Journal of Physical Education and Sport ® (JPES), Vol.19 (issue 2), Art 168, pp. 1158 - 1163, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The relationship between the indicators of morpho-functional state, physical development, physical fitness and health level of girls aged 12-13 years

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Published online: June 30, 2019
(Accepted for publication: June 11, 2019)
DOI:10.7752/jpes.2019.02168

Abstract:
The article presents the results of the pedagogical experiment that lasted during 2017-2018 academic year. Altogether 205 girls of 12-13 years of age were involved in the research. To achieve this goal, an integrated approach was used with the application of the following research methods: analysis and synthesis of references; anthropometric methods; determination of the level of physical health; pedagogical testing; physiological methods; methods of mathematical statistics. The coefficient of canonical correlation between the indicators of physical health, on the one hand, and physical fitness, on the other, in the schoolgirls with a low level of physical health is r = 0.569; in the girls with the level of physical health below the average r = – 0.735 and in the girls with the average level of physical health r = –0.791. It means that each higher level of physical health of the subjects is determined by a higher-quality state of their physical fitness. We found out that of 105 possible comparisons between the individual components of physical health and physical fitness of the 12-13-year-old girls, 67 (or 64 %) positive cases of medium and high dependence were recorded. The results of our research prove that the main components of physical fitness in terms of the impact on the physical health of the girls aged 12-13 years are indicators of aerobic endurance r = 0.440-0.743, of speed-strength qualities r = 0.355-0.692, of strength and strength endurance r = 0.322 - 0.735. Their priority is due to the most significant correlation coefficients with four of the five components of physical health surveyed.
Key words: physical health, physical fitness, girls

Introduction

The current trend towards an increase in the number of school-age children with a deviation in health level determines the relevance of research on the scientifically grounded safe, efficient parameters of physical education and health-improving activities for adolescents (Pityn,2017; Bolotin, 2017). In the opinion of numerous authors (Andreeva, 2002; Arefiev, 2013; Galan, 2017; Kashuba, 2018), to improve the health of the younger generation, we need fundamentally new approaches and technologies corresponding to their individual characteristics, effectively implementing their interests, inclinations and abilities. Programming physical education and health-improving activities for school-age children should be based on adequate methods of pedagogical control and rational parameters of training practices, taking into account the state and level of health, physical abilities of those involved in (Tomenko, 2017; Galan, 2018; Bodnar, 2018). Numerous publications on this issue either have contradictions or concern private aspects (Andrieieva, 2017). Moreover, the assessment of their results is fragmental, and a large number of questions are not well understood. Thus, along with the numerous data on the impact of physical exercises on the body of those who are engaged in (Sergienko, 2005; Krusevich, 2006; Bolotin, 2014;), the aspects of the regulation of physical activity are not well developed, the normative parameters of physical training and health-improving activities are not defined (Ermolova, 2003; Andrieieva, 2018; Leonenko, 2019).

It is of great importance that in the literature there is almost no information about interrelations between the indicators of physical fitness and the health level.

Materials and Methods

The scientific study was conducted on the basis of the Specialized School of the I-III stages No. 130 named after Dante Alighieri of the city of Kyiv; the Specialized School of the I-III stages of the physical and mathematical profile No.6, secondary schools of the I-III stages No.30 and No.33 of the city of Chernivtsi. Altogether 205 girls aged 12-13 years took part in the study, who, for health reasons, were assigned to the main and preparatory medical groups, in particular 103 girls from Kyiv (n = 103) and102 girls from Chernivtsi (n = 102). A complex of interrelated research methods is applied in the research: a theoretical analysis of scientific and methodological literature; anthropometric methods, physiological methods; pedagogical methods;

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determination of indicators of physical health; methods of mathematical statistics. The analysis of the literature was carried out taking into account the diversity of the problem under study. We have analysed both fundamental works on human physiology and works related to individual aspects of the subject of our research. We have paid attention to the publications of the top experts in the sphere of physical activity and physical education of schoolchildren. The works concerning the methods of diagnosing the quantitative level of health, determining the biological age of adolescent girls and organizing the physical education of schoolchildrenwere analysed.

The state of physical health of schoolgirls aged 12-13 years wasstudied with the use of the method of H.L. Apanasenko. The basis for determining the level of physical health is assigned to assess the power and efficiency of the aerobic energy supply. From a physiological point of view, this indicator integrally characterizes the state of the respiratory, circulatory and metabolic functions, and from the biological point of view, the degree of sustainability of a living organism. The method of quantitative rapid assessment of the level of physical health includes the study of indicators of anthropometry (body length, body weight, vital capacity of the lungs - VC, hand dynamometry), as well as analysis of the state of the cardiovascular system.

For a more objective and more accurate assessment of the interaction of indicators of physical fitness and physical health of adolescent girls aged 12-13 years, the correlation analysis was used: canonical correlation coefficients and correlation coefficients.

Results

As noted, the state of physical health of schoolgirls aged 12–13 years was studied with the use of the methodology of H.L. Apanasenko, which provides for the distribution of students in 5 levels of health: low, below average, average, above average and high. Altogether 205 children of the cities of Kyiv and Chernivtsi were examined. At the beginning of the pedagogical experiment, there was no statistically significant difference between the girls aged 12-13 years by all the studied parameters. The results of statistical processing of the physical health indicators of the subjects are presented in Table 1. The indicators of body length of the schoolgirls having low, below the average and average level of physical health (LPH) are mostly the same ($p > 0.05$) and are as follows: for the low level of health -158.9 ± 6.98 cm; for the level below the average - 155.9 ± 8.46 cm; and for the average level - 154.8 ± 8.55 cm.

Table 1. The results of statistical processing of indicators of physical health of the examined adolescent girls, (n = 205)

Level of physical health	Body length. cm	Body weight. kg	SBP. mmHg.	HR_{rest}, beats /min^{-1}	DP,nominal units	VC, l/ body weight	Dynamometry/ body weight	Ruffier index. nominal units
Low (1)	158.9±6.98	51.3±9.16	116.3±6.27	38.9±2.16	92.3±11.12	46.8±10.22	32.1±5.28	13.7±2.35
Below average (2)	155.9±8.46	43.8±6.12	114.6±5.31	38.2±3.11	88.9±9.36	57.6±8.65	35.5±7.35	13.1±2.17
Average (3)	154.8±8.55	43.0±6.21	113.2±6.25	36.1±2.18	83.3±4.23	58.4±8.27	37.2±7.35	9.2±2.06
p_{1-2}	> 0.05	< 0.01	> 0.05	> 0.05	> 0.05	< 0.05	< 0.05	> 0.05
p_{1-3}	> 0.05	< 0.01	> 0.05	< 0.01	< 0.05	< 0.05	< 0.05	< 0.05
p_{2-3}	> 0.05	> 0.05	> 0.05	< 0.01	< 0.05	> 0.05	> 0.05	< 0.05

The body weight (in absolute values) decreases with the increase of LPH (from 51.3 to 43.0 kg). The decrease in the body weight indicators was significant for the groups of girls with low and average LPH ($p < 0.01$); low and below average LPH ($p < 0.01$). In the scheme of assessment of the LPH, some hemo/cardiodynamic indicators are presented: systolic blood pressure, heart rate at rest for 30 s, double product (DP). The first indicator of the schoolgirls with different LPH has no statistically significant differences ($p > 0.05$), while the second indicator of the schoolgirls with the average level on the one hand and low and below average LPH, on the other hand, has statistically significant differences in favour of the girls with the average LPH ($p < 0.01$). In addition to the peculiarities of physical health, the methodology includes indicators that assess physical performance, characteristics of the respiratory and muscular systems. From low to average LPH, the indicators of physical performance in the subjects are improved. The reduction of the Ruffier index from 13.7 ± 2.35 at a low LPH to 9.2 ± 2.06 at an average level of physical health proves this fact. (There is a statistically significant difference between the schoolgirls with the low and average LPH and the schoolgirls with the below average and average LPH). A similarly positive inverse relationship is observed in the indicators of the Robinson index, that is, with an increase in the LPH of the subjects, its value decreases (from 92.3 ± 11.12 to 83.3 ± 4.23).

The direct positive interaction (the higher the LPH of the studied contingent, the higher indicators they have) was found out by means of the life and force indices. The difference in average values is significant between low and below average, as well as the average LPH of the schoolgirls (for both indices).

The canonical correlation coefficient (CCC) enabled determining the degree of connection between the indicators of the two sets. In our case, these are seven indicators of physical fitness, on the one hand, and five indicators of physical health, on the other, in the schoolgirls of the same sample (n=205) The calculations of the correlation coefficient were used to determine the degree of interrelation by a pair of indicators, one of which reflected physical health, and the other - an element of physical fitness. The choice of this correlation coefficient to assess this relationship is explained by the fact that, unlike the pairwise correlation coefficient, it also indicates a non-linear relationship, which is more common in real life than a linear one.

As can be seen from Table 2, the canonical correlation between the indicators of physical health and physical performance of the subjects under study has some peculiar features. The canonical correlation coefficients have a positive value, that is the better comprehensive physical fitness, the higher the level of physical health. This dependence on the total sample (without the distribution of the subjects according to health levels) is of an average degree (CCC = 0.435).

Internal group dependence (after the distribution of the subjects according to the level of physical health) is above the average (CCC = 0.616-0.656) and high (CCC = 0.754). The first coefficients relate to the relationship between the functional and motor indicators of schoolgirls with low and below average levels of physical health, the last - with the average level. It indicates that a high level of physical health of the subjects if other things being equal is due to a higher quality state of their physical fitness. Thus, we have determined the statistical dependence of the level of physical health of the adolescent girls aged 12-13 years from the cumulative impact of their physical fitness. Due to the fact that physical fitness is the result of organized and independent physical activity, it is possible to regulate the level of physical health of schoolgirls developing adequate training programs. Therefore, the next step of our study was to determine the pairwise relationship between the components of physical health and physical fitness in order to identify the degree of their interaction and the significance of the influence of the indicators of individual motor qualities on the components of physical health.

It should be noted that the usual pair correlation coefficients, previously used to solve this issue, do not allow to determine the real interactions between the studied parameters since their capabilities are limited only by a linear dependence. The data presented in Table 2 show that the interaction under study in the general group sample has an average relationship in one-third of cases (in 12 out of 35 possible cases) (η = 0.3-0.4). Comparison of the obtained coefficients by pairwise correlation coefficients are very different. When using the latter, that is, the linear coefficients of the relationship, not a single significant interaction was found between the studied parameters. These positive correlation coefficients of the average degree related to the indicators of physical fitness with the power index (in five cases), physical performance (in four cases) and the life index (in three cases). The Robinson index characterizing the systolic work of heart at rest and relative body weight has no interaction with the indicators of the main moving abilities at the group level. The analysis of interaction of the studied indicators, taking into account the level of physical health (LPH) of schoolgirls, demonstrates much larger number of significant relationships than in the overall group sample. Of 105 possible ratios, 67 (or 64 %) positive cases of average and a high degree of dependence were identified, while in the general group variant their number is 34 %, that is, twice higher.

Table 2. Correlation coefficients between the components of physical fitness (PF) and physical health (PH) of schoolgirls aged12-13 years, (n = 205)

Level of physical health	n	Indicators	Flexion and extension of arms	Standing long jump. cm	Sit-up from the back-lying position.	Running 60 m	Running 1,500 m	Shuttle running 4 × 9 m. sec	Bending forward
Low	86	Robinson index	0.322	0.351	0.327	-0.053	0.464	0.258	0.290
Below average	79		0.353	0.546	0.369	0.048	0.658	0.235	0.258
Average	40		0.442	0.591	0.293	-0.054	0.630	0.134	0.134
Low	86	Life Index	0.358	0.374	0.236	-0.349	-0.455	-0.441	0.352
Below average	79		0.475	0.475	0.279	-0.384	-0.569	-0.694	0.193
Average	40		0.336	0.641	0.247	-0.357	-0.743	-0.791	0.014
Low	86	Force Index	0.448	0.357	0.455	-0.064	0.468	-0.247	0.371
Below average	79		0.735	0.436	0.584	-0.115	0.545	-0.365	0.248
Average	40		0.672	0.692	0.677	-0.147	0.686	-0.374	0.337
Low	86	Ruffier index.	-0.337	0.355	-0.443	-0.054	0.440	-0.082	-0.135
Below average	79		-0.453	0.447	-0.549	-0.037	0.564	0.270	0.098
Average	40		-0.658	0.632	-0.641	0.075	0.683	0.058	-0.155
Low	86	Correspondence of mass to body length	-0.064	-0.158	-0.060	-0.012	0.036	0.037	0.569
Below average	79		0.381	0.012	-0.035	-0.064	0.047	-0.059	0.347
Average	40		-0.139	0.246	-0.275	-0.048	0.118	0.148	0.374

First of all, the increase in the correlation coefficients between the interrelated indicators from low to average LPH of the surveyed is noteworthy.

The Robinson Index characterizes systolic cardiac performance at rest. We found that this indicator has an average and above-average correlation with the level of manifestation of endurance (η = 0.464 - 0.658) and muscular strength (η = 0.293 - 0.591). Of the three indicators of strength used in this work: leg muscle strength, which manifests itself in the shortest possible time; dynamic strength endurance of the muscles of the arms and muscles of the body - the largest relationship of the Robinson index is noted with the first (η = 0.351 - 0.591). We found out that the impact of the studied indicators of agility, flexibility and speed on the maximum aerobic qualities is minimal. There is a low and very low interrelation between them.

The life index (the ratio of VCs to body mass) compared with the Robinson index has relationships with a large number of motor qualities. There are 76 % of significant correlations (16 cases out of 21 possible comparisons) compared with 57 % (12 out of 21) when evaluating the links of the Robinson index. The highest inverse correlation (η = –0.455-0.743) was recorded based on the results of running 1,500 m race. An average correlation was found between the life index and strength endurance of the arms, the explosive strength of the legs, agility and speed with (η = 0.4-0.7). This dependence is obviously due to the relationship of this index with the mass of the body: the lower the body mass of the schoolgirls, the better results they had in the test of flexion and extension of arms in front lying support, standing long jump, in sprint and overcoming inertia forces during the shuttle running. The strength endurance and flexibility are weakly associated with the life index.

The force index (the ratio of the maximum strength to body mass), as expected, is most closely related to the performance of strength tests (η = 0.448-0.735). The indicators of endurance are in the second position; below average, but significant relationships are found with the power index agility (η = 0.247-0.374) and flexibility (η = 0.248-0.371). The positive correlation of the index with flexibility can be explained by the active mobility of the spine, that is, those types of flexibility, the results of which are also affected by the strength potential of the corresponding muscles.

A large number (86 %) of interconnections with the strength index of the components of physical fitness in comparison with previous health indicators attracts attention. Significant relationships are found in 18 out of 21 possible comparisons. Only speed results demonstrate no correlation with the studied index.

The Ruffier Index is interrelated with average and above-average correlation only with the indicators of strength and endurance. Results in tests for speed, agility and flexibility do not have a significant connection with this indicator of health. The dynamic strength endurance of the trunk muscles (η = -0.443-0.641) has the highest correlation with the physical performance level of the three strength tests. Correspondence of body weight to its length, as an indicator of physical health, is proposed for identifying people with obesity or those that are prone to obesity. This indicator is used to level the various rates of biological maturation of children; it varies little with age and has the nature of homeostatic. A distinctive feature of the "compliance index" is the lack of its interaction with the most indicators of physical fitness. Only with three results of flexibility (based on trunk-bending forward) and one strength indicator (for girls below average LPH) a moderate degree of correlation was fixed (η = 0.347- 0.569).

Discussion

In recent years, due to the changes in socio-economic conditions of life and a significant deterioration in the health of the population, the problem of physical inactivity in Ukraine remains relevant (Lazareva, 2017). For the effective and optimal organization of the motion activity, it is necessary to assess the biological patterns and specifics of growth and development of child's body, the heterochronism of development of functional systems and physical qualities, and sexual dimorphism. Adolescence is characterized by several features. During puberty, when the function of the hypothalamo-hypophysial system is significantly rebuilt, all physiological functions undergo significant changes. The development of internals is slower than the intensive growth of the skeletal and muscular system. The heart is ahead of blood vessels in growth, as a result of which the arterial pressure rises and complicates the work of the heart. The body of adolescents reaches the maximum level of oxygen consumption in less time and quickly stops working due to inability to maintain oxygen consumption for a long time at a high level. The emotional sphere is changing. Therefore, in the development of health-improving programs, it should be remembered that significant physical exertion has an inhibiting effect on the development of reproductive function in adolescents. Also, the discrepancy between physical exertion and functional capabilities of the body is often the cause of impaired growth and development of the body of children and adolescents. The research of the authors showed that the hormonal status of the body affects the performance and motor qualities of girls (Vaskan, 2018).

The results of our research confirm the data (Bar-Or O, 2009;Leskiv, 2013; Azhippo, 2015; Nakonechnyi, 2017; Ashanin, 2017; Broďáni, 2017; Yarmak, 2018; Vaskan, 2018), that the human motor activity significantly affects the nature of functioning of each of the body systems separately and on the whole organism, the data that the motor activity and the health status of people of any age group are closely linked. The results of our research complete the data (Pasichnyk, 2018; Galan, 2018; Kozhokar, 2018) that level of physical fitness implicitly reflects the status of functional systems of bodies of schoolchildren, and the data (Yarmak, 2018) that the physical fitness is an equivalent of somatic health.

Conclusions

The study of the correlation relationships between the individual functional and motor indicators of adolescent girls aged 12-13 years with different level of physical health showed that the leading components of physical fitness, in terms of assessing their interaction with the components of physical health, are indicators of aerobic endurance (running 1,500 m race), speed-strength qualities (standing long jump), strength and strength-dynamic endurance (flexion and extension of arms in the front-lying position, sit-up from the back-lying position). Their priority is due to the most significant correlation coefficients with four of the five components of physical health of the subjects. The fifth component of physical health – weight-to-length ratio - has significant correlations only with the indicators of spinal flexibility. Indicators of speed (running 60 m distance) interact at a level below the average only with the life index, and indicators of dexterity (shuttle running 4 × 9 m) at the same level with the tone of muscle tissue activity and at the level above the average also with the life index. The correlation coefficients between interrelated functional and motor components increase with an increase in the level of physical health of the subjects.

Competing Interests

The authors declare that they have no competing interests.

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