

# Analysis of the factor structure of the physical condition of girls 17-19 year-old

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## ABSTRACT

The article analyses the factor structure of the physical condition of girls aged 17-19 years. It was determined percentage of each factor and it was established that the general physical condition is determined by a group of four factors: physical development is 41.8 %, the functional state of the cardiovascular and respiratory system is 28.4 %, physical performance and coordination abilities are 12.4 %, physical readiness, in particular speed, speed-strength qualities, agility and flexibility -2.3 %, which together constitute 84.9 % of the explained dispersion. We have found out that the anthropometric status determines the physical condition even after the end of the puberty period. Most factor loading is accounted for the indicators that characterize the total body size: waist girth ( $r=-0.975$  at  $p<0.01$ ); chest girth ( $r=-0.966$  at  $p<0.01$ ); the pelvis girth of ( $r=-0.956$  for  $p<0.01$ ), as well as indicators characterizing the fat component: the sum of the skin-fat folds ( $r=-0.985$  at  $p<0.01$ ); the supriliac skinfold, ( $r=-0.968$  at  $p<0.01$ ); the medial (inside) calf fold ( $r=-0.950$  at  $p<0.01$ ). Based on the analysis of the studied indicators, which form the basis of all four factors, there were obtained results that have the predictive value for the individualization and differentiation of the pedagogical process, as well as the influence assessment of the basic pedagogical tools and methods in the process of physical education. **Key words:** FACTOR ANALYSIS, PHYSICAL CONDITION, GIRLS.

### Cite this article as:

Yarmak, O., Blagii, O., Palichuk, Y., Hakman, A., Balatska, L., Moroz, O., & Galan, Y. (2018). Analysis of the factor structure of the physical condition of girls 17-19 year-old. *Journal of Human Sport and Exercise*, 13(2proc), S259-S268. doi:<https://doi.org/10.14198/jhse.2018.13.Proc2.11>

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Supplementary Issue: Spring Conferences of Sports Science. Costa Blanca Sports Science Week, 26-28 April 2018. Calpe. Alicante, Spain.

JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

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doi: 10.14198/jhse.2018.13.Proc2.11

## INTRODUCTION

The need for constant monitoring of the student's physical condition arises in the context of the natural biological development and improvement of motor functions in difficult conditions of the interaction with the environment. Through the lens of the fundamental provisions of biology, the physiology of activity, the theory of activity, functional systems, adaptation and health, the physical condition is characterized by a combination of indicators reflecting gender characteristics, anthropometric profile, physical fitness, functional state of the muscular and cardio-respiratory system of man (Proios et al., 2015; Andrieieva et al., 2017; Yarmak et al., 2017; Alatzoglou et al., 2017; Bodnar et al., 2018). In the process of individual development, the contribution of these variables to the formation of a person's physical status is changing. The need for such control is felt even more sharply in conditions when the human body is exposed to artificially directed influences in order to realize certain social, biological, physical or other programs for improving its individual functions or the whole system (Yarmak et al., 2017).

Analysis of the modern scientific research proves that motor activity is an integral part of human behaviour, which should ensure the normal functioning of the body systems and health preservation (Romanenko, 2003; Broďáni et al., 2015; Galan et al., 2016; Ivashchenko et al., 2017; Andrieieva et al., 2017; Kozina et al., 2017; Ramírez et al., 2017). Within recent years, the volume of academic workload of students in higher educational establishments in Ukraine has significantly increased. Influence of the innovative educational loads with a high level of the psychoemotional and intellectual load, perception and processing of various information in the conditions of the time deficit, increased requirements for the knowledge volume and quality, intensive use of computer technology in the teaching process negatively affect the functional capabilities of the organism (Tomenko, 2017). In this regard, in the majority of students it is observed a pronounced tension of all regulatory mechanisms and a decrease in the functional capabilities of the organism against the background of the apparent deficit of physical activity (Galan et al., 2017). The success of mastering the curriculum is attributable to many factors, among which the students' health, physical development, physical performance and fitness are rather significant (Yarmak et al., 2017). The period of study at a higher educational establishment is characterized by the formation of typical for an adult person body parameters, in particular: length, the completion of sexual development, the process of ossification of the vertebral column and the completion of somatic formation (Chyzyk, 2009).

A scientific interest arises to the study of the structure of the physical condition, in particular, the physical development of girls aged 17-19 years, because at this age biological development ends and morpho-functional indicators acquire optimal values (Balamutova, 2011, Sapozhnyk, 2012; Cieślicka, 2012; Kruk, 2013; Bolotin, 2014; Bolotin, 2017; ledynak et al., 2017). At this age, the human body has the greatest stability, economy and reactivity in response to the stress factor of any modality.

## MATERIALS AND METHODS

For the purpose of determining the indicators of physical development of 17-19 year-old girls there were held anthropometric measurements that reflect the level of morphological features: body length (BL), body weight (BW), body mass index (BMI), girth of various body parts, 5 skinfolds, wrist dynamometry. There were used physiological methods of investigation to assess the state of the cardiovascular system of girls: heart rate at rest ( $HR_{rest}$ ), systolic blood pressure (SBP) and diastolic (DBP), systolic blood volume (Stroke Volume) (SV) and minute blood volume (Cardiac Output) (CO); to assess the state of the respiratory system: vital lung capacity (VC), the Robinson index; physical performance (the Ruffier-Dicson index). To characterize physical fitness, motor tests were used (running 100 m race, bending forward from the sitting position, flexion and

extension of arms in front lying support, sit-up from the back-lying position, times for 1 min, rope jumping for 1 min); for the evaluation of coordination abilities (a complicated Romberg test) - shuttle running 4x9 m. The implementation of this set of tests covers many aspects of physical fitness.

The results were processed using mathematical statistics. Research work was carried out on the basis of the Bila Tserkva National Agrarian University of the city of Bila Tserkva with girls aged 17-19 years. The study involved 186 girls; all of them are the first year students.

## RESULTS

To determine the structure of the physical condition of girls aged 17-19 years, we conducted a factor analysis, which allowed us to establish and evaluate the percentage contribution of each factor. Thus, the structure of the physical condition of girls is determined by a group of four factors: physical development (41.8 %), the functional state of the cardiovascular and respiratory system (28.4 %), physical performance and coordination abilities (12.4 %), physical readiness, in particular speed, speed and strength qualities, agility and flexibility (2.3 %).

The first factor, we identified with the physical development of 17-19 year-old girls, has a factor load of indicators that characterize the total body size: the waist girth ( $r=-0.975$  at  $p<0.01$ ); the chest girth ( $r=-0.966$  at  $p<0.01$ ); the pelvis girth ( $r=-0.956$  at  $p<0.01$ ), BL ( $r=0.947$  at  $p<0.01$ ); BW ( $r=-0.929$  at  $p<0.01$ ), BMI ( $r=-0.918$  at  $p<0.01$ ), the shoulder girth ( $r=-0.864$  at  $p<0.01$ ), the thigh girth ( $r=-0.822$  at  $p<0.01$ ). Also the first factor is the factor load of the indicators characterizing the fat component: the sum of the skin and fat folds ( $r=-0.985$  at  $p<0.01$ ), the suprailiac skinfold ( $r=-0.968$  at  $p<0.01$ ), the medial (inside) calf skinfold ( $r=-0.950$  at  $p<0.01$ ), the fold under the shoulder blade – subscapula skinfold ( $r=-0.927$  at  $p<0.01$ ), the biceps skinfold ( $r=-0.906$  at  $p<0.01$ ), the triceps skinfold ( $r=-0.862$  at  $p<0.01$ ). All of them form the basis of the first factor, which has the greatest contribution - 41.8 % to the total dispersion. The average statistical results of the indicators that form the basis of the first factor, presented in Table 1.

Table 1. Indicators of physical condition of the girls aged 17-19 years (n=186)

Indicators	$\bar{x}$	S	Me	25%	75%	Min.	Max.
BL, cm	166.4	5.68	166.0	164.0	169.0	152.0	185.0
BW, kg	61.8	13.01	59.8	53.5	66.4	42.3	99.2
BMI, kg/m <sup>2</sup>	22.4	4.88	21.2	19.2	24.9	15.5	33.9
Chest girth, cm	85.8	8.70	83.0	80.0	90.0	73.0	106.0
Shoulder girth, cm	27.0	3.15	27.0	25.0	29.0	20.0	34.0
Waist girth, cm	68.9	8.09	67.0	63.0	74.0	54.0	92.0
Pelvis girth	95.1	7.05	94.0	90.0	100.0	82.0	117.0
Thigh girth, cm	52.8	6.23	53.0	50.0	56.0	30.0	68.0
The biceps skinfold, mm	12.3	7.80	11.0	6.0	17.0	2.0	34.0
The tricep skinfold, mm	20.3	8.37	18.0	13.0	27.0	9.0	38.0
The subscapula skinfold, mm	16.3	10.18	12.0	7.0	23.0	4.0	42.0
The suprailiac skinfold, mm	14.4	7.65	13.0	8.0	20.0	4.0	33.0
The medial calf skinfold, mm	19.5	8.80	19.5	12.0	25.0	6.0	45.0
Sum of the skin-fat folds, mm	82.3	37.9	77.0	53.0	108.0	31.0	172.0

In the course of the study of the indicators of the physical development of girls aged 17-19 years, the mean values of the anthropometric indices were obtained, the distribution of which was within the limits of age norms. Analysis of individual BMI parameters in young women allowed to state that 16.1% of female students had body mass deficit, 64.5 % of girls had normal body weight, 12.9 % of girls had excess body weight, 6.5 % of people had obesity of the first degree. There is a high variability in the parameters of BW, BMI, five skin-fat folds and their sum, the variation coefficients are in the range from  $V=20.1\%$  to  $V=63.4\%$ , which indicates the heterogeneity of the sample.

The second most important factor determining the structure of the physical condition has factor loadings of indicators characterizing the activity of the cardiovascular and respiratory system:  $HR_{rest}$  (heart rate at rest) ( $r=-0.878$  at  $p<0.01$ ); VC ( $r=0.826$  for  $p<0.01$ ); the Robinson index ( $r=-0.783$  at  $p<0.01$ ); SBP ( $r=0.741$  for  $p<0.01$ ); DBP ( $r=0.736$  at  $p<0.01$ ); SV ( $r=0.734$  at  $p<0.01$ ); CO ( $r=0.722$  for  $p<0.01$ ). This factor is 28 % of the overall dispersion.

The third most important factor has the factor load of indicators that characterize the physical performance and coordination abilities: the Ruffier index ( $r=0.851$  at  $p<0.01$ ); the sharpened Romberg test ( $r=0.793$  at  $p<0.01$ ). This factor is 12.4 % of the overall dispersion. The average statistical results that characterize the second and third factors presented in Table 2.

Table 2. Indicators of the functional condition and physical performance of girls aged 17-19 years (n=186)

Indicators	$\bar{x}$	S	Me	25%	75%	Min.	Max.
VC, l	3.5	0.59	3.5	3.1	3.9	2.0	4.6
Robinson index, nominal units	95.2	17.02	92.4	87.00	104.4	66.0	144.0
$HR_{rest}$ , beats/min <sup>-1</sup>	85.6	16.30	84.0	72.0	96.0	58.0	120.0
SV, ml	64.6	7.93	64.0	60.57	69.8	44.5	78.7
CO, l·min <sup>-1</sup>	5.5	0.45	5.3	4.72	6.3	3.9	9.0
SBP, mmHg	111.5	8.45	110.0	110.0	120.0	100.0	130.0
DBP, mmHg	73.6	7.72	70.0	70.0	80.0	60.0	90.0
Ruffier index, nominal units	9.7	2.90	9.0	8.0	10.4	6.4	18.0
Sharpened Romberg test, sec	15.3	7.55	10.3	6.0	24.0	1.0	54.5

In the overwhelming majority of girls aged 17-19 years, the individual results of VC were within the age limit, and only 19.4 % of the results were below the age norms.

The value of the Robinson index serves as an important criterion for the reserve and economization of the cardio-respiratory system function and indicates the aerobic capacity of the body, so in our work we used this indicator to study the respiratory system. Individual indices of the Robinson index in girls aged 17-19 years were of the below average and average level.

The average result of the heart rate at rest is above the age limit, the signs of bradycardia are incidental to 2.7 % of girls, it is also worrying that in 52.7 % of girls aged 17-19 years the individual results range from 84 beats per min up to 120 beats per min. This fact may indicate a psychoemotional tension.

Systolic BP is one of the most informative functional parameters and it subtly reflects the changes related to the state of its regulatory parts: peripheral vascular resistance, activity of the sympathetic part of the autonomic nervous system, the vasomotor centre tone, the heart force, cardiac output. Diastolic BP depends,

in turn, on the tone of small and medium vessels and is associated with the activity of parasympathetic innervation and the state of the vascular wall. The value of BP is considered to be a homeostatic index, and therefore its deviation in one direction or another may indicate certain changes in the general functional condition of the organism. In the course of our study, we found out that the signs of hypotension are characteristic of 16.1 % of girls (BP <110/70), and of hypertension - for 21.5 %.

The magnitude of CO is an integral characteristic of the circulation, it contributes to the provision of the metabolic needs and depends on the stroke volume and the heart rate at rest. This indicator was determined by the calculation method, which is used mainly during mass surveys, when, due to the considerable time spent using instrumentation techniques, it is not practical. In spite of the fact that the representativeness is less than in comparison with the experimental methods, the calculation methods as a whole make it possible to obtain the necessary information on the status of the leading hemodynamic parameters and their dynamics, in particular, during physical training and sports. Individual indicators of CO and SV in girls aged 17-19 years were within the age limit.

The average result of girls aged 17-19 years corresponds to the average level of the physical performance. The analysis of individual results allowed to state that girls do not have a high level of physical performance, 17.2 % of girls have a sufficient level, 46.2 % of girls have an average level, 28.0 % of female students have a satisfactory level and 8.6 % of girls have an unsatisfactory level of physical performance.

The average statistical index of the sharpened Romberg test, which characterizes static coordination, was within the normal range in girls aged 17-19 years, although a high variability of  $V=49.3\%$  was observed, indicating a heterogeneity of the sample. It should be noted that 24.2 % of girls had individual results that met an unsatisfactory level.

The fourth factor determining the structure of the physical condition of girls aged 17-19 years is the factor load of the indicators characterizing the speed, speed and strength qualities, agility and flexibility: shuttle run 4×9 m ( $r=0.788$  at  $p<0.01$ ), running 100 m race ( $r=0.758$  at  $p<0.01$ ); rope jumping ( $r=0.731$  at  $p<0.01$ ); flexion and extension of arms in front lying support ( $r=0.732$  for  $p<0.01$ ); sit-up from the back-lying position in 1 minute ( $r=0.728$  at  $p<0.01$ ); bending forward from the sitting position ( $r=0.716$  at  $p<0.01$ ). The average statistical results are shown in Table 3.

Table 3. Indicators of the physical fitness of girls aged 17-19 years (n=186)

Indicators	$\bar{x}$	S	Me	25%	75%	Min.	Max.
Running 100m race, sec	17.2	1.32	17.3	16.6	18.1	15.2	21.8
Rope jumping, times/1min	113.4	11.06	111.0	110.0	124.0	81.0	146.0
Flexion and extension of arms in front lying support, times	2.9	3.10	2.0	0.0	5.0	0.0	10.0
Sit-up from the back-lying position, times/1min	29.9	8.47	32.0	27.0	33.0	11.0	48.0
Bending forward from the sitting position, cm	15.1	9.77	16.0	5.0	19.0	0.0	32.0
Shuttle running 4×9 m., sec	10.6	0.27	10.4	10.2	11.1	9.7	12.1

Progressive natural development of speed is observed in girls aged 13-14. In the future, the speed of holistic movements in girls of 15 years is very slowly growing and is stabilized until the age of 17, therefore, with the end of the puberty period, the further biological development of speed practically ceases. In girls the average result in running 100 m race corresponded to the satisfactory score.

The level of the strength development determines the degree of manifestation of other physical qualities. As the muscular-skeletal system performs various kinds of work, the strength of the muscles has specific features, especially when the level of physical fitness is being increased. The average statistical results of girls aged 17-19 years in flexion and extension of arms in front lying support and in sit-up from the back-lying position, showed a satisfactory and unsatisfactory score. 25.8 % of the girls failed to perform the motor test in flexion and extension of arms in front lying support, that indicates a low development of the strength qualities, in particular of the forearm flexors and extensors.

Analysing the individual results of the test for flexibility of 17-19-year-old girls, it was found that in 15.1 % they correspond to an unsatisfactory score. Insufficient mobility in the joints limits the level of manifestation of strength, speed and coordination abilities, worsens intramuscular and intermuscular coordination, leads to a decrease in the exercise economy and often causes damage to muscles and ligaments.

The average result in rope jumping corresponds to an excellent mark, only 9.1 % of girls have a satisfactory mark, and 19.9 % have a good mark.

The variety of types of coordination abilities does not allow assessing the level of their development by a unified criterion. Therefore, to determine the level of agility, a test "shuttle run 4×9 m" was conducted in the physical education of students. The average result in girls 17-19 years old corresponds to the satisfactory mark.

Analysing the indicators characterizing the physical preparedness, in particular speed, speed and strength qualities, agility and flexibility, we observe a high variability in the results of the in flexion and extension of arms in front lying support and in the performance of the flexibility test, the coefficients of variation range from  $V=64.7\%$  to  $V=106.9\%$ , which indicates the heterogeneity of the sample.

In the course of the study, we carried out correlation interrelations between the indicators characterizing the fat component and form the basis of the first factor with other investigated indicators characterizing physical development, functional state of the cardiovascular and respiratory system, physical performance and fitness. The results of the correlation relationships are presented in Table 4.

Table 4. Correlation of the fat component with indicators of physical condition in girls aged 17-19 years (n=186)

Indicators	1	2	3	4	5	6
Age, years	0.332	0.288	-0.180	0.019	0.164	0.097
BL, cm	-0.241	-0.453	0.075	0.037	-0.269	-0.162
BW, kg	0.738	0.843	0.847	0.847	0.816	0.879
BMI, kg/m <sup>2</sup>	0,752	0.890	0.813	0.818	0.833	0.879
Chest girth, cm	0.837	0.749	0.986	0.987	0.863	0.953
Shoulder girth, cm	0.726	0.848	0.686	0.724	0.853	0.816
Waist girth, cm	0.866	0.764	0.977	0.992	0.892	0.965
Pelvis girth, cm	0.821	0.867	0.859	0.883	0.909	0.928
Thigh girth, cm	0.712	0.890	0.621	0.661	0.821	0.784
VC, l	0.328	0.295	0.290	0.339	0.287	0.324
HR, beats / min <sup>-1</sup>	0.216	-0.061	0.327	0.317	0.218	0.225
SBP, mmHg	0.282	0.196	0.506	0.511	0.312	0.399

DBP, mmHg	0.774	0.704	0.235	0.439	0.717	0.576
Sharpened Romberg test, c	-0.120	0.205	-0.158	-0.199	-0.004	-0.061
Dynamometry right hand, kg	0.354	0.251	0.474	0.492	0.499	0.450
Dynamometry left hand, kg	0.192	0.008	0.446	0.422	0.330	0.316
The biceps skinfold, mm	1.000	0.893	0.779	0.894	0.970	0.953
The triceps skinfold, mm;	0.893	1.000	0.670	0.761	0.899	0.885
The subscapula skinfold, mm	0.779	0.670	1.000	0.972	0.818	0.919
The suprilliac skinfold, mm	0.894	0.761	0.972	1.000	0.910	0.973
The medial calf skinfold, mm	0.970	0.899	0.818	0.910	1.000	0.971
Sum of the skin-fat folds, mm	0.953	0.885	0.919	0.973	0.971	1.000
Ruffier index, nominal units	-0.419	-0.359	-0.423	-0.397	-0.427	-0.433
Bending forward from the sitting position, cm	-0.029	-0.078	-0.327	-0.245	0.048	-0.153
Flexion and extension of arms in front lying support, times	0.050	0.188	-0.426	-0.308	0.081	-0.119
Sit-up from the back-lying position, times/1 min	-0.563	-0.232	-0.672	-0.713	-0.614	-0.604
Running 100 m race, sec	0.534	0.285	0.295	0.408	0.359	0.385
Shuttle running 4×9 m, sec	0.310	0.250	0.337	0.313	0.384	0.217
SV, ml	-0.347	-0.329	0.240	0.075	-0.272	-0.097
CO, l min <sup>-1</sup>	-0.109	-0.276	0.370	0.245	-0.060	0.068
Robinson index, nominal units	0.346	0.043	0.533	0.527	0.359	0.399

Note: 1- the biceps skinfold, mm; 2- the triceps skinfold, mm; 3- the subscapula skinfold, mm; 4 - the suprilliac skinfold, mm; 5- the medial (inside) calf skinfold, mm; 6 - sum of the skin-fat folds, mm

Note: n=186; r=0.159 at p<0.05; r=0.208 at p<0.01; r=0.263 at p<0.001

During the study of the correlation relationships between the parameters of the fat component and total body size, the functional state of the cardiovascular and respiratory system, indicators of physical work capacity and preparedness, it was established that the correlation coefficients vary within the limits of high reliability.

## DISCUSSION

One of the important elements of the managing system of the process of physical education is the timely monitoring of the physical condition of the student youth. The essence of control and accounting is the identification, comprehension and assessment of real conditions, specific facts, dynamics and results of the pedagogical process. Thanks to the control and accounting, there are accumulated data on the physical condition, technical and tactical preparedness and quantitative achievements of the persons engaged in physical exercises. In addition, it is systematically checked the effectiveness of the means, methods and organizational forms that are applied in the educational process. These data allow to plan more accurately and to modify the educational process, thereby contributing to the improvement of its quality and effectiveness (Beziazychnyi, 2015).

In the process of the individual development the factor load of indicators that characterize the physical condition of a person are changed, changes are affected by lifestyle, motor activity, professional or sports activities. The age of 17-19 years is a critical period of transition from pubertal to postpubertal stage of development, when the corresponding level of physical condition for the following years is built. In the mentioned age period, the components of the physical condition are most easily influenced by external factors, therefore, study of girls aged 17-19 years have prognostic value for assessing the influence of the

basic pedagogical tools and methods in the process of physical education.

The results of our studies confirm the data (Romanenko, 1999) that physical development takes the leading place among the factors that form the basis of the factor structure of 17-19-year-old girls, and is the main after the puberty period; as well there were confirmed facts about low individual results in strength exercises, in exercises on flexibility, and static coordination (Serhiienko, 2014; Blagii, 2015; Bolotin, 2014; Martins et al., 2017). Our research has acknowledged the high informativeness of the indicators characterizing the fat component for predicting the risk of diseases (Gorshunova, 2008) and the close relationship between the components of the physical condition (Romanenko, 2003). Our studies supplemented the data (Beliak, 2014, Martyniuk, 2016) about the existence of the relationship between the parameters of the girl's body weight and the indicators of physical condition.

## CONCLUSIONS

As a result of factor analysis, we found that the structure of the physical state of girls aged 17-19 is determined by a group of four factors, the leading place belongs to physical development, which has the largest contribution - 41.8 % of the total dispersion. The functional state of the cardiovascular and respiratory system with a factor load of 28.4 % of the total dispersion ranks second for its importance. Physical fitness and coordination abilities, as well as physical readiness, in particular speed, strength, agility and flexibility, form the basis of the third and fourth factors with a factor load of 12.4 % and 2.3 %, respectively.

In determining the correlation between the fat component of girls 17-19 years and the parameters characterizing the total body size, the functional state of the cardiovascular and respiratory system, as well as physical fitness and preparedness, it has been established that the correlation coefficients vary within the limits of high credibility ( $r=0.208$  at  $p<0.01$ ,  $r=0.263$  at  $p<0.001$ ) for the sample  $n=186$ .

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