a measurement of physiological parameters of the cardiovascular and respiratory systems. These parameters were measured with the ESTECK System Complex (LD Technology, USA). We studied heart rate variability (HRV), hemodynamics, indexes of blood oxygen saturation and oxygen uptake from the microcirculation system. The external respiration function was evaluated with the MicroLoop spirometer (CareFusion, UK) and the Spirometry PC Software (CareFusion, UK).

To make the hyperoxic mixture, we used the JAY-10 oxygen concentrator (Longfian, Chine). Oxygen concentration in the mixture amounted to 93±3%, capacity – 5 l/min, exposure – 20 minutes. The hyperoxic mixture was delivered to the airway via a cannula. The inhalations were done daily, and the course included not less than 7 procedures.

The statistical data processing was done with the non-parametric Wilcoxon matched pair test and the Statistica 13.0 software. Difference in values deemed significant when $p<0,05$. The data are presented in median and quartiles (Me (Q1; Q3)) due to the small number of groups studied.

Results and discussion. Taking into account different contributions of aerobic sources into the energy supply of muscle activity in different sports and, consequently, different limiting contributions of the oxygen transport system into performance, we analyzed effects of hyperoxic inhalations during training for athletes with predominantly aerobic and anaerobic lactate mechanisms of energy supply of muscle activity.

Effects of hyperoxic inhalations for athletes, specialized in sports with anaerobic lactate energy supply of muscle activity, during the training camps in middle altitude.

Figure skating. Duration of an optional program – to 4 minutes, short program – to 2.5 minutes. Therefore, the energy supply mechanism is mainly aerobic lactate.
The study included female athletes, who had and did not have COVID-19. They all took a course of hyperoxic mixture inhalations. For those who had and did not have COVID-19, heart rate indices significantly decreased (had COVID-19 – $p<0.02$; did not have COVID-19 – $p<0.05$) while the stress index (SI) decreased and power of high-frequency waves (HF) increased, which reflects positive changes and enhancement of parasympathetic heart rate regulation (table 1).

Athletes, who had COVID-19, had also positive changes in the cardiovascular indices, consisting in an increase of function's efficiency (although the indices were lower than the physiological standard associated with long-term adaptation and sports hypotension), due to a decrease in the stiffness index, mean and diastolic blood pressure (BP) and the index of disturbed oxygen uptake from the microcirculation system (table 2).

The spirometry indices in athletes, who did not have COVID-19, substantially increased after the course (table 3).

Table 1

Changes of heart rate variability in female figure skaters under the effect of oxygen therapy in middle altitude conditions, Me (Q1; Q3)

№	Indices	Standard	Had COVID-19, n=7		P<	Did not have COVID-19, n=10		P<
			before	after		before	after	
1	HR, beats/min	60-80	88.0 (73.8; 102.0)	79.0 (64.1; 80.3)	0.02	93.8 (82.0; 99.0)	86.7 (70.7; 87.2)	0.05
2	HF, %	22-34	30.2 (22.8; 35.6)	31.4 (21.9; 40.0)	-	27.0 (20.2; 32.9)	29.1 (24.0; 34.7)	-
3	LF, %	22-46	28.8 (25.9; 30.9)	29.9 (25.4; 33.1)	-	29.5 (25.3; 31.0)	31.4 (30.2; 34.7)	-
4	LF/HF	0.5-2	0.9 (0.9; 1.1)	1.0 (0.8; 1.0)	-	1.3 (0.8; 1.5)	1.0 (0.9; 1.5)	-
5	SI, c.u.	50-200	142.0 (90.0; 185.4)	119.6 (57.6; 172.1)	-	177.0 (86.0; 224.5)	108.8 (102.3; 146.5)	-
6	SDNN, ms	40-80	50.3 (44.0; 54.9)	48.4 (40.5; 70.5)		40.7 (36.7; 66.4)	55.6 (39.7; 61.2)	-

Note: HR – heart rate; HF – power of high-frequency waves; LF – power of low-frequency waves; LF/HF – balance of the sympathetic/parasympathetic nervous system; SI – stress index; SDNN – standard deviation of NN intervals

Table 2

Changes in the functional status of the cardiovascular system in female figure skaters under the effect of oxygen therapy in middle altitude conditions, Me (Q1; Q3)

№	Indices	Standard	Had COVID-19, n=7		P<	Did not have COVID-19, n=10	
			before	after		before	after
1	SpO_2, %	95-100	95.0 (93.0; 96.0)	96.0 (95.0; 97.0)	-	94.0 (94.0; 96.0)	95.0 (94.0; 96.0)
2	Stiffness index, m/s	7-9	5.3 (5.0; 5.4)	5.1 (4.8; 5.2)	0.04	5.0 (4.7; 5.2)	5.2 (5.0; 5.4)
3	Reflection index, %	30-45	25.0 (25.0; 25.0)	25.0 (25.0; 25.0)	-	25.0 (25.0; 25.0)	25.0 (25.0; 25.0)
4	Augmentation index, c.u.	0.89-1.33	1.0 (1.0; 1.1)	1.0 (1.0; 1.0)	-	1.0 (1.0; 1.0)	1.0 (0.9; 1.0)
5	b/a, c.u.	-0.77--0.41	-1.2 (-1.2; -1.1)	-1.1 (-1.2; -1.1)	-	-1.1 (-1.2; -1.1)	-1.1 (-1.2; -1.0)
6	d/a, c.u.	0.15-0.49	-0.2 (-0.3; -0.2)	-0.3 (-0.3; -0.2)	-	-0.3 (-0.3; -0.2)	-0.3 (-0.3; -0.2)
7	PVR, mPa*S/m³	900-1500	1324.9 (1084.0; 1365.9)	1162.1 (1115.5; 1363.3)	-	1178.9 (1115.8; 1296.8)	1295.0 (1074.8; 1407.0)
8	Cardiac output, l/min	4.6-5.6	5.1 (4.7; 5.4)	4.9 (4.4; 5.4)	-	4.8 (4.6; 5.2)	4.7 (4.3; 5.4)

Table 2 (continued)

9	CI, l/min/m^2	2.6-3.2	3.2 (2.8; 3.3)	3.1 (2.8; 3.3)	-	3.1 (2.8; 3.2)	3.1 (2.8; 3.1)
10	meanBP, mm of Hg	95-110	78.0 (72.7; 84.3)	75.0 (68.7; 75.7)	0.04	74.0 (68.7; 78.3)	78.9 (72.3; 84.7)
11	VO_2, ml/min/m²	200-300	320.0 (320.0; 320.0)	310.0 (190.0; 320.0)	0.05	320.0 (320.0; 320.0)	320.0 (320.0; 320.0)
12	sBP, mm of Hg	110-140	100.0 (90.0; 111.0)	93.0 (92.0; 99.0)	-	99.5 (93.0; 109.0)	110.0 (97.0; 112.0)
13	dBP, mm of Hg	75-90	68.0 (64.0; 70.0)	64.0 (54.0; 66.0)	0.03	60.0 (56.0; 63.0)	65.5 (56.0; 69.0)

Note: SpO_2 – blood oxygen saturation; b/a – marker of the left ventricle function; d/a – stiffness index of the small and medium-sized arteries; PVR – peripheral vascular resistance; CI – volumetric blood flow index; meanBP – mean blood pressure; VO_2 – index of disturbed oxygen uptake from the blood microcirculation system; sBP – systolic blood pressure; dBP – diastolic blood pressure

Table 3

Spirometry indices of female figure skaters under the effect of oxygen therapy in middle altitude conditions, Me (Q1; Q3)

№	Indices	Had COVID-19, n=7		Did not have COVID-19, n=10		P<
		before	after	before	after	
1	VC, l	3.5 (3.2; 3.6)	3.5 (3.4; 3.9)	3.2 (3.2; 3.6)	3.5 (3.2; 3.7)	0.04
2	% proper VC	93.0 (87.0; 95.0)	96.0 (91.0; 99.0)	89.0 (87.0; 96.0)	93.0 (88.0; 100.0)	0.05
3	FVC, л	3.8 (3.5; 4.3)	3.7 (3.5; 4.1)	3.4 (3.1; 3.7)	3.6 (3.3; 3.8)	0.04
4	FEV1/FVC %	86.0 (82.0; 95.0)	89.0 (85.0; 91.0)	93.0 (89.0; 97.0)	89.0 (84.0; 93.0)	0.02

Note: VC – vital capacity; % proper – percentage of proper values; FVC – forced vital capacity; FEV1/FVC – ratio of the forced expiratory volume in the first second and forced vital capacity (Tiffeneau index)

Underwater sports. The length of distances in underwater sports is up to 1500 m, training activity takes place in a state of hypoxia, therefore the anaerobic lactate energy supply mechanism also prevails to a greater extent. The study included athletes, who did not have COVID-19, they took the inhalation course during the training camps. The analysis revealed a statistically significant decrease in SDNN (before: 62.3 (48.1; 78.6) ms, after: 49.8 (48.0; 58.5) ms, $p<0.04$) (fig. 1).

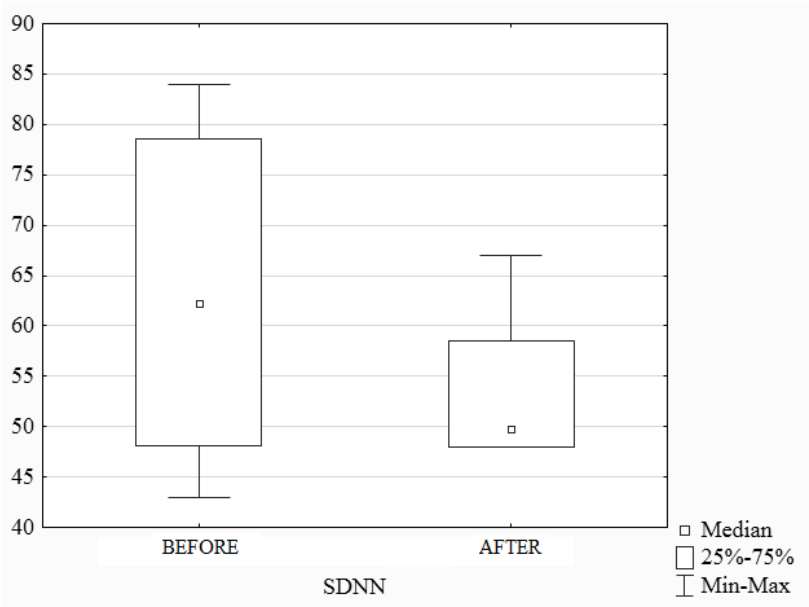

Fig. 1. Changes in standard deviation of NN intervals (SDNN) in men engaged in underwater sports (n=7) in middle altitude conditions before and after the inhalation course

We also registered an increase in SI (before: 73.2 (48.3; 128.5) c.u., after: 137.5 (77.6; 166.9) c.u.), which may reflect stronger sympathetic effect on heart rate.

No statistically significant changes were found in the functional status of the cardiovascular system and blood oxygen saturation. It is important to note that low values of saturation were registered before and after the course (before: 93.0 (93.0; 95.0) %, after: 94.0 (92.0; 94.0) %), which shows signs of hypoxia.

According to the spirometry values, positive changes (without significant differences) were found in a form of increased VC (before: 6.4 (5.1; 6.7) l, after: 6.5 (5.3; 6.9) l) and FVC (before: 6.2 (5.2; 6.8) l, after: 6.4 (5.1; 6.4) l).

Boxing. According to rules, duration of a boxing round is 1 to 3 minutes, which is why the anaerobic lactate mechanism of energy supply manifests itself to a greater extent. The study included female boxers who previously had COVID-19. They did not take the inhalation course. There were no substantial changes in HRV indices. SI decreased (before: 130.1 (106.9; 154.3) c.u., after: 113.1 (84.4; 150.1) c.u.) demonstrating a tendency for a decrease in stress of regulatory systems of a body, weakened activity of the central regulation mechanisms up to the end of the camps.

According to hemodynamic indices, sBP significantly increased (before: 103.0 (96.0; 117.0) mm of Hg, after: 111.0 (107.0; 113.0) mm of Hg, $p<0.05$), and at the end its values were lowered to the physiological standard.

We also registered positive changes in the external respiration indices, shown in increased VC (before: 3.7 (3.6; 4.2) l, after: 4.0 (3.8; 4.3) l) and FVC (before: 3.6 (3.6; 4.1) l, after: 3.9 (3.7; 4.1) l).

Therefore, athletes with the predominant anaerobic lactate mechanism of energy supply, who experience hypoxia during their athletic activity, may also experience it at rest during training in middle altitude. To terminate oxygen debt after physical activity they need additional measures of oxygen intake. Use of hyperoxic gas mixture inhalations for such athletes, especially for those who had COVID-19, contributes to positive changes in the functional status, consisting in a decrease in the stress of regulatory mechanisms, increased tone of the parasympathetic nervous system in the heart rate regulation, increased efficiency of the central hemodynamics parameters, enhanced function of the external respiratory system.

Effects of hyperoxic inhalations in athletes, specialized in mainly aerobic sports during the camps in the middle altitude.

Mountaineering. Mountaineering is connected with long hours of muscle work of high and moderate power. Therefore it is referred to sports with the predominantly aerobic mechanism of energy supply. The study included athletes who did not have COVID-19. They took the course of inhalations. Analysis of changes in HRV indices revealed a substantial decrease in HR (before: 86.2 (81.3; 86.7) beats/min, after: 82.3 (76.5; 86.6) beats/min, $p<0.04$) (fig. 2).

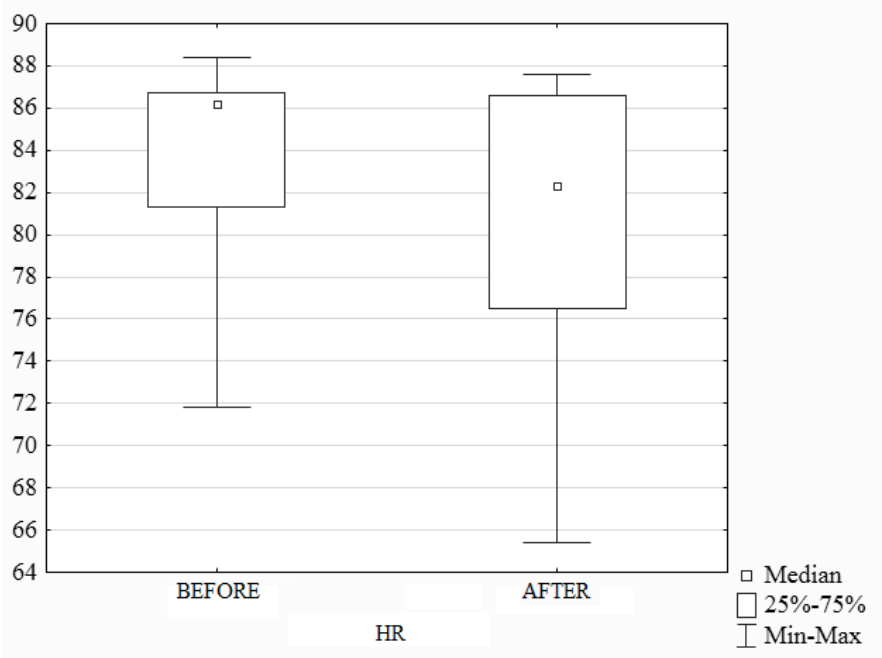

Fig. 2. Changes in heart rate (HR) in male mountaineers (n=5) in middle altitude conditions before and after the course

We also registered a decrease in SI (before: 100.4 (74.7; 143.4) c.u., after: 78.5 (72.4; 144.0) c.u.) and an increase in HF (before: 31.1 (29.8; 31.9) %, after: 36.4 (25.4; 36.9) %), which shows an increased tone of the parasympathetic nervous system in the heart rate regulation.

There were no statistically significant differences in saturation and hemodynamics, however we found a decrease in the volumetric blood flow index. After the inhalation course, value of such index was within the standard values. Both before and after the course, the participants were characterized with a state of sports hypotension (table 4).

Table 4

Changes in the cardiovascular system's functional status of male mountaineers (n=5) in middle altitude conditions under the effect of oxygen therapy, Me (Q1; Q3)

№	Indices	Standard	Before	After
1	SpO_2, %	95-100	96.0 (94.0; 97.0)	95.0 (95.0; 95.0)
2	Stiffness index, m/s	7-9	5.6 (5.3; 5.8)	5.4 (5.4; 5.5)
3	Reflection index, %	30-45	25.0 (25.0; 25.0)	25.0 (25.0; 25.0)
4	Augmentation index, c.u.	0.89-1.33	1.1 (1.1; 1.1)	1.1 (1.0; 1.1)
5	b/a, c.u.	-0.77--0.41	-1.3 (-1.3; -1.2)	-1.3 (-1.3; -1.1)
6	d/a, c.u.	0.15-0.49	-0.3 (-0.3; -0.3)	-0.3 (-0.3; -0.3)

Table 4 (continued)

7	PVR, mPa*S/m³	900-1500	1287,2 (1098.8; 1453.7)	1266,1 (1244.8; 1461.5)
8	Cardiac output, l/min	4.6-5.6	5,6 (5.3; 5.9)	5.4 (4.6; 5.6)
9	CI, l/min/m^2	2.6-3.2	3.4 (3.1; 3.4)	3.1 (2.9; 3.4)
10	meanBP, mm of Hg	95-110	85.0 (81.7; 90.0)	84.3 (81.7; 84.7)
11	VO_2, ml/min/m²	200-300	310.0 (300.0; 320.0)	320.0 (320.0; 320.0)
12	sBP, mm of Hg	110-140	115.0 (115.0; 120.0)	112.0 (109.0; 118.0)
13	dBP, mm of Hg	75-90	70.0 (65.0; 75.0)	71.0 (63.0; 72.0)

Note: SpO_2 – blood oxygen saturation; b/a – marker of the left ventricle function; d/a – stiffness index of the small- and medium-sized arteries; PVR – peripheral vascular resistance; CI – volumetric blood flow index; meanBP – mean blood pressure; VO_2 – index of disturbed oxygen uptake from the blood microcirculation system; sBP – systolic blood pressure; dBP – diastolic blood pressure

When analyzing the spirometry indices, we did not find any statistically significant changes, but all the indices were within the physiological standard.

Ski racing. Competitive distances of ski racers currently vary considerably in duration from submaximal to moderate power, but to a greater extent competition and training work with a predominantly aerobic mechanism of energy supply prevail. The study included athletes, who had COVID-19, all of them took the inhalation course. Ski racers did not have significant changes in HRV indices, however HF increased (before: 34.9 (34.6; 35.5) %, after: 40.0 (33.8; 42.7) %) and SI decreased (before: 86.9 (75.2; 93.3) c.u., after: 79.1 (72.2; 81.8) c.u.).

According to the central hemodynamics indices, we also did not find any statistically significant changes after the oxygen therapy course, although an increase in stiffness index (before: 6.5 (6.5; 6.8) m/s, after: 6.7 (6.2; 6.8) m/s) and saturation (before: 94.0 (94.0; 94.0) %, after: 95.0 (94.0; 95.0) %) was registered.

In regard to spirometry indices, ski racers had an increase in VC (before: 5.51 (5.12; 6.13) l, after: 5.88 (5.80; 6.39) l).

Ski mountaineering. Ski mountaineering involves taking a route in the mountains with ascent on skis with skins and/or on foot with skis and descent on skis without a piste (freeride). Duration of completing competitive distances – 3 minutes to 2 hours. Consequently, as in ski racers, energy supply can be accomplished by both anaerobic and aerobic lactate mechanisms. Most competitions are long, due to which we attributed this sport to sports with the predominantly aerobic mechanism of energy supply. The study included test subjects, who did not have COVID-19, all of them took the inhalation course. Analysis of changes in HRV did not have any statistically significant changes, but we registered a positive trend of decreasing HR (before: 86.5 (71.8; 88.4) beats/min, after: 77.7 (72.6; 95.9) beats/min) and SI (before: 143.4 (74.7; 178.6) c.u., after: 78.5 (60.6; 291.8) c.u.).

In terms of the central hemodynamics indices, we found a statistically significant reduction in sBP ($p<0.03$) alongside with increased oxygen uptake from the microcirculation system ($p<0.04$). There was also a trend of reducing blood oxygen saturation (table 5). It is possible that ski mountaineers had signs of hypoxia during training.

Table 5

Changes in the cardiovascular system's functional status of male ski mountaineers (n=7) in middle altitude conditions under the effect of oxygen therapy, Me (Q1; Q3)

№	Indices	Standard	Before	After	P<
1	SpO_2, %	95-100	96.0 (94.0; 97.0)	95.0 (93.0; 96.0)	-
2	Stiffness index, m/s	7-9	5.8 (5.6; 7.6)	5.5 (5.4; 7.2)	-
3	Reflection index, %	30-45	25.0 (25.0; 30.0)	25.0 (25.0; 30.0)	-
4	Augmentation index, c.u.	0.89-1.33	1.1 (1.1; 1.1)	1.1 (1.0; 1.1)	-
5	b/a, c.u.	-0.77--0.41	-1.1 (-1.3; -1.0)	-1.1 (-1.1; -0.7)	-
6	d/a, c.u.	0.15-0.49	-0.3 (-0.3; -0.3)	-0.3 (-0.3; -0.2)	-
7	PVR, mPa*S/m³	900-1500	1316.0 (1207.1; 1491.8)	1250.5 (1188.6; 1449.9)	-
8	Cardiac output, l/min	4.6-5.6	5.6 (4.8; 6.2)	5.7 (4.3; 5.9)	-
9	CI, l/min/m^2	2.6-3.2	3.4 (3.2; 3.4)	3.1 (3.1; 3.6)	-
10	meanBP, mm of Hg	95-110	90.3 (85.0; 95.7)	85.7 (84.7; 88.0)	-
11	VO_2, ml/min/m²	200-300	300.0 (190.0; 320.0)	320.0 (310.0; 320.0)	0.04
12	sBP, mm of Hg	110-140	120.0 (115.0; 133.0)	118,0 (104.0; 119.0)	0.03
13	dBP, mm of Hg	75-90	77.0 (70.0; 77.0)	72,0 (69.0; 75.0)	-

Note: SpO_2 – blood oxygen saturation; b/a – marker of the left ventricle function; d/a – stiffness index of the small and medium-sized arteries; PVR – peripheral vascular resistance; CI – volumetric blood flow index; meanBP – mean blood pressure; VO_2 – index of disturbed oxygen uptake from the blood microcirculation system; sBP – systolic blood pressure; dBP – diastolic blood pressure

According to the spirometry indices, there were no substantial alterations, but all the studied parameters were within the physiological standard.

Consequently, the course of hyperoxic gas mixture inhalations led to positive changes in the functional status, which was shown in reduced stress of regulatory mechanisms, increased tone of the parasympathetic nervous system and heart rate regulation of athletes with a predominant aerobic energy supply of muscle activity (including those who had COVID-19) during the camps in middle altitude.

Conclusion. The inhalation course that included not less than 7 procedures demonstrated high efficiency. We found a positive effect on the oxygen transport system of athletes of different sports regardless of a predominant energy supply mechanism, including participants, who previously had COVID-19, in conditions of intense training in middle altitude. However, athletes with an anaerobic mechanism especially need additional support with the hyperoxic mixture due to signs of hypoxia and oxygen debt related to specific features of their training and competitive activity.

Conflict of interest. The authors declare no conflict of interest.

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DEVELOPMENT AND SCIENTIFIC SUBSTANTIATION OF THE ORION NO. 1 TERRAIN CURE ROUTE OF THE ORION ATHLETE REHABILITATION AND RECOVERY CENTER IN KISLOVODSK

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Abstract. Aim of the study – the development and scientific substantiation of the Orion No. 1 terrain cure route of the Orion athlete rehabilitation and recovery center in Kislovodsk. The research materials included the results of bioclimatic route monitoring on the Orion No 1 route, as well as reference materials of meteorological observations at the meteorological site in the Kislovodsky National Park for 2023, guiding documents, and scientific articles. The conducted research demonstrated that the integral index of bioclimatic potential (K(BKP)) on the Orion No. 1 route amounted to 2.23 points out of 3.0 possible. Consequently, the developed Orion No. 1 terrain cure route corresponds to a high functional suitability for the arrangement of climate treatment of athletes, favorable conditions for their recreation and recovery.
Keywords: terrain cure path, bioclimatic potential, athletes, rehabilitation, recovery.

Introduction. Modern recreational medicine is characterized by a variety of therapeutic physical culture methods, one of which is terrain cure. Terrain cure is a comprehensive concept based on scientific substantiation of the therapeutic walking method, effect of which may be enhanced by additional effects of the territory, such as climate [1]. Walking is a simple, accessible and familiar movement. This fact makes it possible to widely use terrain cure from the first days of rehabilitation and recovery of athletes, without spending a lot of time on learning the correct technique of walking through therapeutic routes and immediately receiving a positive effect [2]. Controlled walking increases endurance, function of the cardiovascular system, respiratory organs, improves work of the musculoskeletal system, recovers tone of vessels and muscles, improves mental state, metabolism, hardens a body, is considered as the prevention of various diseases [3].

For athletes going through rehabilitation in the Orion center, presence of terrain cures that start from the center itself is an effective, safe and pleasant way to recover and improve health.

Aim of the study: the development and scientific substantiation of the Orion No. 1 terrain cure route of the Orion athlete rehabilitation and recovery center in Kislovodsk.

Methods and organization. Materials of the study included bioclimatic route monitoring on the Orion No. 1 route, as well as reference materials of meteorological observations at the meteorological site in the Kislovodsky National Park for 2023, guiding documents, and scientific articles.

The study included bioclimatic monitoring of the Orion No. 1 route, comprehensive analysis method and model of climate evaluation for athlete rehabilitation and recovery.

The terrain cure bioclimatic monitoring was carried out from February 20 to February 22, 2024. The research program included measurements of the concentration of positive and negative light air ions (with mobility K>0.5 $cm^2/V•s$), the number of aerosol particles of different size gradations (8 gradations in the range from 0.2 to 10 μm) in the surface atmosphere (at the breathing level of 1.5 m), registration of air temperature, humidity and pressure, oxygen and carbon dioxide content in

the air, illumination level in the open place and under the tree crown, ambient dose equivalent power (ADEP) of gamma radiation.

The assessment of bioclimatic potential was done with the bioclimatic component comprehensive analysis (weather element modules, solar radiation mode, circulation mode, humidity mode, natural air ionization mode) of the given territory according to the method [4-5] with the allocation of categories of their suitability for climate therapy for athletes according to the gradations accepted in balneology on the basis of the impact of bioclimatic components on the adaptation systems of a body:

- irritating (unfavorable) – 0 points;
- training (relatively favorable) – 1 point;
- sparingly training (favorable) – 2 points;
- sparing (especially favorable) – 3 points.

Following devices were used in the study: MAC-01 light-sized air ion counter (State Register of measuring instruments No 20429-11), RadiaSkan-801 radiation dosimeter (State Register of measuring instruments No 69478-17), SAChM 4801-01 aerosol analyzer, a mobile version (State Register of measuring instruments No 676936-19-19), DT-1309 light meter, IKV-8 air quality monitor (State Register of measuring instruments No 71394-18), and Polar V800 heart rate monitor.

Results and discussion. The Orion No. 1 terrain cure route is an easy and short route alongside the bank of the Olkhovka River. Its length is 1300 m, height difference is from 0 to 14 m, and the angle of ascent does not exceed 4°. In some places the path is flat, in other places it goes down. The approximate time of the route is 20-30 minutes. The terrain cure route starts and ends at the entrance to the Orion athlete rehabilitation and recovery center in the lower part of the Kislovodsky National Park. The route follows the bank of the Olkhovka River past the Mirror Pond, Crystal Spring, not reaching the Colonnade, turns in the opposite direction on the bridge. The route continues along the bank of the Olkhovka River, past the Flower Calendar, crosses the river through the bridge next to the Glass Jet and returns to the starting point. The route description is presented in a form of coordinates of terrain cure stations (TS) in table 1 and graphically in figure 1.

Table 1

Orion No. 1 terrain cure station (TS) scheme

№ TS	Location description	N. latitude/ E. longtitude,	Altitude ASL, m	Mean HR, beats/min	Average speed, km/h	Max HR, beats/ min
TS-1	Clinic exit, descent	43.89308/ 42.71997	858	83	-	-
TS-2	Bridge, flat area	43.89763/ 42.71748	844	89	5.3	102
TS-3	Bridge, ascent	42.89444/ 42.72032	849	95	4.3	103
TS-4/ TS-1	Clinic entrance	43.89308/ 42.71997	858	100	4,6	112

Note: ASL – above sea level; HR – heart rate. The calculation was carried out for a woman, age – 31 years; body length – 165 cm; body mass – 56 kg. The average and maximum values were registered in the period between terrain cure stations. TS-4 and TS-1 coincide, as the route is circular.

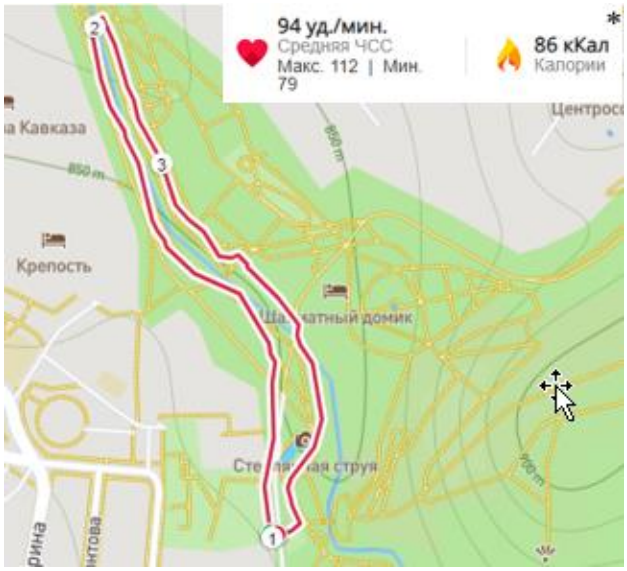

Fig. 1. Scheme of the Orion No. 1 terrain cure route

Energy expenditure during walking on the route amounted to 86 kcal. The calculation was performed for a 31-year-old woman, height – 165 cm, weight – 56 kg, walking at an average speed of 4.86 km/hour. Walking was performed in heart rate zone № 1 (light activity zone) and heart rate zone № 2 (aerobic I, lipid).

According to the data of reconnaissance surveys on the Orion No. 1 route, 3 sample areas (SA) for microbiological studies were registered, their location is shown in table 2.

Bioclimatic features of the Orion No. 1 route are shown in table 3. The obtained data indicate their uniformity over the entire route.

Table 2

Reconnaissance scheme of the Orion No. 1 terrain cure route

№SA	Location description	North latitude, degrees	East longitude, degrees	Altitude above sea level, m
SA-1	Glass Jet	43.89344	42.72052	845
SA-2	Olkhovka River Valley	43.89790	42.71761	827
SA-3	Flower Calendar	43.89687	42.71853	837

Note: SA – sample area

Table 3

Bioclimatic features of the Orion No. 1 terrain cure route

№SA	Bioclimate indices							
	T, °C	RH, %	AP, hPa	O_2, %	CO_2, ppm	∑[(N-)+(N+)] /IUC, background	K/O, klx	ADEP, μSv/h
SA-1	1.2	80	693	21.53	477.5	680/0.28	1,56/5.42	0.09
SA-2	1.2	82.5	694	21.79	477	560/0.6	ns/4.49	0,08
SA-3	1.75	82.5	694	21.77	470.5	520/0.49	ns/5.08	0.09

Note: SA – sample area; T, °C – air temperature; RH, % – relative humidity; O_2, % – relative oxygen content in the air; CO_2, ppm – relative carbon dioxide content in the air, number of units/million; AP, hPa – air pressure; ∑[(-)+(+)]/IUC (ion unipolarity coefficient) – air ionization background on the SA, ion/cm^3; O/T – illuminance (klx), in the open (O), and under the tree crown (T), ns – no shadow; ADEP, μSv/h – ambient dose equivalent power

The air of the Orion No. 1 route is saturated with oxygen. Its content amounted to 21.53-21.77% with the norm of 21%. The content of carbon dioxide slightly exceeded the generally accepted standard: 470.5-477.5 ppm (number of units/million) with the norm for the open area of 450 ppm, which may be due to the proximity of the route to urban infrastructure.

Air ion levels on the route is characterized by its high quality. The sum of negative and positive ions amounted to 520-680 ion/cm^3 with low ion unipolarity coefficient (IUC): 0.28-0.49.

Radiation levels on the route is safe, the obtained values of 0.08-0.09 μSv/h are significantly lower than the standard of 0.5 μSv/h.

Another important parameter of air purity is the level of aerosol particles of the surface layer of the atmosphere in the size range from 0.2 to 10 μm. On the route this index ranges from 49769 (paving stone section) to 55616 (unpaved section) particles/l (table 4).

The level of biologically significant aerosol concentration in the particle size range from 0.5 to 1 μm was slightly exceeded at the 2 sites of high tourist interest (3169 and 3175 particles/l). At the less active site, concentration of this type of aerosol was below 3000 particles/l (2846 particles/l) (table 4).

The bioclimatic potential of the Orion No. 1 terrain cure route was studied according to the following climate-forming factors: modules of weather element, solar radiation mode, circulation mode, humidity mode, natural air ionization mode [6-8]. The obtained results are presented in table 5.

Table 4

Surface atmosphere aerosol pollution on the Orion No. 1 terrain cure route

№ SA	SA name	Aerosol concentration 0.2-10 μm, particles/l	Aerosol concentration 0.5-1 μm, particles/l
SA-1	Glass Jet	49769	3175
SA-2	Olkhovka River Valley	55616	2846
SA-3	Flower Calendar	51415	3169

Table 5

Bioclimatic potential of the Orion No. 1 route

Microbioclimatic modules	Value	Category of medical and climatic conditions	Rate, points
1. Weather element modules (k_1/n = 31/13 = 2.38)			
Number of days per year with comfortable conditions at noon, EET 12-24 c.d.	153	especially favorable	3
Duration of summer period (EET>15 c.d.), days	95	favorable	2
Duration of winter period (EET below -0 c.d.)	102	relatively favorable	1
Duration of frost-free period, days	258	especially favorable	3
Number of days per year with severe weather (EET below -10 c.d.)	18	especially favorable	3
Number of days per year with recreationally favorable weather (EET between 0 and +24 c.d.)	264	especially favorable	3
Number of days per year with hot weather (EET>24 c.d.)	0	especially favorable	3
Average monthly air temperature in July, °C	19.1	especially favorable	3

Table 5 (continued)

Average monthly air temperature in January, °C	-2.9	especially favorable	3
Average annual air temperature, °C	9.4	favorable	2
Number of days per year with ≥1 mm precipitation	130	unfavorable	0
Absolute maximum air temperature, °C	32.7	favorable	2
Absolute minimum air temperature, °C	-15.5	especially favorable	3
2. Solar radiation mode modules (SRM) ($k_2/n = 4/2 = 2$)			
Gradation of solar radiation's biological effect by UVI value and degree of potential danger of damaging effect of UV solar radiation in winter at noon, c.u.	0-2	especially favorable	3
UVI limits from May to August before noon from 06 to 10 hours and after noon from 16 to 19 hours	0-5.2	relatively favorable	1
3. Circulation mode modules (CM) ($k_3/n = 8/3 = 2.67$)			
Number of days with strong wind (>15 m/s) per year	8	favorable	2
Average monthly wind speed in summer, m/s	1.31	especially favorable	3
Average monthly wind speed in winter, m/s	1.93	especially favorable	3
4. Air humidity mode modules (AHM) ($k_4/n = 11/4 = 2.75$)			
Number of days with relative humidity values below 30% per year	0	especially favorable	3
Average annual relative humidity, %	75.5	favorable	2
Average monthly relative humidity at 1 p.m. in July, %	57	especially favorable	3
Average monthly relative humidity at 1 p.m. in January, %	55.5	especially favorable	3
5. Natural air ionization modules ($K_5/n = 4/3 = 1.3$)			
Number of positive light air ions (with mobility >0.5/cm^2/ V•s) in the surface atmosphere, ion/cm^3 (according to the winter episode data)	150-210	unfavorable	0
Number of negative light air ions (with mobility >0.5/cm^2/ V•s) in the surface atmosphere, ion/cm^3 (according to the winter episode data)	350-530	relatively favorable	1
Ion unipolarity coefficient (IUC=N+/N-) (according to the winter episode data)	0.28-0.6	favorable	3
Total: K(BKP)=∑K1+……+ K26 = 58/26 = 2.23 points			

Note: EET – equivalent-effective temperature; UVI – ultraviolet index

Integral index of bioclimatic potential (K(BKP)) on the Orion No. 1 route amounted to 2.23 points out of 3.0 possible, which conditionally corresponds to a high functional suitability for the arrangement of climate treatment of athletes, favorable conditions for their recreation and recovery.

Conclusion. Thus, we developed the Orion No. 1 terrain cure route, length – 1300 m, height difference – from 0 to 14 meters, angle of ascent

– no more than 4°. The terrain cure route runs along the bank of the Olkhovka River, begins and ends at the entrance to the Orion athlete rehabilitation and recovery center. The therapeutic effect of the route in terms of bioclimatic potential is high due to the uniqueness of humidity and circulation mode, the number of days with a favorable stay in the fresh air (264 days), positive impact of solar radiation, as well as the standard value of the ion unipolarity coefficient.

The developed terrain cure route assumes the possibility of gradual increase in physical activity by daily 2-3 times its repetition at different speed until the required therapeutic effect is achieved. It is recommended to exercise not earlier than 1.5-2 hours after eating, therapeutic procedures and finish no later than 1 hour before their start. During the terrain cure route completion, the "work-up" and "finishing the activity" stages occur. Their duration depends on the duration of the time in total, the average is 5-10 minutes. Breathing should be even, through the nose. It should be combined with the rhythm and pace of walking. Clothing and shoes should be comfortable, not constricting movements. A sign of good training is calm and even breathing, as well as slight pleasant feeling of fatigue [9, 10].

Conflict of interest. The authors declare no conflict of interest.

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RATIONALE FOR SPECIAL FLEXIBILITY DEVELOPMENT IN CONDITIONS OF ADDITIONAL SCHOOL EDUCATION

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Abstract. The article presents the data confirming the effectiveness of the system of classes with elements of sambo for the development of special flexibility in 11–12-year-old schoolchildren in conditions of additional school education. We developed two complexes designed for 2 microcycles. The experiment lasted 2 months, during which the developed complexes were applied. The methodology consisted of a series of classes for the development of special flexibility. The pedagogical experiment's results have demonstrated that the methodology of improving special flexibility in 11–12-year-old beginners in sambo during school allows to reach and exceed the standard values in the development of special flexibility and strength endurance. The developed methodology may be recommended for wide use in the practical work of physical education teachers for additional school education.
Keywords: schoolchildren, special flexibility, school classes, sambo, physical culture.

Introduction. The main directions of physical education are healthy life style propaganda, harmonious development of the growing population, increase in the level of physical activity, as well as development of basic motor skills. These directions correspond with the strategy of our state's policy (strategy of healthcare development in the Russian Federation for the period till 2025 approved by the Presidential Decree dated June 6, 2019, N 254) [1-4].

However, most researchers suggest that for adolescents, in order to improve their health, it is necessary to increase motivation to attend physical culture and sport classes both in class time and in conditions of additional school education [5-6].

In accordance with the Order of the Krasnodar Krai Ministry of Education, Science and Youth Policy dated June 29, 2022 No 1516 "On implementation of the All-Russian Project "Sambo to schools" in 2023-2024 academic year" regional programs of additional school education are being actively developed and implemented in the country's regions. "Sambo to school" is one of the largest educational and sports projects aimed at promoting sambo in schools of Russia as a basis of health and safety of schoolchildren, their national unity, success and competitiveness [7-9].

One of the options of introducing martial arts (sambo) into school practice may be extracurricular activities as a factor of attracting students to active physical activity, as well as the development of a system of classes with sambo elements. Sambo includes different exercises: speed, strength, exercises for development of special flexibility et al [10-11].

Aim of the study: theoretically substantiate and confirm experimentally the effectiveness of the system of classes with elements of sambo for the development of special flexibility in 11–12-year-old schoolchildren in conditions of additional school education.

Methods and organization. The study took place in the Altai State Pedagogical University (Barnaul). It included 11–12-year-old schoolchildren in conditions of additional school education (sambo class in school), 16 participants total.

Following methods were applied: scientific literature analysis, pedagogical testing, pedagogical experiment.

The experiment consisted of the implementation of a number of exercise complexes aimed at developing special flexibility. The training

week schedule included 3 classes – on Monday, Wednesday and Friday. Average duration of one class was 60 minutes.

We developed 2 complexes intended for 2 microcycles (2 weeks). The experiment lasted 2 months, during which we implemented the aforementioned complexes. In the first microcycle, a ratio of exercises for developing general and special flexibility was 50:50% (complex No. 1 of 10 exercises); in the second microcycle – 40:60% (complex No. 2 of 10 exercises). The control group trained according to the standard program for beginners in sambo.

In complex No. 1, exercises 1, 2, 3, 9 and 10 aimed at developing general flexibility, exercises 4, 5, 6, 7, 8 – at developing special flexibility.

In complex No. 2 exercises 1, 2, 9 and 10 aimed at improving general flexibility, exercises 3, 4, 5, 6, 7, 8 – at improving special flexibility.

Assessment of the classes' efficiency included an analysis of both special flexibility and strength abilities, which is conditioned by the specificity of sambo as a martial art.

Following tests were used to analyze special flexibility: forward bend, side bend, arching, bridge.

Strength endurance analysis included following tests: pull-ups, l-sits on parallel bars.

The obtained results were statistically processed with the Statistica 13 software package. We calculated the arithmetic mean (X) and standard deviation (σ), significance of differences before and after the experiment was identified with the Wilcoxon signed-rank test, $p<0,05$.

Results and discussion. At the beginning of the experiment, 30-100% of the control group participants and 0-90% of the experimental group participants performed the control exercises perfectly (fig. 1, 2).

The control group experienced most difficulties in two exercises (l-sits and bright), the experimental group – in three exercises (forward bend, arching and l-sits).

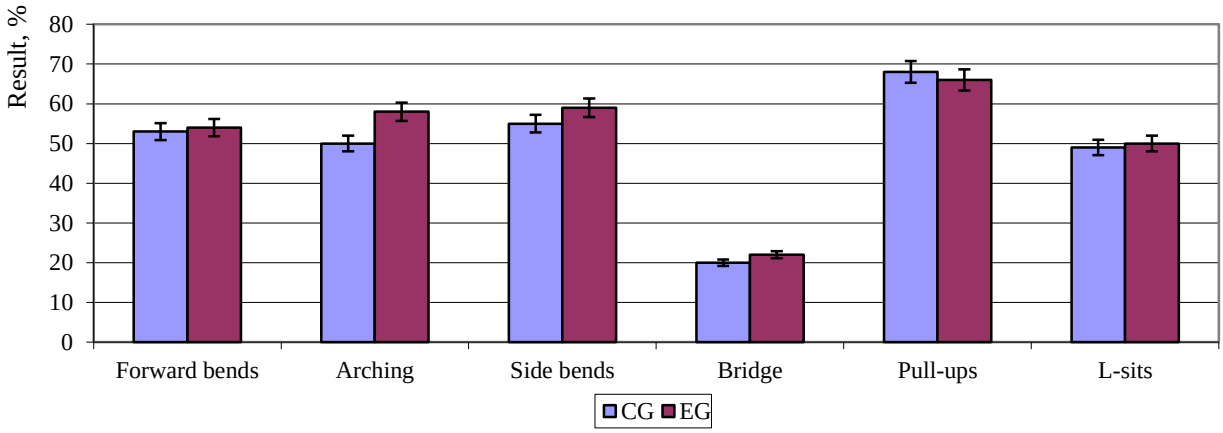

Fig. 1. Indices of special flexibility and strength endurance of 11–12-year-old schoolchildren from control (CG) and experimental (EG) groups before the experiment

At the end all children from the experimental group performed all standard exercises (fig. 2). In the control group, all children performed only one exercise properly (pull-ups), the bridge still caused difficulties for 40% of the participants, results of the remaining exercises met standard values for 60-80% of the children (fig. 2).

Before the experiment, in the control group, average group values in forward bend (6.1 cm) and pull-up (17.6 times) were higher than those in the experimental group (5.4 cm and 19.6 cm respectively), the other values were practically similar (table 1).

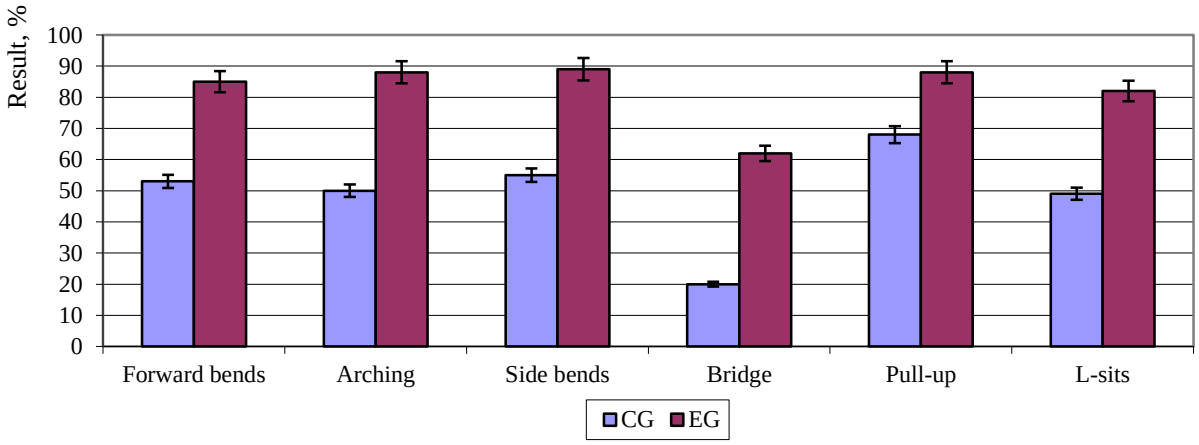

Fig. 2. Indices of special flexibility and strength endurance of 11–12-year-old schoolchildren from the control (CG) and experimental (EG) groups after the experiment

Table 1

Changes in the indices of special flexibility and strength endurance in 11–12-year-old sambo wrestlers before and after the experiment, x±σ

№	Test	Control group		Experimental group	
		Before the experiment	After the experiment	Before the experiment	After the experiment
1	Forward bends, cm	6.1±2.23	7.9±3.98	5.4±2.59	14.6±2.27*
2	Side bends, cm	23.1±3.35	26.0±3.77	23.5±3.72	33.0±3.23*
3	Arching, cm	22.0±2.54	23.5±3.21	21.6±2.27	29.3±1.42*
4	Bridge, cm	39.4±2.63	37.4±2.67	39.9±1.20	28.6±1.43*
5	Pull-ups, times	17.6±1.71	18.1±1.20	16.5±0.97	22.6±1.07*
6	L-sits on parallel bars, s	3.5±0.53	4.8±0.63*	3.4±0.52	10.7±0.67*

Note: * – the differences are significant when $p<0.05$

Analysis of the results of the special physical fitness average group indices in the experimental group has shown that they were significantly higher ($p<0.05$) than in the control group. Thus, the experimental group was ahead of the control group in all studied indices: in forward bend – 14.6 cm, while in KG – 7.9 cm, in side bend – 33 cm, in KG – 26.0 cm, in flexion – 29.3 cm, while in KG – 23.5 cm, in bridge – 28.6 cm, in KG – 37.4 cm, in pull-ups – 22.6 times, while in KG – 18.1 times, l-sits on parallel bars – 10.7 s, while in KG – 4.8 s.

It should be noted that in the control group by the end of the experiment there was a decrease in the average group values in pull-ups, which is associated with a decrease in the volume of training load, while in the experimental group no decrease in these indices was registered.

Growth rates of special physical fitness in the CG amounted to 5.2-21.3%, in the EG – 14.2-58.3% (table 2).

Table 2

Growth rates of special flexibility and strength endurance of the control (CG) and experimental (EG) groups, %

№	Test	CG	EG
1	Forward bend, cm	25.7	57.3
2	Side bend, cm	11.8	21.0
3	Arching, cm	6.6	19.6
4	Bridge, cm	-5.2	-14.2
5	Pull-ups, times	5.2	23.4
6	L-sits on parallel bars, s	21.3	50.5

It is also important to note that the control group had low growth rates in all exercises, the lowest ones – in bridge, pull-ups (5.2% both) and arching (6.6%).

In the experimental group, average growth rates were registered in forward bend (57.3%) and l-sits on parallel bars (50.5%), accompanied by low growth rates in the rest of the exercises (14.2-23.4%). However, they were higher than those in the control group (5.2-11.8%).

Therefore, application of the aforementioned methodology has an effect on special flexibility of 11–12-year-old schoolchildren. 80% of the participants managed to reach standard values.

Conclusion. Consequently, application of the methodology for developing special flexibility for 11–12-year-old beginners in sambo in conditions of additional school education allows achieving and exceeding standard values in the development of special flexibility and strength endurance. In the experimental group, average group values exceeded those of the control group in all indices and were as follows ($p \leq 0.05$): in forward bend – 14.6±2.27 cm; in side bend – 29.0±3.23 cm; in arching – 26.3±1.42 cm; in bridge – 34.6 cm; in pull-ups – 19.6±1.07 times; in l-sits on parallel bars – 5.7±0.67 s.

Conflict of interest. The authors declare no conflict of interest.

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SOMATOTYPICAL, FUNCTIONAL AND STRENGTH CHARACTERISTICS OF GIRLS AT DIFFERENT STAGES OF RECREATIONAL FITNESS TRAINING

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Abstract. The aim of the study was to evaluate somatotypical features, functional state and strength fitness of girls during power fitness classes at different stages of the annual training cycle. To achieve this goal, we implemented the following methods: anthropometric research, functional tests, measurement of heart rate and vital capacity of the lungs. According to the results obtained, body mass index, relative strength, Pignet index, waist/height ratio were also calculated. A somatotype was identified according to the classification developed by V.M. Chernorutskij. To assess strength abilities of the subjects, the following tests were applied: push-ups, squats, standing and wrist dynamometry. The research assessed somatotypical characteristics, functional state and developmental level of girls' strength abilities during fitness classes. We also performed a comparative analysis of data obtained experimentally at the beginning and end of the training cycle. Positive dynamics were discovered in the morphofunctional state and strength indices of female students at the end of the survey.

Keywords: somatotype, girls, fitness training, functional state, strength endurance, absolute strength, relative strength.

Introduction. Estimation of body constitution features of girls may serve as a model criterion for selection in different sports, as well as for construction of the training process, current and stage control [1]. On one hand, morphological differences of athletes of different sports are due to influence of exercises they perform, on the other hand – due to sports selection.

For women specialized in strength sports the most significant factor in morphological state (as well as for men) is active cell mass. The second one, compared to men, is fat mass, the third – bone mass. Studies show that for female weightlifters values of shoulder girth, chest girth and skinfold thickness on the back are close to men not engaged in sports [2].

A somatotype of female dancers have differences in the degree of influence of phenotypical features on a female body depending on the type of activity. Those engaged in dance sport and rock-and-roll significantly differ in body mass and length, body-weight index. Women engaged in rock-and-roll have an ecto-mesomorphic somatotype, those engaged in dance sport – an ecto-endomorphic somatotype [3].

The researchers registered statistically significant differences in body composition and anthropometric parameters between athletes of team and cyclic sports [4]. Volleyball players have higher values of height and weight, hip and pelvis girth, fat and active cell mass compared to the similar parameters of sprinters [4].

Therefore, depending mainly on training activity of female athletes (strength, speed-strength etc), a somatotype and body composition have different phenotypical features.

Taking into account individual somatotypical features of women is important not only in sports, but also in recreational physical culture. Control over a morphological status of those who work out contribute to posture correction, increased level of physical fitness and functional reserves of the body [5]. In diagnosing physical state of women with different body constitution researchers discovered individual characteristics of their physical development and fitness [6]. It is of utmost importance to regularly monitor functional fitness and somatic

health level of female students during physical education classes in universities. Such procedure would allow to form practical recommendations to enhance mental working capacity and to instill healthy lifestyle habits in students [7].

Aim of the study: to assess somatotypical features, functional state and strength fitness of girls during power fitness classes at different stages of the annual training cycle.

Methods and organization. The study took place during the 2022-2023 academic year in the Department of Physical Culture and Sports of the Yaroslavl State Medical University. In included 12 students from different faculties engaged in athletic gymnastics (average training experience – 2 years, average age – 19 years, 1.5-hour 3 classes per week). The applied sets that included exercises with dumbbells, an exercise ball, a barbell, exercises with body weight resistance and weight on training devices were aimed towards developing strength endurance and correction of body shape. The examination consisted of 2 stages:

1) beginning of the year (September);

2) end of the year (May).

For anthropometric parameters and functional state assessment we measured height and weight, chest girth (CG), shoulder girth (SG), waist girth (WG), hip girth (HG), heart rate (HR), vital capacity (VC), respiratory test on inhale, functional test of 20 squats in 30 seconds (t_{recov}). According to the experimentally received data, we calculated body mass index (BMI), relative strength, Pignet index – body build (PI), waist/height ratio (WHR). A somatotype of the participants was identified according to the classification of V.M. Chernorutskij (1925) and WHR (table 1), based on which the following types of constitution were distinguished: asthenic (PI>30), normosthenic (PI from 10 to 30) and hypersthenic (PI<10) [8].

Table 1

Physical shape of women

Waist/height index	Physical shape
Less than 0.35	pathological thinness, weight deficiency
0.35-0.42	evident thinness
0.42-0.46	healthy lean physique
0.46-0.49	healthy normal physique
0.49-0.54	overweight
0.54-0.58	evident overweight, obesity
More than 0.58	evident obesity

To estimate strength abilities of the participants, we used following tests: push-ups, squats, standing and wrist dynamometry.

Statistical data processing was carried out in Statistica 6.1. We calculated the arithmetic mean (M) and standard deviation (±σ) of the received values. Significance of differences was calculated with the Student's t-test for dependent variables. The distribution normalcy was estimated with the Shapiro-Wilk test. In case of the normalcy's absence we compared the data with the Wilcoxon signed-rank test.

Results and discussion. At the initial stage, it was found that the anthropometric data (height, weight, BMI, LC) and HR corresponded with physiological norm (table 2). Results of the respiration test were in line with the average indices of female athletes [9]. The physical fitness level of the athletes evaluated according to the HR recovery time after 20 squats in 30 s, was above the average according to the classification of G.L. Apanasenko [10].

At the beginning of the year, all participants had a normosthenic type (Pignet index) and characterized by evident thinness (waist/height ratio). CG corresponded with the results from the population-based survey of physical development of 18-20-year-old female students [11].

At the beginning, physical fitness of the girls (standards of GTO tests, VII stage) according to the push-up test corresponded with the bronze standard (table 3).

Table 2

Morhpofunctional and somatotypical indices of the girls during the annual training cycle, M±σ (n=12)

Index	Beginning of the year	End of the year	P
HR, beats/min	86.2±18.1	81.8±13.1	0.05
Height, cm	165.0±4.9	165.6±4.9	0.01
Weight, kg	60.0±11.0	60.9±11.5	0.04
BMI, kg/m^2	22.0 ±3.6	22.2±3.8	-
VC, ml^3	3250.0±462.1	3359.1±456.5	0.008
Respiration test on inhale, s	52.9±18.5	55.9±19.2	-
$t_{recover}$, s	85.8±13.9	83.6±10.6	-
CG, cm	87.9±6.9	87.5±6.6	-
SG, cm	99.7±6.9	99.8±7.3	-
WG, cm	67.9±7.6	67.1±8.6	-
HG, cm	55.0±5.5	55.8±5.7	-
Pignet index	20.2±12.8	20.6±11.3	-
Waist/height ratio	0.41±0.04	0.40±0.05	-

Note: HR – heart rate; BMI – body mass index; VC – vital capacity of the lungs; CG – chest girth; SG – shoulder girth; WG – waist girth; HG – hip girth

Table 3

Strength fitness of the girls during the annual training cycle, M±σ (n=12)

Index	Beginning of the year	End of the year	P
Squats, times/min	68.3±6.1	70.2±5.5	0.05
Push-ups, times	10.9±5.6	14.0±7.0	0.0007
Standing dynamometry, kg	57.3±13.2	67.8±12.2	0.0004
Wrist dynamometry, kg	25.7±4.7	28.9±5.2	0.005
Relative strength, r.u.	0.96±0.17	1.15±0.26	0.01

Wrist strength was approximately 26 kg, which was almost 17% higher than the same index of female students engaged in recreative aerobics according to the scientific reference data [12].

At the final stage we registered significant changes in HR, VC, height and weight compared to the data from the initial stage (table 2). HR decreased by 5%, which shows economization of the cardiovascular system's function at rest. The previous studies demonstrate that positive changes in the cardiorespiratory system's indices during fitness classes are associated with a normosthenic somatotype [13], which was also registered in our survey. The height increased by 0.6 cm on average, which is possibly associated with posture changes under the effect of fitness classes. Weight increased by 1 kg, probably due to the muscle component as a result of a long-term adjustment of the body to strength activity. It is important to note that BMI remained unchanged. We also found that power fitness classes contribute to an increase in VC of the female students (by 3% on average, $p<0.008$). In addition, there was a tendency for an increase in results of the respiration test and decrease of HR recovery time after controlled activity. Thus, the obtained results indicate a significant improvement in the functional state of the cardiovascular and respiratory systems of the examined girls at the end of the training cycle.

Somatotyping of the subjects at the end of the year revealed no significant changes. The indices of body build, physical shape, SG, CG, WG and HG were identical to the data from the initial stage.

At the same time, we registered a significant improvement of all estimated strength abilities of female students at the end of the test (table 3). For example a number of squats increased by 3% ($p<0.05$). An increase in a number of push-ups was more substantial (by 28%, $p<0.0007$), and the test results corresponded with the silver standard of the GTO complex, VII stage, 2023 (at the beginning – 11 repeats, at the end – 14). Strength of the wrist flexor muscles and standing muscle strength improved by 12% ($p<0.005$) and 18% ($p<0.0004$) respectively. Different strength indices correlate with weight, and consideration of relative strength, i.e. strength applied by a person in terms of 1 kg of their own weight, has important value [14-15]: it was improved by 20% ($p<0.01$). Therefore, power fitness classes resulted in a significant improvement of various strength indices of the girls during the year: strength endurance of the leg and shoulder girdle muscles, absolute and relative strength of the back extensor muscles accompanied with a slight increase in weight.

Conclusion:

1) At the beginning of the year, we registered the following: normosthenic type of body constitution, compliance of the anthropometric data and functional state of the cardiovascular and respiratory systems to standard values. Strength endurance indices of female students in the push-up test was assessed according to the bronze standard of GTO. Results of changes in standing and wrist strength of the participants corresponded with the average values typical of their age group.

2) At the end, a somatotype of female athletes remained unchanged. At the same time, we found a significant reduction of HR at rest, increase in VC, height and weight of the subjects compared to the data from the initial stage. We also registered a trend of improvement in functional fitness of girls. A statistically significant increase of indices of different strength abilities was also discovered: strength endurance, absolute and relative strength. Results of the push-up test correspond with the silver standard of GTO.

Conflict of interest. The authors declare no conflict of interest.

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PLASTIC EXPRESSION AS ONE OF THE COMPONENTS OF RHYTHMIC GYMNASTS' SKILL

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Abstract. The main difference of rhythmic gymnastics is that its greatest role is attributed to its plastic component, i.e. the beauty of performed exercises. When analyzing competitive compositions in rhythmic gymnastics, experts and judges often conclude that the majority of female athletes should manifest integrity and cohesion in their movements and should be able to demonstrate plastic expression and emotionality typical to gymnastics. This article considers the main components of plastic expression, as well as views of different authors on the interpretation of the concept of this phenomenon.
Keywords: rhythmic gymnastics, plastic expression, emotionality.

Introduction. A rich and controversial legacy of several centuries lies at the basis of rhythmic gymnastics' originality. A researcher discovers a vivid palette of diverse schools and systems (gymnastic, rhythmic, plastic, dance), which have a significant value in terms of finding the origins of specificity in the self-definition of the sport. Distinctive features are stated in the very name of rhythmic gymnastics. The term "rhythmic" means "maximally expressive" [1]. Most leading experts in this sport share an opinion by B.G. Bataen and E.V. Avsenev [2] that a rhythmic gymnast should be distinguished by "perfection, completeness, expression, elegance, originality of execution of movements and exercises as a whole". It's no coincidence that T.S. Lisitskaya [3] suggested the "art of expressive movement" as an object of study and assessment in rhythmic gymnastics.

Therefore, expression of performances takes a substantial place among other components of gymnasts' sportsmanship, and their training is considered as one of the most important tasks of theory and practice in rhythmic gymnastics [4]. In order to solve this task, we need to study content, structure, main signs of plastic expression and methods of its formation.

The purpose of the study: an analysis of the plastic expression's components and different views of authors on the chosen quality.

Methods and organization. We have studied and analyzed the available data of domestic literature on applying the method of forming plastic expression during training. We used content analysis of references, scientific and methodological literature.

Results and discussion. Plastic expression refer to very capacious phenomena, which have not yet been defined [5]. Meanwhile, traditional (classic) aesthetics define it as an expression of the internal (feelings, thoughts, movements) as the external: in sounds, body movements, speech etc. [6]. Because of that, expression is a significant characteristic of an artistic form. B. Lowe suggested another definition: "a sport of expressive form" [7]. In other words, art implies an impressive expression of the content in the form of a piece. Since in rhythmic gymnastics a piece of art has a bodily character, plasticity acquires a special artistic significance.

In rhythmic gymnastics, plasticity is the only original "language" fit to perform an exercise and express different feelings and ideas [6]. This is the reason why plasticity is considered as a combination of body movements in a gymnast's exercise that correspond with their character and manner [8]. It is a special group of expressive measures (it is often called "expressive plasticity", "free plasticity", or "specific movements"), which includes waves, wave-like movements, swings [9].

A term “plastic expression” (a synonym for “body expression”) has firmly entered the lexicon of theater and sports to evaluate the plasticity of a performer in a role or during a performance [10]. A phenomenon of plastic expression in rhythmic gymnastics has deep psychological roots. Only the movement that is filled with a specific feeling or thought becomes an expressor of the human condition.

M. Eremina points out a historically formed connection of dance plasticity of a performer with their emotions [11], saying that “a primal dance was created from emotions and was directly connected with strong experience”. Music lies at the fundamental of such connection [9]. According to Z.D. Verbova [5], in a music piece, “in addition to the rhythm, there are also the composer's emotions, moods and shades of experience. Music is not only the soul but also a dance’s matter”. Which is why in an effort to give expression to the movements, the essential point is to perform them in accordance with the character of the music [4].

According to M.V. Pristavkina [12], personal factors influence on manifestation of expression and its scope, such as psychological makeup, temperament, general and motor skills, knowledge, age. Largely due to this reason, a gymnast at a certain stage of achieving perfection becomes capable of delving deep into the music, begins to show a predisposition to music and movements of a certain character (to the so-called emotional expression according to M.V. Pristavkina) [12].

Another significant side to this phenomenon is the so-called “technical expression” [9]. When comparing the concepts of internal and technical expression, it is inappropriate to give the latter only a secondary role to achieve true plastic expression. Z.D. Verbova gives a solid proof in favor of this thought [5]. She suggests that “ability of have emotional experiences is not expression, since the manifestation of emotionality should have a beautiful rhythmic form. If there is no form, emotionality will not have its manifestation”. Therefore, a gymnast should have an ability to think through a sound of each element and exercise as a whole, considering them not only as a demonstration of technical prowess, but also as a “speechless” language, as a way to express different shades of feelings [5].

This is the reason why close attention to technical training is needed in terms of forming plastic expression. In this context, it is not enough to possess a “skill of external artistry” while including several learned decorative elements in a performance program [10]. When it comes to a gymnast's true plastic expression, any movement action of an exercise combination, without regard to its level of difficulty, must be mastered at a radically higher level of “expressive movement skill”. According to T.S. Lisitskaya [9], the exercise should be brought to that degree of technical perfection when it is capable of conveying a certain emotional and semantic connotation.

In the current rules for judging rhythmic gymnastics competitions [13], several of the main requirements to exercises without an object include dynamicity and dancing character of their performance. Therefore, this is a direction, in which young gymnasts should perform.

Integrity, according to a definition of many experts in rhythmic gymnastics, means participation of all body parts in a performed motor action [3]. Modern rhythmic gymnastics follow the rule of “polyphony” of movements of different body parts, which gives them softness, plasticity and femininity, according to Z.D. Verbova [5]. In other words, signs of integrity are, on one hand, simultaneous performance of the main and additional movements, on the other hand – their ability to fuse (the following movement begins when the previous one is not yet finished). One of the interesting approaches is one developed by V.S. Tikhomirov, who considers plasticity as an important element of stage dance, making the movement complete. In order for the movement to become plastic, to be perceived as a whole, a performer should “make a continuous line in motion”.

As a result of analyzing performance technique [14], we may conclude that the best example of integrity among means of rhythmic gymnastics are specific movements, such as waves, wave-like movements and swings. Zh.

Shishmanova [15] implies that "any gymnastic movement that pretends to be rhythmic should begin with movements of the head and arms". According to results presented by V.B. Korenberg [16], amplitude head movements in integral elements of expressive plasticity significantly increase the requirements for coordination and distribution of the gymnast's attention. However, T.V. Tikhonravova implies that [14], "the head cannot remain "inanimate", it "involves" arms in movements". In turn, arms are the most melodic body part of a gymnast [14]. It proves the point that arms plasticity takes a leading role in creating body movements' intonation, i.e. in emphasizing the emotional state of a gymnast.

The data from the gathered material points out that currently experts do not have a common understanding of plastic expression and therefore its full definition. Results of the survey of rhythmic gymnastics coaches also serve as an evidence. Most often they choose "artistry" of movements, their integrity, completeness, unity, "sense of movement", "sense of line", "sense of pose", "movement culture" as characteristics of plastic expression. It means that the experts point out only separate components of this phenomenon, completely missing the point of it.

Along with that, the reference analysis underlines a comprehensive structure of plastic expression in rhythmic gymnastics. Thus, there is an author's view on the issue that expression of performing gymnastic exercises is achieved when its internal and external, technical components are interacting, i.e. when a gymnast's sensuality and mastery of motor skills to express this sensuality are harmonically fused in a performance[9].

In terms of this approach, definitions of plastic expression were given by M.V. Pristavkina [12], A.B. Nemerovskij [17], G.V. Morozova [18]. All of them define it as an ability to convey a certain emotional state in movements. It is important to note that such interpretation has a general character. A more detailed definition in terms of its originality of plastic language was given by Z.D. Verbova [5]. According to her concept, it is "a quality that is shown in proper technique, school of movement, "aplomb" and tempo of rotations, elegance, great amplitude, with full clarity of the emotional component". However, this explanation lacks the structuring of its aspects.

Taking the aforementioned issues into account, there is a need to clarify the definition of plastic expression. In this regard, it is appropriate to consider plastic expression as an ability to convey the emotional and semantic component of a music piece by means of a holistic, dynamic, dance character of the exercise performance.

In order to form this ability a more detailed study of its both motor and psychological components is required.

In the Aerial and Aesthetic Gymnastics Federation (Sochi) the training process of young gymnasts includes a method of forming plastic expression, which included specific ways to learn this ability. The main measures are as follows:

1) correction of a gymnast's movement with explanation, demonstration, physical assistance and music;

2) self-control with/without a mirror;

3) assessment of the performance's quality by a coach;

4) contrasting performance and perception of movements (right/wrong, beautiful/not beautiful);

5) "imagination" games;

6) improvisations of a gymnast to music;

7) watching video footage of one's own performance and performances of professional gymnasts;

8) showcase;

9) assessment of the performance's quality by a student;

10) choreography.

The preparation part includes combinations of dance and gymnastic steps, elements of expressive plasticity: wave-like movements of arms and body, swings, relaxation exercises. Coaches of the Federation also combine these exercises with object manipulations. The used method of conjugate influence has a positive effect on coordination and

associated with them abilities of training gymnasts (an ability to keep balance in case of increased vestibular activity, an ability to control muscle stress and relaxation in movement).

Exercise lessons also contain a combination of exercise performance with psychotechnical games and tasks. These distracting tasks, aside from their main goal to optimize muscle tone, also become an effective way to improve the psychomotor control level (differently speaking, training for concentration, attention switch and distribution) and develop such mental processes, as logical thinking and imagining:

- to call off without "forbidden" numbers;
- to catch a ball or other gymnastic equipment when hearing one's own name;
- to come up with the greatest number of ways to use the named equipment;
- to "draw" an imaginary geometric figure with spatial imagining when interacting in a group;
- to find as many common features of two randomly selected words as possible;
- to find as many objects as possible that possess the set feature.

When choosing these tasks as active leisure between repeats, coaches make sure to maintain proper level of mental working capacity during the whole training session.

Conclusion. Consequently, the most important component of performance prowess in rhythmic gymnastics is plastic expression. It is revealed as an ability to convey emotional and semantic content of a music piece by the means of integral, dynamic, dance character of performing an exercise. Formation of such ability is one of the primary tasks of training from the initial stages to the exercise one [19].

The experts have concluded that a relatively low level of plastic expression is attributed to both young and highly qualified gymnasts. At the same time, there is no significant increase in this level with the growth of sports qualification of athletes. A high level of plastic expression was registered only in world-class gymnasts. At the modern stage of development of rhythmic gymnastics, in coach practice there is not enough attention given to formation of plastic expression at the stage of initial specialized training. Most experts solve this issue at the stage of athletic perfection, which does not always leads to expected results.

Achievement of plastic expression depends on an array of factors: technical prowess in performing specific elements without equipment, coordination fitness (development level of abilities to precisely regulate spatial, dynamic parameters of movement, maintain static and dynamic balance in complicated conditions, to relax muscles rationally), psychological features of a gymnast [20].

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THE INFLUENCE OF CLUSTER SETS DURING WEIGHT TRAINING ON ATHLETES' STRENGTH PERFORMANCE: AN UMBRELLA REVIEW OF SYSTEMATIC REVIEWS AND META-ANALYSES

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Abstract. Cluster resistance training is aimed at improving athletic performance by increasing the maximum number of repeats, jump height and sprint efficiency. Objective: to conduct a systematic search and analysis of systematic reviews and meta-analyses on the impact of cluster sets on athletes' strength performance. The study was conducted in accordance with the recommendations on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and umbrella reviews (Preferred Reporting Items for Overviews of Reviews (PRIOR)). Literature was searched in the PubMed and Epistemonikos databases. Filter by date – from 2004 to March 7, 2024. The methodological quality of the included articles was assessed using A MeaSurement Tool to Assess systematic Reviews (AMSTAR-2). A total of 34 mentions were identified in the databases. 2 systematic reviews met the inclusion criteria. The authors of 2 systematic reviews came to a conclusion on the effectiveness of using cluster sets for strength training of athletes.
Keywords: cluster sets, strength training, resistance training, athletic performance.

Introduction. Structured and continuous resistance training (RT) is an important component in the development of various physical performance characteristics of athletes [1]. In particular, strength [2], power and speed [3], muscle hypertrophy [4] and endurance [5] are essential components of athletes' development, performance and overall health. RT variables such as exercise selection, exercise intensity (mass of weights), number of repeats and sets, rest interval between sets and training sessions' frequency have received a lot of attention from the scientific community in recent decades. It is well known that traditional RT [6] is prescribed based on attempt configurations in which continuous repeats are performed followed by rest periods of 1 to 5 minutes between sets. These configurations are referred to as "traditional sets" in the literature [7], and although "traditional sets" cause severe fatigue and metabolite accumulation, they can have positive effects on muscle hypertrophy [8] and strength [9]. In addition to "traditional sets", some advanced RT methods have been created and developed to enhance the adaptation of strength training [10]. Among these methods, cluster sets (CS) have attracted special attention of the scientific community [11]. The CS method can be defined as an approach that includes short rest periods between individual repeats or groups of repeats [12]. By providing short rest periods, athletes can dramatically reduce fatigue, thereby achieving greater strength, speed, and power in each repeat. In addition, studies have shown that CS improves performance and training volume compared to the traditional set configuration [13]. Although CS has the potential to induce stronger hypertrophic response, the literature on the effects of CS on strength adaptations in athletes is contradictory. Based on the analysis of the matter, data from current scientific literature and requests from sports biologists, coaches and athletes, the purpose of the study was formed.

Objective: to search and analyze systematic reviews and meta-analyses on the effects of CS on athletes' strength performance.

Methods and organization. *Protocol.* The study was conducted in the Department of Sports Medicine of the Russian University of Sport in accordance with the recommendations on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [14] and umbrella reviews (Preferred Reporting Items for Overviews of Reviews (PRIOR)) [15]. The study protocol was established before

and was not changed during or after the search, according to the Preferred Reporting Items for Systematic Review and Meta Analysis Protocols (PRISMA-P) [16]. The study protocol was registered in the OSF international database: https://doi.org/10.17605/OSF.IO/BSGXP.

Prior to the search, it was determined that only systematic reviews and/or meta-analyses would be included, as this type of study is the gold standard of evidence-based medicine and provides a comprehensive picture of the benefits and harms associated with an intervention.

Sources of information and search strategies. The literature search for the umbrella review was performed in the PubMed and Epistemonikos databases as advised by Goossen et al [17]. The search was performed using the following keywords (table 1).

Table 1

Keywords for literature search

Pubmed	All Fields: (“cluster sets in sports”) OR (“cluster sets and athletes”)
Epistemonikos	Title/Abstract: “cluster sets”, “inter-set rest”, “rest-pause”, “intra set”, “traditional set”, “work-to-rest ratio”

Studies from the last ~20 years were examined (filtered by date from 2004 to March 07, 2024). Exclusion of systematic reviews published before 2004 was based on methodological, statistical, and protocol limitations of previous work compared to the current evidence base. A language barrier was not considered in the search. In order to increase the coverage of the topic at hand, a search for “gray” literature was conducted in the SportRχiv database according to the checklist of Benzies et al [18]. The reference lists of retrieved studies were then manually searched to identify potentially relevant studies not covered by the search. For a study to be included in the review, it had to meet the following PICOS inclusion criteria [19]. P (Population) – athletes over 18 years of age; I (Intervention) – cluster sets in resistance training; C (Comparison) – comparison with control group; O (Outcomes) – any strength tests; S (Study) – systematic reviews and/or meta-analyses only.

Selection of studies. Initially, two review authors (A.V. Shevtsov and A.V. Meshtel) in parallel, independently of each other, checked article titles, abstracts, and, if necessary, full texts from the database records according to the eligibility criteria. Duplicates and articles not meeting the criteria were excluded from the search. Any discrepancies were resolved by consensus discussion, and any disagreements were resolved by another reviewer (A.B. Miroshnikov).

Retrieval of studies. After the search, two review authors (A.V. Shevtsov and A.V. Meshtel) extracted full texts in parallel, independently of each other, in accordance with the inclusion criteria. Whenever there was disagreement between the two researchers' assessments, consensus was reached either through discussion or with the help of a third reviewer (A.B. Miroshnikov). Interrater (kappa) agreement ranged from 0.56 (weak) to 1.00 (almost perfect), as recommended by M. McHugh [20].

Quality of research and data extraction. The methodological quality of included articles was assessed with A MeaSurement Tool to Assess Systematic Reviews (AMSTAR-2) [21], which consists of 16 items. The quality of each eligible article was independently analyzed by two researchers (A.V. Shevtsov and A.V. Mestel). Whenever there was disagreement between the assessments of the two researchers, consensus was reached either through discussion or with the help of a third reviewer (A.B. Miroshnikov). This review highlighted critical issues that could significantly affect the validity of the review and its conclusions, as was suggested by Shea et al [21]. Since in this study the data were presented descriptively, statistical analysis was not performed.

Results and discussion. A total of 34 references were identified in the databases. Only 2 systematic reviews met the inclusion criteria [22-23]. The figure shows a flowchart of the PRISMA study selection process.

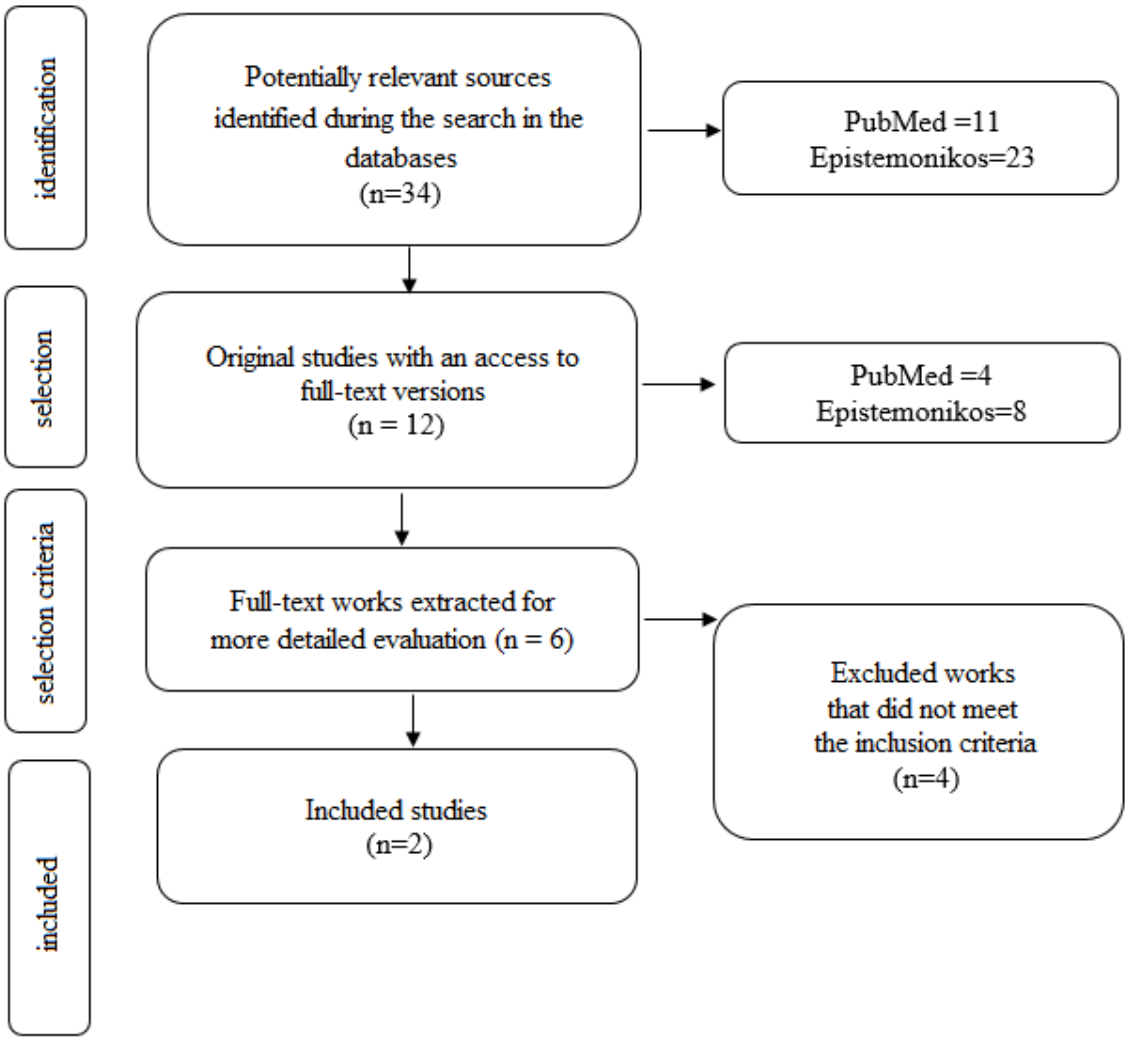

Fig. PRISMA study search and selection flowchart

We excluded the following systematic reviews for noncompliance with PICOS: Refalo et al [24], Marshall et al [25], Jukic et al [26], Davies et al [27], and Krzysztofik et al [28]. Of the 2 articles included in this comprehensive review, one study was a systematic review [22] and the other was a meta-analysis [23]. The chronological analysis of the articles considered in this review shows the recent advances in this field of research, emphasizing that 100% of the systematic reviews were published within the last 7 years (from 2017 to 2023), with the earliest one published in 2017 (table 2). The number of studies included in these reviews ranged from 25 [23] to 34 [22].

The reviews combined randomized controlled trials (RCTs) and non-RCTs without explaining the reason for this combination. None of the reviews identified conflicts of interest or funding for the studies included in them. Latella et al [23] analyzed studies that used cluster sets in the training of weightlifters, basketball players, soccer players, and judokas. Tufano et al [22] analyzed studies that used cluster sets in the training of track-and-field athletes, weightlifters, rugby players, judokas, basketball players and soccer players.

Table 2

Included systematic reviews evaluating the effects of cluster sets on athletes' strength performance

Review authors, publication year	Number of included studies	Main summary findings	AMSTAR-2
Tufano et al., 2017 [22]	34	Different types of CS can help maintain peak strength throughout a training session, and the length of rest between repeats or rest interval within a set appears to influence the ability to attenuate strength loss, with longer rest intervals resulting in better maintenance of peak strength.	CL
Latella et al., 2019 [23]	25	CS are a useful strategy to reduce the loss of speed, power and peak strength during RT and should be used to maintain neuromuscular performance, especially when emphasizing kinetic outcomes.	CL

Note: CS – cluster sets; RT – resistance training

Review quality. The overall methodological quality of the two included reviews is summarized in table 2. Based on the overall validity assessment using AMSTAR-2 [12], the total reliability of the reviews was rated as "extremely low". As systematic reviews and meta-analyses are a recent method of research in sport and sports medicine, we did not exclude any of the studies from further analysis based on quality assessment.

Discussion. Analysis of systematic reviews has shown that adding short rest periods within a set and while maintaining normal rest periods between sets may offer a methodology to reduce the accumulated fatigue observed during exercise [22]. Since resistance training at maximal speed may be more effective for strength development, and speed is better maintained with CS than with "traditional sets", CS may play a role in increasing maximal strength and hypertrophy [29]. In addition, CS allows for a greater number of repeats to be performed with a given load [13], resulting in a greater volume load, and this leads to a greater stimulus to develop maximal strength [26]. Furthermore, the use of CS appears to allow for a greater number of repeats to be performed compared to traditional sets [13], which will ultimately lead to a greater volume of total work, providing a stimulus for increased muscle hypertrophy. Alternatively, if the number of repeats remains constant, CS may allow the use of a higher training intensity, which may also increase the hypertrophic stimulus. Given this potential advantage of CS, they may be most suitable for sports where strength is fundamental (martial arts, weightlifting, sprinting, etc.), as higher training loads may induce specific hypertrophy of type II fibers that athletes need to improve their performance [10]. However, strength and conditioning professionals should be mindful of the additional time that may be required to perform CS as part of a resistance training program. Any increase in training time depends on the structure of the set, including rest intervals within the set and between repeats, and the number of repeats performed in each cluster. Therefore, the scientific literature often suggests using CS with only one or two key exercises. Wave and ascending clusters can be unique methods for adding variation to a resistance training program and may be appropriate for strength sports or well-trained athletes [10].

Conclusion. An umbrella review of systematic reviews and meta-analyses on the

effects of cluster sets on athletes' strength performance was conducted to identify current gaps in the literature and to make suggestions for further research. Study on the effects of cluster sets on athletes' strength performance has been of growing interest over the past 20 years. However, a significant number (100% in this review) of systematic reviews and meta-analyses have been published in the last 6 years (i.e., 2017 to 2023). In addition to potential shortcomings (small sample size, lack of randomization rules, etc.) found in the original studies, the present umbrella review revealed an overall critically low methodological quality of systematic reviews, suggesting the need for significant improvements in methodological procedures in such reviews. The authors of the 2 systematic reviews included in the umbrella review agreed on the efficiency of cluster sets for strength training in athletes. Additional RCTs in this area on national and elite level athletes are needed.

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