



ORIGINAL ARTICLES. PHYSICAL EDUCATION

Relationship between indicators of physical development and indicators of anaerobic productivity of the body of women 25-35 years old

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Abstract

Background and purpose

Purpose. To establish the relationship between body mass, body composition with indicators of anaerobic productivity of women aged 25-35.

Materials and methods

392 women aged 25-35 years participated in the study. The power of anaerobic alactate productivity was determined by the 10-second Wingate test. The power of anaerobic lactate productivity was determined by the 30-second Wingate test. The capacity of anaerobic lactate productivity was determined by the e maximum amount of external mechanical work per 1 minute. Body fat percentage, body muscle percentage, and visceral fat content were determined by the bioelectrical impedance method.

Results

It was found that the correlation of body mass, body mass index and percentage of the muscle component of women aged 25-35 with performance in anaerobic tests is characterized as direct. The degree of correlation of indicators of physical development with absolute indicators of anaerobic productivity is higher than with relative indicators. Performance in anaerobic tests is most strongly correlated with body mass and body mass index. The degree of correlation of body mass, body mass index with tests characterizing the power of anaerobic alactate and lactate productivity of the body corresponds to "high". A "high" degree of correlation of the capacity of anaerobic lactate productivity of the body was established only with body mass.

Conclusions

Among indicators of physical development, body mass and body mass index have the greatest influence on the anaerobic capabilities of the body of women aged 25-35, who do not play sports. Higher values of body mass and body mass index are predictive of higher level of anaerobic productivity. The high degree of correlation with body mass and body mass index is due to the specifics of the cycle ergometric tests. Running anaerobic tests will not give a direct correlation of a high degree, because they are related to the movement of body weight along the distance. The percentage content of fat and muscle components, the level of visceral fat cannot be predictors of the level of anaerobic productivity of the body in women who do not do sports.

Keywords: women, fat, muscles, anaerobic capabilities, correlation



Анотація

В'ячеслав Мірошніченко, Ірина Калабіська, Оксана Швец, Андрій Ковальчук, Микола Галайдюк. Зв'язок між показниками фізичного розвитку та показниками анаеробної продуктивності організму жінок 25-35 років

Обрунтування і мета

Мета. Встановити зв'язок маси тіла, компонентного складу тіла із показниками анаеробної продуктивності організму жінок 25-35 років.

Матеріали і методи

У дослідженні взяли участь 392 особи жіночої статі віком 25-35 років. Потужність анаеробної алактатної продуктивності визначали за 10-секундним Вінгатським тестом. Потужність анаеробної лактатної продуктивності визначали за 30-секундним Вінгатським тестом. Ємність анаеробної лактатної продуктивності визначали за максимальною кількістю зовнішньої механічної роботи за 1 хв. Відсотковий вміст жиру в організмі, відсотковий вміст м'язів в організмі, вміст вісцерального жиру визначали методом біоелектричного імпедансу.

Результати

Виявлено, що кореляція маси тіла, індексу маси тіла та відсоткового вмісту м'язового компоненту жінок 25-35 років із результативністю у анаеробних тестах характеризується як пряма. Ступінь кореляції показників фізичного розвитку із абсолютними показниками анаеробної продуктивності вища, ніж із відносними. Найвищий ступінь кореляції із продуктивністю в анаеробних тестах встановлено із масою тіла та індексом маси тіла. Ступінь кореляції маси тіла, індексу маси тіла із тестами які характеризують потужність анаеробної алактатної та лактатної продуктивності організму відповідає «високому». «Високий» ступінь кореляції ємності анаеробної лактатної продуктивності організму встановлено лише із масою тіла.

Висновки

Серед показників фізичного розвитку найбільший вплив на анаеробні можливості організму жінок 25-35 років, які не займаються спортом, мають маса тіла та індекс маси тіла. Більші значення маси тіла та індексу маси тіла є предикторами вищого рівня анаеробної продуктивності. Високий ступінь кореляції з масою тіла та індексом маси тіла обумовлений специфікою виконання тесту на велоергометрі. Бігові анаеробні тести не дадуть прямої кореляції високого ступеню, оскільки пов'язані із переміщенням маси тіла по дистанції. Відсотковий вміст жирового та м'язового компонентів, рівень вісцерального жиру не можуть бути предикторами рівня анаеробної продуктивності організму жінок, які не займаються спортом.

Ключові слова: жінки, жир, м'язи, анаеробні можливості, кореляція

Аннотация

Вячеслав Мирошніченко, Ирина Калабиская, Оксана Швец, Андрей Ковальчук, Николай Галайдюк. Связь показателей физического развития с показателями анаэробной производительности организма женщин 25-35 лет

Цель. Установить связь массы тела, компонентного состава тела с показателями анаэробной производительности организма женщин 25-35 лет.

Материалы и методы

В исследовании приняли участие 392 человека женского пола в возрасте 25-35 лет. Мощность анаэробной алактатной производительности определяли по 10-секундному Вингатскому тесту. Мощность анаэробной лактатной производительности определяли по 30-секундному Вингатскому тесту. Емкость анаэробной лактатной производительности определяли по максимальному количеству внешней механической работы за 1 мин. Процентное содержание жира в организме, содержание мышц в организме, содержание висцерального жира определяли методом биоэлектрического импеданса.

Результаты

Выведено, что корреляция массы тела, индекса массы тела и процентного содержания мышечного компонента женщин 25-35 лет с результативностью в анаэробных тестах характеризуется как прямая. Степень корреляции характеристик физического развития с абсолютными показателями анаэробной производительности выше, чем с относительными. Самая высокая степень корреляции с производительностью в анаэробных тестах установлена с массой тела и индексом массы тела. Степень корреляции массы тела, индекса массы тела с тестами, характеризующими мощность анаэробной алактатной и лактатной производительности организма, соответствует «высокому». «Высокая» степень корреляции емкости анаэробной лактатной производительности организма установлена только с массой тела.

Выводы

Среди показателей физического развития наибольшее влияние на анаэробные возможности организма женщин 25-35 лет, не занимающихся спортом, оказывают масса тела и индекс массы тела. Большие значения массы тела и индекса массы тела являются предикторами более высокого уровня анаэробной производительности. Высокая степень корреляции с массой тела и индексом массы тела обусловлена спецификой выполнения теста на велоэргометре. Беговые анаэробные тесты не дадут прямую корреляцию высокой степени, поскольку связаны с перемещением массы тела по дистанции. Процентное содержание жирового и мышечного компонентов, уровень висцерального жира не могут быть предикторами уровня анаэробной производительности организма женщин, не занимающихся спортом.

Ключевые слова: женщины, жир, мышцы, анаэробные возможности, корреляция



Introduction

The level of functional preparedness depends on the efficiency of aerobic and anaerobic metabolic processes of energy supply for muscle activity. In the total amount of the body's energy potential, aerobic energy generation significantly outweighs anaerobic energy production [1]. Perhaps that is why much more attention is paid to the study of the aerobic component of preparedness. This is indicated by the number of scientific publications on this topic. Y Furman et al. [2] believe that the study of only the aerobic component does not provide complete information about the state of the processes that determine the level of functional preparedness. In our publications, we also supported this statement [3].

There are many factors that have an impact on the functional capabilities of a person. This is a genetic factor and environmental factors. Zhanneta Kozina et al. [4] established differences in the level of functional preparedness in persons of different heights, which is genetically determined. Only by conducting a correlation analysis between indicators of functional preparedness and indicators that, according to scientists, affect their level, it is possible to reliably establish the role of one or another factor.

Fat and muscle components are metabolically active. Muscles are the main consumer of energy during high-intensity work. Fat, in addition to its energy function, affects the synthesis, accumulation and metabolism of hormones. The significant influence of the fat component on the hormonal background of the body has been proven [5]. It is known that hormones are regulators of physiological processes in the body, in particular those that ensure muscle activity [6]. Adipose tissue plays a special role in regulating the physiological processes of the female body [1]. Therefore, attention is paid to the study of the relationship between the component composition of the body and functional preparedness in athletes of various specializations. Krzysztof Durkalec-Michalski et al. [7] established that in rowers, the component composition of the body is closely related to the level of aerobic and anaerobic power. Such connections have been investigated fragmentarily in persons engaged in health-improving types of motor activity. The problem investigate of the relationship of body mass, body mass index, body composition with indicators of

anaerobic productivity in representatives of different age groups and gender is relevant.

When studying the correlation of anaerobic performance indicators with body mass, a number of factors related to the informativeness of the tests should be taken into account. Thus, running tests or step tests are associated with the movement of body weight. Accordingly, higher values of body weight will not contribute to performance. Therefore, the correlation of the performance of the running test with body mass can be direct, weak or inverse (depending on the contingent of subjects). Cycle ergometric load is not related to the movement of body weight. During cycle ergometer loads, most of the body weight is concentrated on the seat of the cycle ergometer, and the legs perform pedaling. In such tests, body weight contributes to performance. Therefore, the correlation of body mass with performance in cycle ergometric tests should be expected to be higher. The difference in the results of anaerobic power assessment between the VAN T 30 test and the running test is indicated in work by Burgess K et al. [8]. A number of researchers hold the same opinion.

In our previous studies, we investigated the correlation of maximum oxygen consumption with body structural components, body mass, and body mass index in women in the first period of mature age [9]. The dependence of the level of development of physical qualities on the aerobic and anaerobic productivity of the organism was also investigated [10, 11, 12]. We developed models of functional preparedness that cover all modes of energy supply of muscle activity - aerobic and anaerobic [2]. We found that among women aged 25-35, anaerobic productivity is higher in representatives of somatypes characterized by a larger body mass. Such data allow us to assume the existence of a correlation between the anaerobic productivity of the body of women aged 25-35 and body mass. In addition, it is important to establish the relationship fat and muscle components with anaerobic performance of women who do not play sports. Therefore, the purpose of our study was to test the hypothesis about the existence of a relationship between indicators of physical development and indicators of anaerobic productivity of the body in women in the first period of mature age.



Material and methods

Participants

392 women aged 25-35 took part in the study. All the subjects did not have experience of systematic training in physical activity and sports. All subjects gave consent to participate in the experiment.

Ethical principles

The study was conducted in accordance with the provisions of the Declaration of Helsinki and was approved by the Ethics Committee of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine.

Procedures

Physical development indicators were determined by the bioelectrical impedance method using the OMRON BF-511 body composition monitor. According to the indicators of this device, the percentage of body fat, the percentage of muscles in the body, the content of visceral fat, body mass and body mass index (BMI) were determined.

Functional preparedness was determined by indicators of anaerobic productivity of the body. The power of anaerobic alactic energy supply processes was determined by the 10-second Wingate anaerobic test (WAnT 10) [13]. This test involves performing a bicycle ergometric load lasting 10 seconds with the maximum possible pedaling frequency. Starting from the third second from the start of pedaling, the number of complete revolutions of the pedals was counted. The result was evaluated by the maximum amount of external mechanical work performed in 10 seconds.

The power of anaerobic lactic processes of energy supply was determined by the 30-second Wingate anaerobic test (WAnT 30) [13]. This test involves performing a bicycle ergometric load lasting 30 seconds with the maximum possible pedaling frequency. The technology for performing the VAnT 30 test is similar to the VAnT10 test. The result was evaluated by the maximum amount of external mechanical work performed in 30 seconds. The technology for performing Wingate anaerobic tests is described by Furman et al. [12].

To determine the capacity of anaerobic

lactatic processes energy supply, the method developed by Shogy & Cherebetin [11] was used. This test involves performing a bicycle ergometric load lasting 60 seconds with the maximum possible pedaling frequency. The maximum amount of external mechanical work per 1 min (MQMK) was determined. Details of the technology of this test are described by Furman et al. [12].

Absolute and relative indicators were calculated for all tests. Functional fitness testing was performed on a Christopheit Sport AX-1 bicycle ergometer.

Statistical analysis

Statistical processing of experimental data was performed in the STATISTICA 13 program. First, data series were checked for compliance with the law of normal distribution using the Shapiro-Wilk criteria. If the actual value of P according to the Shapiro-Wilk criteria does not exceed $p < 0.05$, then the hypothesis of a normal distribution of data was rejected. If at least one series of data did not correspond to the normal distribution law, Spearman's rank correlation coefficient was used. To carry out correlation analysis, the following were determined: arithmetic mean (Means), standard deviation (Std. Dev.), Spearman's paired correlation coefficient (p_{xy}) and the reliability of the relationship (p). The relationship was considered reliable at $p < 0.05$. The degree of correlation was evaluated by the Chaddock criteria (Table 1).

Table 1

The degree of correlation according to the Chaddock criteria

Degree of correlation	The value of the correlation coefficient
Very tall	$0.90 \leq r_{xy} \leq 0.99$
High	$0.7 \leq r_{xy} < 0.9$
Notable	$0.5 \leq r_{xy} < 0.7$
Moderate	$0.3 \leq r_{xy} < 0.5$
Weak	$0.1 \leq r_{xy} < 0.3$

Results

The data in Table 2 show that the data series for none of the indicators of functional preparedness do not correspond to the law of normal distribution according to the Shapiro-Wilk criteria.



Table 2

Analysis of data indicators of functional preparedness of women 25-35 years old for compliance with the law of normal distribution according to the Shapiro-Wilk criterion (n=392)

Indicators of physical preparedness	Means	Standard Deviation	Criterion value Shapiro-Wilk	Level of significance p
The maximum amount of external mechanical work in 1 min, $\text{kg}\cdot\text{min}^{-1}$	1488.303	278.356	W=0.97763	0.000
The maximum amount of external mechanical work in 1 min, $\text{kg}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$	24.408	3.237	W=0.94160	0.000
30-second Wingate anaerobic test, $\text{kg}\cdot\text{min}^{-1}$	2115.315	514.054	W=0.98252	0.000
30-second Wingate anaerobic test, $\text{kg}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$	34.360	5.421	W=0.98452	0.000
10-second Wingate anaerobic test, $\text{kg}\cdot\text{min}^{-1}$	2351.145	516.327	W=0.98525	0.000
10-second Wingate anaerobic test, $\text{kg}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$	38.273	4.902	W=0.96352	0.000

Table 3

Analysis of data indicators of physical development of women 25-35 years old for compliance with the law of normal distribution according to the Shapiro-Wilk criterion (n=392)

Indicators of physical development	Means	Standard Deviation	Criterion value Shapiro-Wilk	Level of significance p
Body mass, kg	60.930	7.795	W=0.98242	0.000
Body mass index, units	21.313	2.672	W=0.96220	0.000
Fat content in the body, %	29.576	4.303	W=0.93276	0.000
Muscle content in the body, %	30.036	1.620	W=0.98504	0.000
Content of visceral fat, units	4.204	1.956	W=0.89282	0.000

Table 4

The relationship between indicators of anaerobic lactate productivity of the body and indicators of physical development in women aged 25-35 (n = 392)

Indicators of physical development	MQMK _{abs.}		MQMK _{rel.}		WAnT30 _{abs.}		WAnT30 _{rel.}	
	p_{xy}	p	p_{xy}	p	p_{xy}	p	p_{xy}	p
Body mass, kg	0.745	p<0.05	0.036	p>0.05	0.850	p<0.05	0.547	p<0.05
Body mass index, units	0.637	p<0.05	0.033	p>0.05	0.754	p<0.05	0.496	p<0.05
Fat content in the body, %	0.369	p<0.05	-0.151	p<0.05	0.509	p<0.05	0.278	p<0.05
Muscle content in the body, %	0.102	p<0.05	0.343	p<0.05	0.035	p>0.05	0.210	p<0.05
Content of visceral fat, units	0.506	p<0.05	-0.038	p>0.05	0.621	p<0.05	0.392	p<0.05

Notes: MQMK_{abs.} – absolute indicator of the maximum amount of external mechanical work in 1 minute; MQMK_{rel.} – relative indicator of the maximum amount of external mechanical work in 1 minute; WAnT30_{abs.} – the absolute index of the 30-second Wingate anaerobic test; WAnT30_{rel.} – relative index of the 30-second Wingate anaerobic test; p_{xy} – Spearman's correlation coefficient.



Table 5

The relationship between indicators of anaerobic alactate productivity of the body and indicators of physical development in women aged 25-35 (n = 392)

Indicators of physical development	WAnT10 _{abs.}		WAnT10 _{rel.}	
	ρ_{xy}	p	ρ_{xy}	p
Body mass, kg	0.871	p<0.05	0.526	p<0.05
Body mass index, units	0.814	p<0.05	0.542	p<0.05
Fat content in the body, %	0.546	p<0.05	0.280	p<0.05
Muscle content in the body, %	0.033	p>0.05	0.249	p<0.05
Content of visceral fat, units	0.662	p<0.05	0.408	p<0.05

Notes: WAnT10_{abs.} – the absolute indicator of the 10-second Wingate anaerobic test; WAnT10_{rel.} – relative indicator of the 10-second Wingate anaerobic test; ρ_{xy} – Spearman's correlation coefficient

The series of data indicators of physical development also do not correspond to the law of normal distribution (Table 3). Therefore, we used a non-parametric criterion - Spearman's pairwise correlation coefficient - to carry out correlation analysis.

The results of the correlation analysis of indicators of anaerobic lactate productivity with indicators of physical development are shown in Table 4. A high degree of direct correlation of the absolute indicators of the maximum amount of external mechanical work in 1 min and the 30-second Wingate anaerobic test with body mass was revealed. Such data indicate that higher values of body mass cause a higher level of power and capacity of anaerobic lactate processes of energy supply in women of the first period of mature age. A high degree of direct correlation was established between the absolute values of the 30-second Wingate anaerobic test and the body mass index. Such data indicate that higher values of the body mass index are a predictor of a higher level of power of anaerobic lactate processes of energy supply in women of the first period of mature age.

The direct correlation between the percentage of fat and muscle in the body indicates their positive influence on the power and capacity of the anaerobic lactate processes of energy supply of muscle activity. But the degree of such connection does not exceed a notable level. Therefore, fat and muscle components do not have a significant influence on the anaerobic lactate productivity of the body of women in the first period of mature age.

Correlation of indicators of physical development with relative indicators of anaerobic lactate productivity is characterized by a lower

degree of connection.

Correlation of indicators of anaerobic alactate productivity with indicators of physical development has similar trends (Table 5). A high degree of direct correlation was established the absolute values of the 10-second Wingate anaerobic test with body mass and body mass index. Therefore, larger values of body mass and body mass index are predictors of a higher level of power of anaerobic alactate productivity of the body of women of the first period of mature age. Fat and muscle components do not have a significant effect on the anaerobic alactate productivity of the body. This is indicated by the degree of correlation, which does not exceed a notable level.

The correlation of indicators of physical development with the relative indicator of anaerobic alactate productivity is characterized by a lower degree of connection.

Discussion

According to the data we received, the highest degree of correlation of anaerobic productivity indicators was found with body mass and body mass index. At the same time, the degree of such connection of the absolute values of all anaerobic indicators is higher than the relative values. The data we obtained are consistent with the results of studies conducted with other age groups. Thus, in 17-19-year-old female students who do not play sports, a correlation was established between body mass and the absolute indicator of the maximum amount of external mechanical work per 1 minute (MQMK) at the level of $r=0.618$, and with relative indicator - at the level of $r=-0.089$ [12]. Dotan R, Bar-Or O. [14], exploring children 10-12 years old,



also found a high degree of correlation between body mass and productivity in the 30-second Wingate test. A. Mossayebi et al. [15] established a high degree of positive correlation of body mass index with peak power ($r=0.83$) and a very high degree of positive correlation with anaerobic capacity ($r=0.94$) in women aged 27.31 ± 6.8 years who do not do sports. Pei Yang et al. [16] found a positive correlation of body weight with hand strength in women aged 26-30. A positive correlation between anaerobic alactatic productivity and hand strength in women in the first period of mature age has been proven [10]. Considering this, according to the results of Pei Yang et al. [16] indirectly, it can be judged that higher values of body mass cause a higher level of anaerobic alactatic productivity. Similar results were obtained by Chae Kwan Lee et al. [17], exploring 10-year-old children.

The high degree of positive correlation of the results of the WAnT 10, WAnT 30, MQMK bicycle ergometric tests with body mass explains the reason for the difference between the results of the bicycle ergometric and running tests, which was noted by Burgess K et al. [8]. Since running tests involve the movement of body mass in a distance, an increase in body weight will negatively test results. Such a difference will be greater in untrained persons.

The vast majority of publications devoted to the study of the correlation of the component composition of the body with the anaerobic productivity of the body concern athletes. At the same time, the data of different authors are often contradictory. The data of Kale M., Akdoğan E. [18] indicate a negative effect of the fat component on the peak power and average power of the 30-second Wingate test in female handball players. Selma Arzu Vardar et al. [19] did not find a relationship between the fat component and the performance of the 30-second Wingate test in young female wrestlers. Instead, a high degree of association with fat-free body mass was established. Jacquelyn Zera et al. [20] found better VAnT 30 test results in female swimmers with a higher fat-free body mass. Such data indirectly indicate the negative influence of the fat component and the positive influence of the muscle component on the power of anaerobic lactatic energy supply processes for muscle activity.

There is a limited number of publications on this topic, where research was conducted with adults who do not play sports. O. Dulo et al. [21] found a greater negative effect of the fat component

on anaerobic productivity in men than in women. At the same time, the authors found that in men with an increase in the relative content of fat, the value of the maximum amount of external mechanical work per 1 minute (MQMK) decreases. The authors also established a decrease in the power of anaerobic alactatic processes of energy supply for muscle activity according to the 10-second Wingate test with an increase in the content of the fat component in men. O. Dulo et al. [22] conclude that the fat component in women provides energy for muscle work and therefore does not have a negative effect on functional fitness. Pei Yang et al. [16] claim that in women aged 21-25, subcutaneous fat is negatively correlated with hand strength, and visceral fat is positively correlated with hand strength. The hand strength depends on the degree of development of anaerobic alactatic processes of energy supply. Therefore, indirectly, such data indicate a positive effect of visceral fat and a negative effect of subcutaneous fat on anaerobic alactatic productivity. The data obtained by us indicate that the fat component has a positive effect on the anaerobic capabilities of women in the first period of of mature age. But the strength of such an influence is insignificant, since the correlation of the fat component with performance in anaerobic tests does not exceed a notable degree.

Sports physiologists indicate that the strength of a muscle depends on the anatomical (for parallel-fiber muscles) or physiological (for feathered muscles) cross-sectional area [1]. Strength and speed are closely related qualities. All of the anaerobic cycling ergometric tests we applied involved maximal pedaling speed for 10, 30, and 60 seconds, overcoming a standard pedaling resistance of 225 W. It is logical to assume that performance in these tests largely depends on the percentage of muscle in the body. Our data indicate a weak degree of positive correlation, or its absence, between the percentage content of the muscle component and performance in the 10-second and 30-second anaerobic tests. The degree of correlation of the muscle component with performance in the 60-second test is characterized as direct moderate. It can be assumed that this discrepancy is due to the fact that physiologists study the strength of a single muscle, while we study the role of muscles in the whole system of the body. This is indicated in the work of Travis Byrd et al. [23]. The authors found that the anaerobic component is closely related to the local mass of thigh muscles and weakly related to the percentage of muscle in



the body. Data from the scientific literature are consistent with the results of our research. Froese & Houston [24] did not find a relationship between performance in the 30-second Wingate anaerobic test and the relative area of muscle fibers in women who do not do sports. At the same time, the authors found a high degree of correlation of performance in the 30-second Wingate test with the morphology of a single muscle (vastus lateralis).

Conclusions

Among indicators of physical development, body mass and body mass index have the greatest influence on the anaerobic capabilities of the body of women aged 25-35, who do not play sports.

Higher values of body mass and body mass index are predictive of higher level of anaerobic productivity. The high degree of correlation with body mass and body mass index is due to the specifics of the cycle ergometric tests. Running anaerobic tests will not give a direct correlation of a high degree, because they are related to the movement of body weight along the distance. The percentage content of fat and muscle components, the level of visceral fat cannot be predictors of the level of anaerobic productivity of the body in women who do not do sports.

Conflict of interest

The authors declare no conflict of interest.

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