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PHYSICAL FITNESS AND MORPHO-FUNCTIONAL STATE OF ADOLESCENTS WITH DIFFERENT AEROBIC PRODUCTIVITY LEVEL

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Abstracts

Introduction. Insufficient level of schoolchildren physical fitness and physical health determines the relevance of studying of physical qualities development in relation to adolescents' body aerobic productivity and physical development. The *purpose* of the study is to investigate the relationship between the components of physical fitness and physical development of adolescents with different levels of aerobic productivity. **Materials and Methods.** Assessment of schoolchildren physical fitness (L. P. Sergienko, 2010); aerobic productivity determination step-ergometry method (V. L. Karpman, 1988). Physical development assessment was carried out on the basis of the power indexes definition, body mass index and Pinie's index. Muscle mass value for power indexes calculation was determined by Matejko method. The study involved 423 adolescents, 211 of them were females and 212 were males. **Results.** Aerobic productivity level reducing is accompanied by body mass index increasing and Pinie's index reducing, which reflects the important role of physical development somatometric features in determining organism functional capabilities. Aerobic productivity level increasing is connected with muscle strength increasing that is testified by power indexes dynamics, determined by ratio indicators of hand and static dynamometry to the muscular mass in both girls and boys bodies, as well as hands flexion- extension in lying position to body mass in male adolescents. **Conclusions.** With the reducing in aerobic productivity level there is an increasing in the proportion of children with below average physical preparedness level and reducing in above average physical preparedness level. The presence of respondents with above average physical preparedness level in each experimental group indicates the opportunities to improve the physical qualities development level. The obtained results can be used to develop differentiated approaches in physical education of students with different aerobic productivity levels.

Key words: physical fitness, physical development, aerobic productivity, adolescents.

Олександр Лемак, Ірина Султанова, Ірина Іванишин, Родіон Арламовський. Фізична підготовленість та морфофункціональний стан підлітків із різним рівнем аеробної продуктивності. **Актуальність.** Недостатній рівень фізичної підготовленості та соматичного здоров'я школярів обумовлює актуальність вивчення розвитку фізичних якостей у взаємозв'язку з аеробною продуктивністю та фізичним розвитком організму підлітків. **Завдання дослідження** – виявити взаємозв'язок складників фізичної підготовленості й фізичного розвитку підлітків із різним рівнем аеробної продуктивності. **Матеріал і методи дослідження** – оцінка фізичної підготовленості школярів (Сергієнко Л.П., 2010); визначення аеробної продуктивності методом степ-ергометрії (Карпман В. Л., 1988). Оцінку фізичного розвитку проводили на підставі визначення силових індексів, індекса маси тіла та індекса Пін'є. Кількість м'язової маси для розрахунку силових індексів визначали за методом Матейка. У дослідженні взяло участь 423 підлітки, 211 – із них жіночої та 212 – чоловічої статі. **Результати дослідження.** Зниження рівня аеробної продуктивності супроводжується збільшенням індексу маси тіла та зниженням індексу Пін'є, що відображає важливу роль соматометричних ознак фізичного розвитку в детермінуванні функціональних можливостей організму. Підвищення рівня аеробної продуктивності пов'язано зі збільшенням м'язової сили, про що свідчить динаміка силових індексів, визначених за даними співвідношення показників кистьової та станової динамометрії до м'язової маси тіла в дівчат і хлопців, а також згинання-розгинання рук в упорі лежачи до маси тіла в підлітків чоловічої статі. **Висновки.** Зі зниженням аеробної продуктивності зростає частка дітей із нижчим від середнього рівнем фізичної підготовленості та зменшується частка дітей із вищим від середнього рівнем фізичної підготовленості. Наявність респондентів із вищим від середнього рівнем фізичної підготовленості в кожній дослідній групі свідчить про наявні можливості до підвищення рівня розвитку фізичних якостей. Отримані результати можна використати для розробки диференційованих підходів у фізичному вихованні школярів із різним рівнем аеробної продуктивності.

Ключові слова: фізична підготовленість, фізичний розвиток, аеробна продуктивність, підлітки

Александр Лемак, Ирина Султанова, Ирина Ивановна, Родион Арламовский. **Физическая подготовленность и морфофункциональное состояние подростков с разным уровнем аэробной продуктивности. Актуальность.** Недостаточный уровень физической подготовленности и соматического здоровья школьников обуславливает актуальность изучения развития физических качеств во взаимосвязи с аэробной производительностью и физическим развитием подростков. **Задачи исследования** – выявить взаимосвязь составляющих физической подготовленности и физического развития подростков с разным уровнем аэробной производительности. **Материал и методы исследования:** оценка физической подготовленности (Сергиенко Л. П., 2010), определение аэробной продуктивности методом степ-эргометрии (Карпман В. Л., 1988). Оценку физического развития проводили путем определения силовых индексов, индекса массы тела, индекса Пинье. Количество мышечной массы для расчета силовых индексов определяли по формуле Матейка. В исследовании приняло участие 423 подростка,

211 – из них женского и 212 – мужского пола. **Результаты исследования.** Снижение уровня аэробной производительности сопровождается увеличением индекса массы тела и уменьшением индекса Пинье, что отражает важный вклад соматометрических признаков физического развития в функциональное состояние организма. Повышение уровня аэробной производительности связано с увеличением мышечной силы, о чем свидетельствует динамика силовых индексов, рассчитанных путем определения соотношения показателей кистевой и становой динамометрии к количеству мышечной массы тела у подростков женского и мужского пола, а также сгибания-разгибания рук в упоре лежа к массе тела у подростков мужского пола. **Выводы.** Со снижением уровня аэробной производительности увеличивается количество детей с ниже среднего уровнем физической подготовленности в каждой исследуемой группе и уменьшается количество детей с выше среднего уровнем физической подготовленности. Наличие в каждой группе детей с выше среднего уровнем физической подготовленности свидетельствует о возможности повышения уровня развития физических качеств. Полученные результаты можно использовать для разработки дифференцированных подходов в физическом воспитании школьников с разным уровнем аэробной производительности.

Ключевые слова: физическая подготовленность, физическое развитие, аэробная производительность, подростки.

Introduction. Modern scientific researches show insufficient level of schoolchildren physical fitness [4; 6] and somatic health [7; 8; 12].

One of physical education tasks is the health formation and the promotion of younger generation harmonious physical development [1; 4], the above facts predetermine the need to develop and implement effective approaches aimed at improving the physical qualities development and health care reserves of children in all ages.

It is known that an objective criterion that both quantitatively characterizes human health and reflects aerobic productivity level is the value of maximum oxygen consumption ($VO_{2\max}$). At the same time, this indicator regulates physical activity intensity. However, information about the degree of physical qualities development in adolescents versus the body aerobic capacity level and physical development indicators is insufficient. Therefore, the study of physical qualities development in connection with the body aerobic capacity level and physical development of children in all ages is an actual issue of nowadays.

The Purpose of the Research is to investigate the distinctions between physical fitness and physical development components of adolescents with different aerobic productivity levels.

Materials and Methods of the Research. To achieve the goal there were used the following research methods: scientific and methodological literature analysis and synthesis, schoolchildren physical fitness assessment [9]; aerobic endurance determination by V.L. Karpman's step-ergometry method [3]. Physical development evaluation was carried out on the basis of the strength indexes, body mass index (BMI) and Pignet index [5]. Muscle component of body weight for strength indexes calculation was determined by Matejko's method [10].

In order to leveling anthropometric parameters influence on somatomotoric qualities development there were determined physical fitness indices [9] (upper limb muscles strength index (SI_{UB}) as ratios: pull-up test results to the hand length (SI_{prhl}), flexed-arm hang test results to the body weight (SI_{fhw}) and push up test results to body weight (SI_{prbw}) and standing long jump test to the body height (SI_{ljbw})). The study involved 423 adolescents, 211 of them were females and 212 were males. The results of the study were statistically analyzed using descriptive statistics method and statistical hypothesis testing.

Results of the Research. The obtained results of physical fitness testing of female adolescents with different aerobic endurance level are presented in Tabl. 1.

Table 1

Physical fitness of female adolescents with different aerobic endurance level

| Indicator | Aerobic Endurance level (VO _{2max} /kg, ml/kg/min) | | |
|--------------------------|---|------------------------------------|-------------------------------|
| | high (n = 54) 56,88±0,56 | average (n = 100) 46,96±0,28 | low (n = 57) 38,36±0,37 |
| Push-Ups test, times | 11,44±0,84 | 11,06±0,74♦ | 8,40±0,70* |
| Standing Long Jump , sm | 146,89±2,72 | 149,35±1,96♦ | 140,26±2,66 |
| Pull-Ups, times | 11,82±0,95 | 12,07±0,58♦ | 9,61±0,79 |
| Sit-Ups in 30 s, times | 20,93±0,49# | 19,74±0,34 | 18,53±0,53* |
| Flexed-Arm Hang test, s | 9,15±1,26 | 10,42±1,06♦ | 7,38±0,96 |
| Sit and Reach test, sm | 4,46±0,93 | 6,73±0,98 | 4,48±1,03 |
| Physical fitness, points | 22,22±0,72 | 21,15±0,56♦ | 17,42±0,60* |

Notes. Significant differences (P < 0,05) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low aerobic endurance groups; # – between indicators of high and average aerobic endurance groups

The conducted studies have shown that aerobic endurance level reducing results in simultaneous indicators of Push-Up test, 30 s Sit-Ups test results and general physical fitness preparedness.

A similar tendency was observed in values of physical fitness indexes (See Tabl. 2).

Table 2

Physical fitness indexes of female adolescents with different aerobic productivity level

| Indicator | Aerobic Endurance level (VO _{2max} /kg, ml/kg/min) | | |
|--------------------|---|------------------------------------|-------------------------------|
| | high (n = 54) 56,88±0,56 | average (n = 100) 46,96±0,28 | low (n = 57) 38,36±0,37 |
| SI _{prhl} | 0,25±0,04 | 0,23±0,02♦ | 0,13±0,02* |
| SI _{fhbw} | 0,30±0,03# | 0,24±0,02♦ | 0,15±0,01* |
| SI _{prbw} | 0,97±0,02 | 0,95±0,01♦ | 0,89±0,02* |
| SI _{ijbw} | 0,18±0,02 | 0,17±0,01♦ | 0,12±0,01* |
| SI _{UB} | 13,02±0,98 | 13,16±0,62♦ | 10,39±0,81* |

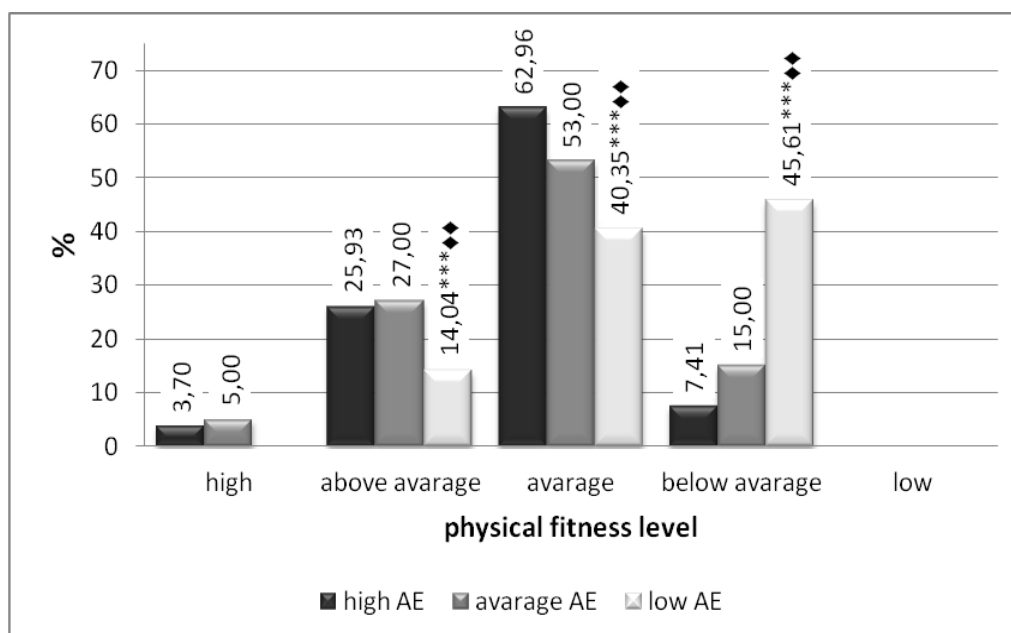
Notes. Significant differences (P < 0,05) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low aerobic endurance groups; # – between indicators of high and average aerobic endurance groups

General physical fitness of girls with a low aerobic endurance level was significantly lower than in other experimental groups, however, there was shown the average level of physical fitness in three experimental groups.

In the group of girls with high aerobic productivity level the average physical fitness level was pointed in 62,96 %, below average – 7,41 %, above average – 25,93 % and high – 3,70 % (See Fig. 1).

In female adolescents with an average aerobic productivity level the average level of physical fitness had 53,00 %, below average – 15,00 %, above average – in 27,00 % and high – 5,00 %.

In female adolescents with a low aerobic productivity level the above average physical fitness level had 14,04 %, average – 40,35%, below average – 45,61%.



Notes. Significant differences are marked: * – between the indicators of high and low aerobic endurance groups (***) – $P < 0,001$); ♦ – between indicators of average and low aerobic endurance groups (♦♦ – $P < 0,01$)

Fig. 1. Distribution of physical fitness level of female adolescents depending on the different aerobic productivity level

Consequently, with the reducing in aerobic productivity level there is the significant reducing in the quantity of children having average and above average physical fitness level and increasing the quantity of such with below average physical fitness level.

The results of physical fitness testing in male adolescents with different aerobic productivity level are presented in Tabl. 3.

Table 3

Physical fitness of male adolescents with different aerobic productivity level

| Indicator | Aerobic productivity level (VO_{2max} /kg, ml/kg/min) | | |
|--------------------------|--|------------------------------------|-------------------------------|
| | high (n = 41) 68,29±1,51 | average (n = 116) 50,59±0,36 | low (n = 50) 40,09±0,56 |
| Push-Up test, times | 36,46±2,11 | 32,97±1,12♦ | 27,34±1,77* |
| Standing Long Jump , sm | 188,00±4,31 | 192,19±2,20 | 182,94±4,15 |
| Pull-Ups, times | 6,12±0,78 | 5,41±0,37 | 4,8±0,54 |
| Sit-Ups in 30 s, times | 24,71±0,79 | 24,60±0,35 | 23,84±0,70 |
| Flexed-Arm Hang test, s | 20,07±1,36 | 20,45±1,09♦ | 15,63±1,48* |
| Sit and Reach test, sm | 0,44±1,29 | 2,13±0,75♦ | 2,13±0,75 |
| Physical fitness, points | 22,37±0,83 | 22,26±0,51 | 19,26±0,77* |

Notes. Significant differences ($P < 0,05$) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low productivity aerobic groups; # – between indicators of high and average aerobic productivity groups

The obtained results showed that with the reducing of aerobic productivity level there is observed the reducing of results in Push-Up and Pull-Ups, 30 s Sit-Ups test, Flexed-Arm Hang test and general physical fitness level.

A similar tendency is also observed in physical fitness indexes of male adolescents (See Tabl. 4).

In male teenagers of low aerobic productivity group the general physical fitness was significantly lower than in group with high physical fitness level.

Table 4

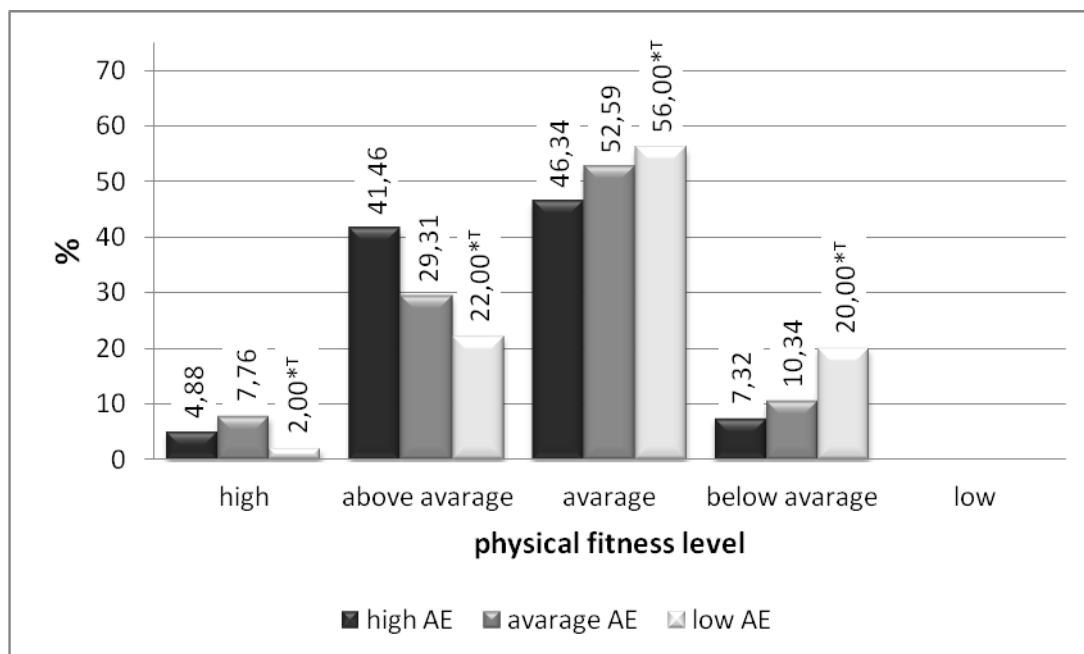
Physical preparedness indexes of male adolescents with different aerobic productivity level

| Indicator | Aerobic Endurance level (VO_{2max} /kg, ml/kg/min) | | |
|--------------------|---|------------------------------------|-------------------------------|
| | high (n = 41) 68,29±1,51 | average (n = 116) 50,59±0,36 | low (n = 50) 40,09±0,56 |
| SI _{prhl} | 0,45±0,03 | 0,40±0,02♦ | 0,25±0,02* |
| SI _{fhbw} | 0,84±0,05# | 0,64±0,02♦ | 0,44±0,03* |
| SI _{prbw} | 1,18±0,02 | 1,17±0,01♦ | 1,08±0,02* |
| SI _{jfbw} | 0,08±0,01 | 0,07±0,004 | 0,06±0,007 |
| SI _{UB} | 9,65±0,89 | 8,43±0,42 | 7,15±0,62* |

Notes. Significant differences ($P < 0,05$) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low aerobic productivity groups; # – between indicators of high and average aerobic productivity groups

Also both in girls and boys of all experimental groups physical fitness indicators were at the average level.

Thus, in a group with high aerobic productivity level there was observed 46,34 % of male adolescents with an average level of physical fitness, 7,32 % with below average and 41,46 % with above average and 4,88 % – with high level of physical fitness (See Fig. 2).



Notes. Significant differences are marked: * – significant differences between the indicators of high and low aerobic productivity groups (* – $P < 0,05$); ♦ – difference between indicators of average and low aerobic productivity groups on statistical tendency level ($T - P < 0,1$)

Fig. 2. Distribution of physical fitness level of male adolescents depending on different aerobic productivity level

In the group of male adolescents with an average aerobic productivity level there was observed 52,59 % of adolescents with an average physical fitness level, 10,34 % – below average level, 29,31 % – above average level and 7,76 % – with high physical fitness level.

In a group with a low aerobic endurance level there was observed 56,00 % of male adolescents with an average physical fitness level, 20,00 % – with below average, 22,00 % – with above average and 2,00 % with high physical fitness level, that were significant differ compare to group with high level of aerobic endurance ($\chi^2 = 6,28$; $P < 0,05$).

Consequently, in male teenagers with the reducing in aerobic endurance level there is reducing in quantity of respondents with above average physical fitness level and increasing with below average physical fitness level.

Studying physical development indicators there was pointed an increasing of BMI simultaneously with reducing of aerobic productivity level of female (See Tabl. 5) and male (See Tabl. 6) adolescents.

Table 5

Morpho-functional state of female adolescents with different aerobic productivity level

| Indicator | Aerobic Endurance level (VO _{2max} /kg, ml/kg/min) | | |
|---|---|------------------------------------|-------------------------------|
| | High (n = 54) 56,88±0,56 | Average (n = 100) 46,96±0,28 | Low (n = 57) 38,36±0,37 |
| Body mass index (BMI), kg/m ² | 17,10±0,27# | 19,10±0,20♦ | 22,07±0,32* |
| Pignet index, equiv.un. | 38,52±1,11# | 30,51±0,84♦ | 18,78±1,45* |
| Handgrip Strength /Muscle Mass, equiv.un. | 96,97±3,39# | 86,69±1,89♦ | 75,16±2,08* |
| Deadlift / Muscle Mass, equiv.un. | 230,44±9,97# | 201,79±6,19♦ | 171,29±7,58* |

Notes. Significant differences ($P < 0,05$) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low aerobic productivity groups; # – between indicators of high and average aerobic productivity groups

Table 6

Morpho-functional state of male adolescents with different aerobic productivity level

| Indicator | Aerobic Endurance level (VO _{2max} /kg, ml/kg/min) | | |
|---|---|------------------------------------|-------------------------------|
| | high (n = 41) 68,29±1,51 | average (n = 116) 50,59±0,36 | low (n = 50) 40,09±0,56 |
| Body mass index (BMI), kg/m ² | 17,10±0,27# | 19,10±0,20♦ | 22,07±0,32* |
| Pignet index, equiv.un. | 38,52±1,11# | 30,51±0,84♦ | 18,78±1,45* |
| Handgrip Strength /Muscular Mass, equiv.un. | 125,27±2,40 | 120,82±2,12♦ | 106,56±3,12* |
| Deadlift / Muscular Mass, equiv.un. | 346,12±12,19 | 325,52±6,65♦ | 283,71±7,17* |

Notes. Significant differences ($P < 0,05$) are marked: * – between the indicators of high and low aerobic productivity groups; ♦ – between indicators of average and low aerobic productivity groups; # – between indicators of high and average aerobic productivity groups

Similar changes are established in strength indexes, determined by ratio of Handgrip and Deadlift dynamometry to the muscular mass in girls. The inverse tendency has been found during studying the relation of Pignet's index with aerobic productivity.

It is known that the physical qualities development in ontogeny has a heterochronous character [1; 4; 11]. Certain physical qualities reach their natural maximal development at different ages due to different development rates of individual body tissues, organs and organism systems. At the same time, the rates of schoolchildren physical development [1; 14] and biological maturation [2] play a role in determining of sensitive periods limits. It is established that one of the informative criteria characterizing health reserves along with VO_{2max} is BMI [13]. Our research confirms the scientific data [13] that with the body weight increasing the adolescents' functional reserves are reducing and reflecting the importance of body structure type in the development of organism aerobic capacity. The results demonstrate that adolescents with a high aerobic productive level have the highest muscle strength level. All this testifies to the need of separate homogeneous schoolchildren's groups creation in order to develop the effective programs aimed at increasing physical fitness level and health of children in all ages depends on their aerobic productivity level.

Conclusions Prospects for Further Research. Aerobic productivity level reducing is accompanied by body mass index increasing and Pignet's index reducing, which reflects the important role of physical development somatometric features in determining of organism functional capabilities.

Aerobic productivity level increasing is connected with muscle strength increasing that is testified by strength indexes dynamics, determined by ratio indicators of Handgrip and Deadlift dynamometry to the muscular mass in both girls and boys, as well as push-ups test result to body weight in male adolescents.

With the reducing of aerobic productivity level there is an increasing in the percentage of children with below average physical fitness level and reducing in above average physical fitness level. The presence of respondents with above average physical fitness level in each experimental group indicates the opportunities to improve the level of physical qualities development.

The obtained results can be used to develop differentiated approaches in physical education of schoolchildren with different aerobic productivity level.

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