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Research article

INFLUENCE OF MORPHOLOGICAL CHARACTERISTICS ON THE PARAMETERS OF HEALTH-RELATED FITNESS IN OVERWEIGHT AND OBESE BOYS

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Abstract. *The aim of this study was to determine the influence of morphological characteristics on the health–related fitness parameters in overweight and obese eight-year-old boys. The research involved 314 boys who attended second grade in the cities of South-East Serbia. The parameters of longitudinal (3), transversal, (3) circular dimensions (3), and body mass and measurement of subcutaneous adipose tissue (3) were used to assess morphological characteristics. Health-related fitness parameters were determined using tests to assess muscle fitness, body composition and cardiorespiratory fitness. Regression analysis was used to determine the influence of morphological characteristics on the parameters of health-related fitness. The results of the research indicate that there is a statistically significant influence (p=.000) of morphological characteristics on most parameters of health-related fitness. No statistically significant effect was found in the forward bend - backward bend - throw test ∑ in the studied sample.*

Key words: *Fitness Parameters, Morphological Characteristics, Health-Related Fitness, Cardiorespiratory Fitness*

INTRODUCTION

Health-related physical fitness implies the physical fitness of children and adults, i.e. those components that are related to their health status, such as body composition, muscle fitness, flexibility, cardiorespiratory fitness, and strength (Corbin, Pangrazi, & Franks, 2000).

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In addition to this type of fitness, there is also skill-related physical fitness, which includes those skills related to achievements in sports (balance, coordination, agility, speed, strength, and reaction time) (Jarani, Grøntved, Muca, Spahi, Qefalia, Ushtelenca et al., 2016). The health-related physical fitness of children and adolescents is one of the main indicators of their current health status, but also of their health status in adulthood (Armstrong, Lambert, & Lambert, 2017). A large number of factors affect the occurrence of overweight and obesity in childhood (Reilly, Armstrong, Dorosty, Emmett, Ness, Rogers et al., 2005), besides genetic predispositions, but above all these conditions are caused by a positive energy balance of calorie intake, which is higher than the energy consumption (Kumar & Kelly, 2017). The World Health Organization (WHO, 2016) states that there is a prevalence of overweight and obese children in all countries. However, the most of obese children live in developing countries where the growth rate is as much as 30% higher than in developed countries (WHO, 2016). The number of obese children is increasing, and this trend has been more pronounced in the last 20 years (Skinner & Skelton, 2014; Anderson, 2018). The incidence of overweight and obesity in Europe changed from 20% between 1999 and 2006, to 22.9% between 2011 and 2016. In the United States there is a steady increase in the prevalence of overweight as well as obesity among children (Ogden, Carroll, Lawman, Fryar, Kruszon-Moran, Kit, & Flegal, 2016), with a significant increase in extreme obesity in children aged two to five in 2013 and 2014, a trend that is continuing in other age groups (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018). When it comes to the world population, it is estimated that 41 million children under the age of 5 are overweight or obese (WHO, 2018). Between 1975 and 2016, the global prevalence of obesity increased from 5 to 50 million in girls and from 6 to 74 million in boys (Abarca-Gómez, Abdeen, Hamid, Abu-Rmeileh, Acosta-Cazares, Acuin et al., 2017). Obesity among children and adolescents in Serbia is taking on epidemic proportions, as is the case with other countries in transition (Ostojić, Stojanović, Stojanović, Marić, & Njaradi, 2011). In 2015, the prevalence of obesity among Serbian children aged six to nine was 23.1% (Đorđić, Radisavljević, Milanović, Božić, Grbić, Jorga, & Ostojić, 2016), which is in the range of countries with a high degree of obesity. The greatest impact on the increase of obesity prevalence in children and adolescents, in addition to inadequate and excessive nutrition, has a reduced and insufficient physical activity: children and adolescents often spend a huge amount of their leisure time on writing homework, watching TV, using a computer and their smartphones, that is, they spend most of their time in sedentary activities (Song, Gong, Ding, Yuan, Zhang, Feng et al., 2019). The World Health Organization (WHO, 2010) has given their recommendations concerning physical activities, according to which children should be physically active (activities of moderate or high intensity) for at least 60 minutes a day. The results of some studies indicate that a large number of children are not physically active enough and do not meet the guidelines given by the WHO (Martins, Ricardo, Mendonca, de Rosa, da Gama Bastos, Coll, & Bielemann, 2018; Wang, Hsieh, Hsueh, Liu, & Liao, 2019), and that boys are physically more active than girls (Glinkowska, & Glinkowski, 2018).

Given that, in children and adolescents fitness is an important indicator of their current and future health status (Colley, Clarke, Doyon, Janssen, Lang, Timmons, & Tremblay, 2019), it is a worrying fact that the parameters of health-related fitness of children and adolescents stagnate over time, i.e. there is a decline in the levels of certain fitness abilities such as flexibility (Costa, Costa, Reis, Ferreira, Martins, & Pereira, 2017), cardiorespiratory fitness (Colley et al., 2019) and muscle strength and endurance (Dong, Lau, Dong, Zou, Yang, Wen et al., 2019). Studies that have addressed this issue suggest that being overweight significantly affects athletic performance, especially jumping performance, running speed, and maximum oxygen consumption (Moncef, Said, Olfa, & Dagbaji, 2012), as well as that children who are taller and have higher values of body mass tend to achieve higher strength values, and children with lower values of body mass achieve better results when it comes to aerobic endurance (Vandendriessche, Vandorpe, Coelho-e-Silva, Vaeyens, Lenoir, Lefevre, & Philippaerts, 2011). The aim of the research is to determine the influence of morphological characteristics on the health-related fitness parameters in overweight and obese eight-year-old boys.

METHODS

Sample of participants

For the purpose of the research, a sample of 314 boys (Age: 8.9±0.15 years, Body height: 137.70±5.93 cm, Body mass: 41.90±5.13 kg), who attended the second grade, from the territory of the cities of Niš, Paraćin, Bela Palanka, Leskovac and others, was used. The sample was taken from the populations of overweight and obese boys tested within the project "Anthropological characteristics of children in southeastern Serbia - state, changes and trend", which is implemented by the Faculty of Sports and Physical Education of the University of Niš.

The participants were selected based on the specific body mass index (BMI) values developed by Cole, Bellizzi, Flegal, & Dietz (2000) for children and adolescents 2 to 18 years of age, and according to these values, overweight and obese boys who participated in the study had BMI>18.44 kg/m^2. The research was conducted in accordance with the Declaration of Helsinki (WMA, 2013), and in order for a child to participate in the research, the consent of a parent or guardian was required.

Measuring instruments

For the needs of the research, the parameters for the assessment of morphological characteristics and the parameters for the assessment of the health-related fitness of boys of the stated age were tested.

From the area of morphological characteristics, the following parameters were measured: body height (in cm), arm length (in cm), leg length (in cm), shoulders width (in cm), pelvic width (in cm), hip width (in cm), body mass (in kg), mean chest circumference (in cm), forearm circumference of the outstretched arm, thigh circumference (in cm), skinfold of the upper arm, back and abdomen (in mm). Techniques proposed by the International Biological Program (Weiner & Lourie, 1969) were used for the assessment of the above mentioned morphological characteristics.

The following tests were used for the assessment of fitness parameters: the plyometric jump (in cm) was used to assess muscle fitness, i.e. explosive strength of the legs (Nazarenko, 2000) and the forward bend - backward bend - throw test ∑ (in cm) (Kostić, Đurašković, Pantelić, Živković, Uzunović, & Živković, 2009) to assess explosive strength of the arms, shoulders, and trunk. The body fat percentage was determined using the values of the skinfolds of the triceps, abdomen and back, using the equation given by Slaughter, Lohman, Boileau, Horewill, Stillman, Van Loan, & Bemben (1988). BMI was determined by using the ratio of body mass to body height (kg/m^2). Cardiorespiratory fitness was determined using the 20 m shuttle run test, and the validity of this test has been confirmed in earlier studies (Leger & Lambert, 1982; Leger, Mercier, Gadoury, & Lambert, 1988; Council of Europe, 1993). An algorithm according to Leger & Gadoury (1989) was used to calculate the maximum oxygen consumption (VO_2max). The parameters analyzed in the study are Absolute VO_2max (L) and Relative VO_2max (ml/kg/min).

Data processing

Data processing was performed using the statistical package Statistics 6.0. Basic descriptive parameters were calculated: Mean, Minimum Value (Min), Maximum Value (Max), Standard Deviation (SD), Range. Regression analysis was used to determine the influence of morphological characteristics on the parameters of health-related fitness.

RESULTS

Table 1 shows the values of descriptive parameters of morphological characteristics and health-related fitness parameters in overweight and obese eight-year-old boys.

Table 1 Descriptive statistics of morphological characteristics

	Mean	SD	Min	Max	Range
Body height	137.70	5.93	120.00	156.20	36.20
Leg length	76.56	4.37	63.20	98.20	35.00
Arm length	57.73	3.04	47.20	69.30	22.10
Shoulder width	31.96	1.62	27.50	37.20	9.70
Pelvic width	23.39	1.45	19.00	31.40	12.40
Hip width	25.96	1.37	22.30	30.00	7.70
Body mass	41.90	5.13	30.55	56.50	25.95
Chest circumference	68.50	4.81	45.20	85.50	40.30
Upper arm circumference	21.41	1.68	15.50	32.20	16.70
Thigh circumference	42.28	3.00	33.30	51.00	17.70
Upper arm skinfold	16.32	4.20	6.80	33.20	26.40
Back skinfold	14.40	4.48	6.50	30.80	24.30
Abdomen skinfold	19.53	6.10	6.40	43.20	36.80
Plyometric jump	17.88	5.51	4.00	48.00	44.00
Forward bend - backward bend - throw test ∑	56.17	24.17	12.00	154.00	142.00
Body fat %	30.85	5.19	19.77	45.92	26.15
BMI	21.51	1.63	19.18	25.12	5.94
VO_2max L	1.79	0.02	1.76	1.96	0.20
VO_2max ml	44.33	5.09	32.75	59.88	27.13

Legend: Mean - mean value, SD - standard deviation, Min - minimum value, Max -maximum value, BMI - Body Mass Index, VO_2max L - absolute oxygen consumption, VO_2max ml - relative oxygen consumption.

Table 2 shows the results of the influence of morphological characteristics on the parameters of muscle fitness in overweight and obese eight-year-old boys.

Table 2 Influence of morphological characteristics on muscle fitness

	Morphological characteristics – the plyometric jump				Morphological characteristics – the forward bend - backward bend - throw test ∑			
	R	Part R	Beta	p	R	Part R	Beta	p
Body height	-.02	-.05	-.13	.413	-.02	.10	.28	.089
Leg length	.03	.06	.13	.266	-.05	-.07	-.15	.221
Arm length	.01	.01	.02	.817	-.04	-.02	-.02	.813
Shoulder width	.03	.14	.20	.012*	-.04	-.01	-.00	.973
Pelvic width	-.09	.01	.01	.877	-.06	-.01	-.01	.937
Hip width	-.07	-.00	-.01	.935	-.04	.01	.01	.896
Body mass	-.14	-.03	-.09	.609	-.06	-.08	-.26	.150
Chest circumference	-.18	-.10	-.15	.097	-.04	.03	.05	.589
Upper arm circumference	-.15	-.04	-.06	.449	-.02	.05	.08	.366
Thigh circumference	-.06	.11	.15	.061	-.05	-.01	-.00	.976
Upper arm skinfold	-.17	.01	.01	.889	-.04	-.01	-.01	.852
Back skinfold	-.28	-.12	-.18	.039*	-.05	.01	.01	.946
Abdomen skinfold	-.24	-.07	-.09	.247	-.04	.01	.00	.981
	R= .35 R^2= .12 F= 3,18 p=.000**				R= .13 R^2 = .17 F= 0,40 p=.967			

Legend: R - multiple correlation coefficient of the criterion variable and predictor system, Part R - partial correlation, Beta - standard partial regression coefficient of each predictor variable with a criterion; F - F-test; p - level of statistical significance; ** p<.01; * p<.05.

Based on the obtained results (Table 2), it can be concluded that there is a statistically significant influence of morphological characteristics on the values of the plyometric jump at the multivariate level (p=.000). The variables shoulder width and back skinfolds have a statistically significant effect on the plyometric jump (p=.012 and p=.039, respectively). Other morphological characteristics do not have a statistically significant effect on the plyometric jump of eight-year-old boys.

Based on a further analysis of Table 2, which shows the results of the influence of the system of morphological characteristics on the result of the forward bend - backward bend - throw test ∑ for eight-year-old participants, it can be concluded that there is no statistically significant influence (p=.967).

Table 3 presents the results of the influence of morphological characteristics on body fat and BMI of overweight and obese boys.

The results of individual regression coefficients indicate that the variable upper arm skinfold (p=.000) has the greatest influence on the body fat percentage in overweight and obese boys, followed by the back skinfold (p=.000), and upper arm circumference (p=.037).

The analysis shows that there is a statistically significant influence of morphological characteristics on BMI at the multivariate level (p=.000, Table 3). It can be concluded that body height (p=.000) and body mass (p=.000) have the greatest influence on BMI, based on the results of individual regression coefficients, followed by hip width (p=.001) and upper arm circumference (p=.002). Other morphological characteristics do not have a statistically significant effect on the BMI of eight-year-old boys.

Table 3 Influence of morphological characteristics on body fat and BMI

	Morphological characteristics - Body fat				Morphological characteristics - BMI			
	R	Part R	Beta	p	R	Part R	Beta	p
Body height	.20	-.03	-.01	.596	.18	-.97	-1.101	.000**
Leg length	.13	-.03	-.01	.631	.09	.04	.01	.508
Arm length	.14	-.03	-.01	.616	.18	-.09	-.01	.100
Shoulder width	.22	-.07	-.01	.231	.34	-.06	-.01	.264
Pelvic width	.45	.06	.01	.332	.53	-.06	-.01	.316
Hip width	.41	.03	.01	.592	.53	.19	.04	.001**
Body mass	.52	.03	.01	.611	.73	.98	1.567	.000**
Chest circumference	.47	-.02	-.00	.707	.64	.08	.013	.164
Upper arm circumference	.50	.12	.02	.037*	.62	.18	.026	.002**
Thigh circumference	.38	.02	.01	.790	.57	.04	.006	.463
Upper arm skinfold	.87	.96	.53	.000**	.48	.03	.004	.551
Back skinfold	.88	.95	.57	.000**	.63	.00	.001	.932
Abdomen skinfold	.68	.01	.01	.917	.55	.03	.004	.644
	R= .99 R^2= .98 F= 149,60 p=.000**				R= .99 R^2= .99 F= 2464,10 p=.000**			

Legend: R - multiple correlation coefficient of the criterion variable and predictor system, Part R - partial correlation, Beta - standard partial regression coefficient of each predictor variable with a criterion; F - F-test; p - level of statistical significance; ** $p<.01$; * $p<.05$.

Table 4 shows the results of the influence of morphological characteristics on cardiorespiratory fitness (absolute and relative oxygen consumption) in boys aged eight.

Table 4 Influence of morphological characteristics on cardiorespiratory fitness

	Morphological characteristics – VO_2max L				Morphological characteristics – VO_2max ml/kg/min			
	R	Part R	Beta	p	R	Part R	Beta	p
Body height	.56	-.01	-.00	.995	-.79	-.15	-.09	.007**
Leg length	.46	-.05	-.07	.412	-.65	-.03	-.01	.623
Arm length	.50	.06	.08	.277	-.66	.11	.04	.055*
Shoulder width	.48	.03	.02	.657	-.64	.07	.02	.235
Pelvic width	.52	.09	.11	.127	-.72	.06	.02	.279
Hip width	.52	-.06	- .08	.282	-.78	-.15	-.05	.009**
Body mass	.67	.32	.79	.000**	-.98	-.81	-.84	.000**
Chest circumference	.47	-.07	- .08	.245	-.74	-.09	-.03	.115
Upper arm circumference	.38	-.12	- .12	.042*	-.70	-.19	-.06	.001**
Thigh circumference	.42	.02	.02	.719	-.65	-.03	-.01	.605
Upper arm skinfold	.22	.03	.03	.591	-.39	-.02	-.01	.682
Back skinfold	.29	-.04	- .04	.474	-.52	-.01	-.00	.929
Abdomen skinfold	.24	-.06	- .05	.327	-.48	-.05	-.02	.342
	R= .86 R^2= .46 F= 20,31 p=.000**				R= .98 R^2= .96 F= 613,29 p=.000**			

Legend: R - multiple correlation coefficient of the criterion variable and predictor system, Part R - partial correlation, Beta - standard partial regression coefficient of each predictor variable with a criterion; F - F-test; p - level of statistical significance; ** $p<.01$; * $p<.05$.

It can be stated that there is a statistically significant influence of morphological characteristics on the absolute oxygen consumption at the multivariate level (p=.000, Table 4). Based on the results of individual regression coefficients, it can be stated that the variable body mass and upper arm circumference have a statistically significant influence on absolute maximum oxygen consumption (p=.000 and p=.042, respectively). Other morphological characteristics do not have a statistically significant effect on the criterion variable in boys aged eight.

Based on the results of te regression coefficients, the variable body mass (p=.000), then upper arm circumference (p=.001), body height (p=.007) and hip width (p=.009) have a statistically significant effect on relative VO_2max (p=.000, Table 4). Other morphological characteristics do not have a statistically significant effect on the criterion variable of relative oxygen consumption in boys aged eight.

DISCUSSION

The obtained results of the influence of morphological characteristics on the parameters of muscle fitness indicate that shoulder width and back skinfold have the greatest influence on the explosive strength of the legs (the plyometric jump). Subcutaneous adipose tissue and transversal dimensionality affect the performance of plyometric jumping (Ara, Moreno, Leiva, Gutin, & Casajús, 2007; Đorđević, Pantelić, Kostić, & Uzunović, 2015) by disrupting and making it difficult to perform tasks that require body displacement (Živković, Ranđelović, Đorđević, Pantelić, & Malobabić, 2018). Excess subcutaneous adipose tissue is an additional load that needs to be moved during certain motor tasks, which has been determined in other studies (Siahkouhian, Mahmoodi, & Salehi, 2011; Sepúlveda, Méndez, Duarte, Herrera, Gómez-Campos, Lazari, & Cossio-Bolanos, 2018). In contrast to the determined statistically significant influence of morphological characteristics on the explosive strength of the legs, the effect on the explosive strength of the arms, i.e. on the forward bend - backward bend - throw test ∑, is missing (Table 2). Considering the fact that in the forward bend - backward bend - throw test ∑ is not necessary to lift and move your own body in space, which absolutely explains the fact that excess body weight is not an obstructively factor. Children, adolescents, as well as overweight and obese adults, tend to achieve better results than those of normal weight when it comes to explosive arm strength, i.e. higher body mass values have a positive effect on motor tasks such as the athletic throw (the shot put, hammer throw, discus) (Živković et al., 2018). In the current research such results have not been obtained, and the reason for this might be the fact that sensitive periods for this motor ability appear at a later age (Balyi & Way, 2005), and also that morphological characteristics do not affect certain fitness parameters in prepuberty, which was the conclusion of some authors (Silva, Birkbeck, Russel, & Wilson, 1984; Ball, Massey, Misner, Mckeown, & Lohman, 1992).

The variables skinfold of the upper arm and back, just like the circumference of the upper arm, have a statistically significant effect on body fat percentage in overweight and obese boys (Table 3). The upper arm and back skinfolds directly affect the result of the body fat percentage and, accordingly, are an integral part of the equation used to calculate it (Slaughter et al., 1988). The evidence of a strong correlation between these variables is also found in other studies that used ultrasound methods to determine the correlations of subcutaneous fat and body fat percentage (Leahy, Toomey, McCreesh, O'Neill, & Jakeman, 2012; Singh, Varte, & Rawat, 2014). Based on the obtained results it can be concluded that body height, body mass, then hip width and the upper arm circumference have the greatest influence on the body mass index (Table 3). Body height and body mass directly affect the body mass index, and are an integral part of the BMI equation (WHO, 1997). Transversal skeletal dimensionality and voluminosity in overweight and obese boys affected the body mass index value and it could be assumed that participants with higher values of adipose tissue would have higher values of transversal dimensionality (especially when it comes to hip width) and voluminosity (especially upper arm circumference and body mass), and therefore the values of the body mass index will be influenced by them. The similar results were found in the study of Đorđević & Kostić (2016).

Further analysis of the results shows that there is a statistically significant influence of morphological characteristics on the cardiorespiratory system. The results indicate that body mass and upper arm circumference (Table 4) have the largest influence on absolute oxygen consumption (VO_2max L): boys with higher values of body mass have higher values of absolute oxygen consumption, which suggests that body mass directly affects VO_2max L (Đošić, Bratić, Jezdimirović, Purenović-Ivanović, Živković, & Bratić, 2019; Johansson, Brissman, Morinder, Westerståhl, & Marcus, 2020). Excessive body mass imposes an unfavorable load on cardiac function and oxygen intake by working muscles, and when obese people have a higher value of absolute oxygen consumption, they indicate a higher cardiac load during physical activity. Overweight and obese children are insufficiently physically active and experience more stress during physical activity than normally nourished children, which affects cardiorespiratory fitness (Chatterjee, Chatterjee, & Bandhopadhyay, 2005). This result speaks in favor of the fact that obese people are exposed to higher metabolic requirements due to the higher values of body mass, which results in higher values of absolute oxygen consumption.

A more objective method for assessing the state of cardiorespiratory fitness in overweight and obese boys is relative oxygen consumption. Variables for estimating longitudinal and transversal skeletal dimensionality, as well as voluminosity, have a statistically significant effect on relative VO_2max. The results indicate that higher values of the mentioned dimensions will negatively affect relative oxygen consumption, and this is confirmed by other studies (Chatterjee et al., 2005; Živković et al., 2018; Johansson et al., 2020). A human body loaded with fat deposits cannot accept an adequate amount of oxygen and pass it to the working muscles, and the reduced use of oxygen by adipose tissue also reduces the total VO_2max. The biggest negative predictor of obesity is the level of cardiorespiratory endurance. It has been found that the risk of obesity decreases by as much as 10% with an increase in VO_2max of only 1 ml/kg/min (Ortega, Labayen, Ruiz, Kurvinen, Loit, Harro et al., 2011).

CONCLUSION

The aim of the study was to determine the influence of morphological characteristics on the parameters of health-related fitness in overweight and obese boys aged eight. Based on the obtained results it was determined that there is a statistically significant influence of morphological characteristics on the parameters of health-related fitness in each of the selected variables (the plyometric jump, Body fat %, BMI, VO_2max L and VO_2max ml), except for the variable the forward bend - backward bend - throw test $\sum$.

Excess body mass and obesity negatively affect the parameters of health-related fitness and interfere with the performance of certain motor tasks. These results suggest that it is necessary to influence the reduction of the prevalence of overweight and obesity, to promote and influence the increase of the level of physical activity in children in order to improve the parameters of health-related fitness from earliest childhood, and use it as a strategy in the fight against the prevalence of children obesity.

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UTICAJ MORFOLOŠKIH KARAKTERISTIKA NA PARAMETRE ZDRAVSTVENOG FITNESA PREKOMERNO UHRANJENIH I GOJAZNIH DEČAKA

Cilj rada bio je da se utvrdi uticaj morfoloških karakteristika na parametre zdravstvenog fitnesa prekomerno uhranjenih i gojaznih dečaka uzrasta osam godina. U istraživanju je učestvovalo 314 dečaka koji su pohađali drugi razred osnovnih škola na teritorijama gradova jugoistočne Srbije. Za procenu morfoloških karakteristika korišćeni su parametari longitudinalnih (3), transverzalnih, (3), cirkularnih dimenzija (3) i mase tela i mere potkožnog masnog tkiva (3). Parametri zdravstvenog fitnesa utvrđeni su pomoću testova za procenu mišićnog fitnesa, telesne kompozicije i kardiorespiratornog fitnessa. Za utvrđivanje uticaja morfoloških karakteristika na parametre zdravstvenog fitnesa korišćena je regresiona analiza. Rezultati istraživanja ukazuju da postoji statistički značajan uticaj (p=.000) morfoloških karakteristika na većinu parametara zdravstvenog fitnesa. Statistički značajan uticaj nije utvrđen kod testa pretklon-zaklon-izbačaj ∑ kod ispitivanog uzorka.

Ključne reči: *fitnes parametri, morfološke karakteristike, zdravstveni fitnes, kardiorespiratorni fitnes*