

Publication date: 01.03.2024
DOI: 10.24412/2782-6570-2024_03_01_2
UDC 612.6

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

A.P. Tychinina, Yu.V. Koryagina, O.N. Akimkina

FSBI "North-Caucasian Federal Research and Clinical Center of the Federal Medical and Biological Agency", Essentuki, Russia

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.

REFERENCES

1. Peterkova V.A., Taranushenko T.E., Kiseleva N.G., Tepper E.A., Terentyeva O.A. Evaluation of child growth status. *Medical Council*, 2016, no. 7. Available at: <https://cyberleninka.ru/article/n/otsenka-pokazateley-fizicheskogo-razvitiya-v-detskom-vozraste/viewer> (accessed 04.03.2024) (in Russ.)
2. Filatova O.V., Kutseva E.V. Complex evaluation of children physical development (the case of Barnaul residents, first childhood period). *Acta Biologica Sibirica*, 2015, no. 1 (1-2). Available at: <https://cyberleninka.ru/article/n/kompleksnaya-otsenka-fizicheskogo-razvitiya-detey-perioda-pervogo-detstva-g-barnaul> (accessed 04.03.2024) (in Russ.)
3. Komissarova E.N., Panasyuk T.V., Sazonova L.A., Tambovtseva R.V. Initial stages of puberty of girls in the second childhood with regard to body constitution. *Novye issledovania*, 2015. Available at: <https://cyberleninka.ru/article/n/nachalnye-etapy-polovogo-sozrevaniya-devochek-vo-vtorom-detske-s-uchetom-konstitutsionalnoy-prinadlezhnosti/viewer> (accessed 04.03.2024) (in Russ.)
4. Federal law dated 27.07.2006 N 152-FZ (ed. dated 06.02.2023) “On personal data”.
5. Tutelyan V.A., Nikityuk D.B., Klochkova S.V. et al. Method of complex anthropometry in sports and clinical practice: methodological guidelines. Moscow: Sport, 2018. 64 p. (in Russ.)
6. Koryagina Y.V., Nopin S.V. Human body mass composition. *Programmy dlya EVM. Bazy dannykh. Topologii integral'nykh mikrosistem*, 2008, no. 2, p. 13. (in Russ.)
7. Tambovtseva R.V., Panasyuk T.V. Continuity of growth and maturation in both-gender childhood. *Novye issledovania*, 2015. Available at: <https://cyberleninka.ru/article/n/preemstvennost-rosta-i-sozrevaniya-v-dvupolom-detstve/viewer> (accessed 04.03.2024) (in Russ.)

INFORMATION ABOUT THE AUTHORS:

Aleksandra P. Tychinina – Researcher of the Center of Biomedical Technologies, FSBI “North-Caucasian Federal Research and Clinical Center of Federal Medical and Biological Agency”, Essentuki, e-mail: a.cozinowa@yandex.ru.

Yulia V. Koryagina – Doctor of Biological Sciences, Professor, Head of the Center of Biomedical Technologies, FSBI “North-Caucasian Federal Research and Clinical Center of Federal Medical and Biological Agency”, Essentuki, e-mail: nauka@skfmba.ru.

Oxana N. Akimkina – Junior Researcher of the Center of Biomedical Technologies, FSBI “North-Caucasian Federal Research and Clinical Center of the FMBA of Russia”, Essentuki, e-mail: randomrecords@yandex.ru.

For citation: Tychinina A.P., Koryagina Yu.V., Akimkina O.N. Comparative and structural analysis of physical development indices of girls of the first and second childhood. *Russian Journal of Sports Science: Medicine, Physiology, Training*, 2024, vol. 3, no. 1. DOI: 10.24412/2782-6570-2024_03_01_2