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Relación entre actividad física y composición corporal de adolescentes

Association between physical activity and body composition of high school students

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Resumen: El objetivo de este estudio fue determinar el efecto de la actividad física en la composición corporal de adolescentes. La muestra del estudio fueron 735 estudiantes (299 chicos: edad media 17.20 años; 436 chicas: edad media 17.16 años). El nivel de actividad física se determinó mediante la versión larga del International Physical Activity Questionnaire (IPAQ). Los cuestionarios fueron administrados online mediante el sistema INDARES. La composición corporal se midió con el analizador de la composición corporal InBody 230. Los parámetros analizados fueron: índice de masa corporal (IMC), índice de masa grasa (IMG), índice de masa libre de grasa (IMLG), porcentaje de masa grasa (MG%), área de grasa visceral e índice cintura cadera (ICC). Respecto al análisis estadístico, se utilizó t de student para muestras independientes para determinar las diferencias significativas entre chicos y chicas, activos e inactivos. Los resultados medios de composición corporal fueron más favorables en los estudiantes menos físicamente activos. En el caso de los chicos, estas diferencias fueron estadísticamente significativas en IMG (p 0.049), MG% (p 0.038), ICC (0.026); en el caso de las chicas en IMC (0.021) e IMLG (p 0.004). Los resultados de esta investigación no confirmaron el efecto positivo de la actividad física en los parámetros de salud estudiados.
Palabras clave: Salud. Índice de Masa Corporal. Índice de Masa Grasa (IMG), Índice de Masa Libre de Grasa. Área de Grasa visceral.

Abstract: The purpose of this study was to determine the effect of physical activity on the body composition of adolescents. The study sample consisted of 735 students (299 boys: mean age 17.20 years; 436 girls: mean age 17.16 years). Physical activity levels were determined using the long version of International Physical Activity Questionnaire (IPAQ). Questionnaires were administered online within teaching using INDARES system. Body composition was measured using body composition analyzer InBody 230. The parameters examined were: body mass index (BMI), body fat mass index (BFMI), fat free mass index (FFMI), percent fat mass (FM%), visceral fat area (VFA) and waist-hip ratio (WHR). For determining statistically significant differences between more physically active and less physically active (S_0) girls and boys was used t-test for independent samples. Average results of body composition were more favorable in students who failed to meet physical activity guidelines. These differences were statistically significant for boys in BFMI (p 0.049), FM% (p 0.038), WHR (0.026) and for girls in BMI (0.021) and FFMI (p 0.004). The results of the present study did not confirm positive effect of physical activity on the parameters of health investigated.
Key words: Health. Body Mass Index. Body fat mass index. Fat free mass index. Visceral fat area.

Introduction

Throughout evolution, human organism in the fight for its existence adjusted to the volume of daily physical activity. However, at present there is declining interest in being physically active, which leads to sedentary lifestyles accompanied by physical inactivity (López Sánchez, López Sánchez, & Díaz Suárez, 2015a; Sigmundová & Sigmund, 2011). From the global perspective, low physical activity level or physical inactivity are considered to be the fourth most prevalent risk factor causing premature death and according to Lee et al. (2012) worldwide physical inactivity causes 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes and 10% of breast cancer. Moreover, there are 5.3 million of premature deaths worldwide related on physical inactivity. Despite the fact that physical activity is regarded as a normal part of our lives; however, it is a vicious circle of each person's individual development because bad habits negatively affect the life of future generations. Physically inactive children tend to have greater predispositions for obesity and other health disorders, which lead to decreased school attendance and lower level of academic achievement (Antala, 2013; López Sánchez, Borrego Balsalobre & Díaz Suárez, 2013). Overweight and obesity are associated with health-related quality of life. Obese people suffer from a poor level of health-related quality of life compared to their counterparts with optimal body weight (Larsson, Karlsson & Sullivan, 2002). According to WHO (2014), more than 40 million children in 2012 were overweight or obese. In EU countries, the number of overweight or obese children increases by 400,000 per year. Childhood and adolescent obesity are considered as risk factors for adult obesity, with its consequent mortality and morbidity (Singal & Schwenk, 2007). The development of overweight and obesity is determined by a variety of factors (genetic, hormonal and metabolic); however, the primary cause is the inadequate ratio of energy intake to energy expenditure (Moreira et al. 2011; Soderlund, Fischer & Johansson, 2009). WHO (2009) has confirmed that overweight and

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obesity may be influenced by several factors. Among these are factors that cannot be influenced are genetic predispositions, medication, metabolic effects, or psychogenic factors and factors that can be influenced mainly insufficient energy expenditure, or low volume of physical activity. Bunc (2007) reported that only 2-5 % of all cases of overweight and obesity were caused by objective health problems. A variety of studies investigated the quality of body composition in relation to the possible effect of physical activity on optimization of body composition (Artiloli et al., 2010; Baker & Davies, 2006). Body composition is proportionate to physical effort and genetic dispositions of every individual (Bláha, Susanne & Rebato, 2007). A lot of research studies have demonstrated positive effects of physical activity on physical fitness and weight reduction of obese children (Bar-Or & Baranowski, 1994; López Sánchez, López Sánchez, & Díaz Suárez, 2015b).

Regular physical activity prevents or limits weight gain, and gain in Body Mass Index, or body fat. Researches point to the fact that physical activity is positively associated with higher proportion of fat-free mass and reduction in body fat (Kyle, Genton, Gremion, Slosman & Richard, 2004). Body fat amount significantly depends on the balance between energy intake and energy expenditure; moreover, energy expenditure has been shown to be affected by physical activity, nutrition and heredity. The minimal volume of physical activity which brings about health benefits equals energy expenditure 6-8 kcal/kg per day^{-1} (Pangrazi, 2000). Such caloric expenditure is considered minimal and amounts to 60 minutes or more of various moderate intensity physical activities daily.

Young people should get the opportunity to acquire attitudes and behaviors leading to lifetime physical activity. Research has shown that physical activity levels decrease with age. Higher caloric expenditure in childhood, which is determined by higher intensity of physical activities, is considered to be a guarantee of higher volume of physical activity in adulthood (Dobrý & Čechovská, 2011). Sallis and Patrick (1994) found that adolescents should be physically active daily or nearly every day. Physical activities of moderate intensity should last at least 30 minutes and 3-times per 20 minutes should be spend doing physical activities of vigorous intensity.

At present, among the most important physical activity guidelines are Physical Activity Guidelines for Americans (USDHHS, 2008) and guidelines of European Union countries. American children and adolescents should do 60 minutes or more of physical activity daily. Vigorous-intensity physical activity should be performed at least 3 days a week. Muscle-strengthening and bone-strengthening physical activities should be performed at least 3 days of the week as part of 60 or more minutes of daily physical activity. It is important to add that these activities should be varied, appropriate for children age and abilities (USDHHS, 2008). Considering age-related ontogenetic and psychosocial differences, physical activity guidelines should not be identical from 3 to 18 years of age for both boys and girls. Moreover, for 11- to 18-year-olds it is recommended to do 60 minutes or more of medium-intensity physical activity daily or at least 30 minutes of medium-intensity physical activity daily, or walk 5 times a week combined with high-intensity physical activity performed for 20 minutes or more 3x a week (Sigmundová & Sigmund, 2011).

The combination of the physical activity guidelines may be divided into at least 10-minute periods during the day. The solution to the obesity issue requires a complex approach, which considers biological, psychosocial and health-related factors. It leads to a lifestyle change by adhering to the health-promoting principles. Taking into consideration such complexity, successful combat against overweight and obesity lies in increased energy expenditure achieved through physical activity and in maintaining or reducing the energy intake (Liba & Buková, 2012). In childhood and adolescence, regular physical activity is highly beneficial for bone health and muscular fitness. Physical activity also aids in body weight optimization and brings an array of health benefits in adulthood and late life (Savela et al., 2010).

Methods

The research group consisted of 735 students of high schools in Presov region. Of these, 299 were boys (average age 17.20 years; BMI 22.04) and 436 were girls (average age 17.16 years; BMI 21.47).

Physical activity levels were assessed using the international physical activity questionnaire IPAQ (long version). The whole process of questionnaire administration was carried out under the expert supervision of experienced researchers who respectfully maintain manual of INDARES system electronic form that was conducted by the Center for Kinanthropology Research at the Faculty of Physical Culture in Olomouc.

Body composition measures, i.e. body mass index (BMI), body fat mass index (BFMI), fat-free mass index (FFMI), fat mass percentage (FM %), waist-to-hip ratio index (WHRI) and visceral fat area (VFA) were measured using a direct segmental multi-frequency bioelectrical impedance analysis InBody 230. According to WHO, BMI values higher than 25.0 kg/m^2 pose a relative health risk and values higher than 30.00 kg/m^2 indicate obesity. Excess body mass could be referred as a proportion of fat mass or muscle hypertrophy (Seidell, 2002). For more precise body composition assessment of individuals, we used fat free mass index (FFMI) and fat mass index (FMI). These indices and percent fat mass (FM %) were evaluated according to Kyle, et al. (2004). Besides total

body fat percentage, an important measure is also the body fat distribution because the excess fat storage in the waist area poses a health risk. To determine this type of health risk, we evaluated visceral fat area (VFA) and (waist-hip ratio index) WHR. The VFA values were classified into two groups: values lower or equal 100cm^2 and values higher than 100cm^2. This borderline value indicates the presence of a health risk (Han, Lim, Sun, Paek & Kim, 2010). WHR values were divided into three subcategories. Optimal WHR values ranged from 0.75 to 0.85.

Collected data on body composition were processed using software LookinBody 3.0. Data were analyzed using statistical software STATISTICA 12. For processing gained data we used mathematical-statistical methods: mean for measuring central tendency and standard deviation for measuring variability. Statistical differences were determined using t-test for independent samples.

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Results and discussion

A key concept in current general physical activity guidelines is regular participation in physical activity. This is the reason why analysis of physical activity includes also the parameter of frequency. Physical activity guidelines recommend practicing moderate physical activity for 30 minutes at least 5x per week or 20 minutes of intensive physical activity 3x per week. Generally, 30 minute moderate activity represents the lowest level of activity which an individual should achieve during a day. Standards for general physical activity guidelines was met by 21.68% more boys than girls; these findings are in accordance with several studies that have confirmed higher PA for boys compared to girls (Frömel, Novosad & Svozil, 1999; Hrdličková, 2011) (Table 1).

Table 1. Meeting physical activity guidelines in percentage.

Standard	%	
	boys	girls
5x30 minutes of moderate physical activity	26.4	12.2
3x20 minutes of intensive physical activity	12.4	10.6
Meeting both standards	9	3.2

Although students displayed relatively high volume of the performed activity, we detected a low level of meeting physical activity guidelines using in-depth analysis focused on the frequency (3x20 intensive PA or 5x30 moderate PA). Overall, 26.42% of boys and 12.15% of girls from our sample met the lowest standard for moderate physical activity. From the perspective of health, it is important to perform intensive physical activity for 20 minutes at least and only 12.37% of boys and 10.55% of girls perform it three times per week (Table 1.).

In terms of general physical activity guidelines, we divided the sample into two subgroups, S_0 – students who do not meet lowest standards for general physical activity guidelines and S_1 – students who meet one or both physical activity levels.

Currently, we do not have any possibility to compare anthropometric characteristics obtained in our research with similar studies or standards for this age category in Slovakia. Therefore we attempt to compare the results with similar foreign studies. The prevalence of obesity in Europe is lower than in the USA (Seidell, 2002) but, generally, the situation in Slovakia is considered unfavorable and the collected data indicate the prevalence of being overweight in 12% of children (TASR, 2008). In the screened sample, we recorded a great difference in the percentage of boys in overweight and obese categories in terms of BMI in disfavor of more active boys (S_0 – 11.5%; S_{1-} 18.9%) (Table 3). The difference of average BMI values between physically active and inactive girls was evaluated, comparing to boys, as statistically significant (Table 2) again not in favor of physically active girls. In category of overweight and obesity was monitored 13.6 % of physically inactive and 14.9 % of physically active girls.

Table 2. Average values of the selected health-related indicators in terms of performed physical activity.

M		Do not meet guidelinesfor PA		Meet guidelinesfor PA		
		M	***SD***	***M***	***SD***	***p <.05***
BMI	boys	49.90	28.01	52.45	29.72	0.0511
	girls	47.97	27.81	54.89	26.63	0.0214 *
BFMI	boys	3.07	2.10	3.55	2.11	0.0494*
	girls	5.90	2.38	6.26	2.62	0.1721
FFMI	boys	18.81	6.77	18.68	1.94	0.8231
	girls	15.37	1.32	15.78	1.25	0.0043*
FM %	boys	13.58	6.56	15.18	6.73	0.0385*
	girls	26.86	6.88	27.45	7.05	0.4355
VFA	boys	42.11	32.79	49.14	31.59	0.0606
	girls	62.68	30.05	68.66	31.78	0.0729
WHR	boys	0.82	0.07	0.84	0.06	0.0261*
	girls	0.85	0.05	0.86	0.05	0.0852

Note: PA – physical activity;M – mean; SD – standard deviation; p< .05 level of significance; BMI – body mass index percentiles; BFMI – body fat mass index; FFMI – fat free mass index; FM % - body fat percentage; VFA – visceral fat area; WHR – waist-hip ratio.

Table 3. Number of girls from S_0 a S_1 in the selected categories of health-related indicators.

C		BMI		BFMI		FFMI		FM %	
		S0	S1	S0	S1	S0	S1	S0	S1
		<5		<1.8		<16.7		<10.8	
1	n	12	8	31	21	24	20	63	41
	%	7.7	5.6	19.9	14.7	15.4	13.4	40.4	28.7
		5-85		1.8-5.1		16.7-19.7		10.8-21.6	
2	n	126	108	111	96	100	80	79	73
	%	80.8	75.5	71.2	67.1	64.1	55.9	50.6	51.1
		85-95		5.2-8.2		19.8-21.6		21.7-28.7	
3	n	12	17	7	20	30	32	5	24
	%	7.7	11.9	4.5	14	19.2	22.4	3.2	16.8
		>95		>8.3		>21.7		>21.7	
4	n	6	10	7	6	2	11	9	5
	%	3.9	7.0	4.5	4.2	1.3	7.7	5.8	3.5

Note: C – category; BMI – body mass index percentiles; BFMI – body fat mass index; FFMI – fat free mass index; FM % - body fat percentage; S_0- does not meet lowest standards for general physical activity guidelines; S_1 – meets lowest standards for general physical activity guidelines; n – number.

Assessment of the state of the body on the basis of BMI values is not satisfactory since this index does not reflect the proportion of body fat mass (BFM) and fat free mass (FFM). The most variable component of human body is considered to be body fat which presence significantly changes by the influence of ontogenetic development and lifestyle. From the somatic point of view, the effect of physical activity it most noticeable in reduction of fat mass and increase of muscle mass. However, results of studies indicate that BFM values in active individuals decrease, whilst FFM values elevate (Kyle et al, 2004; Shutz, Kyle & Pichard, 2002).

Our results only partially confirm the above mentioned findings. Participation in physical activity did not show reduction of fat mass in the group of boys (BFMI S_0-3.066 kg/m^2; S_1 3.548 kg/m^2) (Table 2); moreover, the difference between boys groups S_1 and S_0 was statistically significant in average FM% (Table 2). We can see the growth of muscle mass where boys of group S_1 have muscles developed up to 9.55% above the average. In the group of girls, we detected very similar proportion in all standards in relation to BF% in both active and inactive participants. On the contrary, in the case of BFMI, we recorded a higher number of active girls but in terms of this index we classified them into overweight and obese categories. Simultaneously we detected lower number of physically active boys in category with muscle mass developed below the average (Table 3). Higher average value of body fat mass index (BFMI) was found in physically more active girls (Table 2) that also had more numerous presence in overweight and obesity categories (S_0 – 14.9 %; S_1 – 20.2 %) (Table 4).

The difference in average values of body fat percentiles between girls groups was not statistically significant and according to this health parameter number in categories of overweight and obesity was approximately similar (S_0 – 21.8 %; S_1 – 23.7 %) (Table 4). Pubescent period is significant risk period for obesity development especially in girls. From the ontogenetic perspective the puberty is considered to be critical period with hormonal changes, interests' changes and limitation of physical activities. Obesity, overweight and actual body composition can be influenced by lifestyle and one of the fundamental ways for reversion of the negative state is adequate physical activity and nutrition changes. Fat free mass expressed by the FFM index in active girls is at a higher level when 84.21% of active and 72.37% of inactive girls meet or exceed the recommended standard (Table 4). Knowledge that physical activity positively influence the development of muscle mass also confirms our research result because up to 11.8 % of less physically active girls have insufficiently or below average developed muscles (Table 4).

Table 4. Number of girls from S_0 a S_1 in the selected categories of health-related indicators.

C		BMI		BFMI		FFMI		FM %	
		S0	S1	S0	S1	S0	S1	S0	S1
		<5		≤3.7		≤14.5		≤21.6	
1	n	18	5	69	19	89	18	82	27
	%	5.6	4.4	21.4	16.7	27.6	15.8	25.5	23.7
		5-85		3.8-8.1		14.6-16.7		21.7-33.1	
2	n	260	94	205	72	196	75	170	60
	%	80.8	82.5	63.7	63.2	60.9	65.8	52.8	52.6
		85-95		8.2-11.7		16.8-18.1		33.2-39.9	
3	n	32	12	41	18	27	18	52	21
	%	9.9	10.5	12.7	15.8	8.4	15.8	16.2	18.4
		>95		≥11.8		≥18.2		≥40	
4	n	12	3	7	5	10	3	18	6
	%	3.7	2.6	2.2	4.4	3.1	2.6	5.6	5.3

Note: C – category; BMI – body mass index percentiles; BFMI – body fat mass index; FFMI – fat free mass index; FM % - body fat percentage; S_0- does not meet lowest standards for general physical activity guidelines; S_1 – meets lowest standards for general physical activity guidelines; n – number

Based on the above described results we can state that physical activity of girls and boys from our sample does not significantly affect reduction of fat mass but it rather influences the growth of muscle mass. This can also be supported by Petersen et al. (2004) who suggested that a lack of physical activity does not necessarily result in increased overweight

and obesity. On the contrary, overweight and obesity represent a barrier which often leads to a sedentary way of life.

The effect of physical activity is also reflected in changes of body fat distribution which can be observed on the basis of the WHR index and visceral fat area (VFA). We positively evaluate the fact that more than 90 % of boys and 85 % of girls have the value of visceral fat in recommended health zone that do not indicate higher risk of cardiovascular complications. Comparing groups of more and less active students was found that less active girls and also boys showed lower average values of body composition components (VFA, WHR) (Table 2). Furthermore, above the recommended norm of VFA were numerous groups of physically more active boys and girls (Table 5). Similar situation is with WHR values. More optimal values according to health guidelines achieved groups of physically less active boys and girls (Table 6). It is necessary to determine whether and to what extent the intervention in the form of physical activity affects redistribution of fat mass and fat free mass in such young age. However, this would require more exact monitoring of physical activity.

Table 5. Number of boys and girls in the VFA categories.

C		VFA			
		Boys (299)		**Girls (436)**	
		S0 (156)	**S1 (143)**	**S0 (322)**	**S1 (114)**
		≤100			
1	n	146	132	288	96
	%	93.6	92.3	89.5	84.2
		>100			
2	n	10	11	34	18
	%	6.4	7.7	10.5	15.8

Note: C – category; VFA – visceral fat area; S_0- does not meet lowest standards for general physical activity guidelines; S_1 – meets lowest standards for general physical activity guidelines; n – number

The relationship between the current general physical activity guidelines with an emphasis on frequency during a week and selected health-related parameters, namely BMI, FM%, WHR and VFA has been shown as positive in many studies. Along with increasing frequency of meeting these guidelines, average values of individual health-related indicators, as a potential risk of overweight and obesity development, decreased (Pelclová et al. 2009; Schwarz et al. 2007). Based on our results, we cannot confirm any positive effect of physical activity on these parameters. We believe that different results can be caused by both different types of research and a high measure of subjectivity in estimating volume and intensity of the physical activity performed, which students noted in the questionnaire as ex post facto design.

Table 6. Number of boys and girls in the WHR categories.

C		WHR			
		Boys (299)		**Girls (436)**	
		S0 (156)	**S1 (143)**	**S0 (322)**	**S1 (114)**
		<0.75			
1	n	8	3	2	1
	%	5.1	2.1	0.6	0.9
		0.75-0.85			
2	n	116	97	196	66
	%	74.4	67.8	60.9	57.9
		>0.85			
3		n	32	43	124
		%	20.5	30.1	38.5

Note: C – category; WHR – waist-hip ratio; S_0- does not meet lowest standards for general physical activity guidelines; S_1 – meets lowest standards for general physical activity guidelines; n – number

Conclusions

At present, the assessment and promotion of physical activity is often supported by information technologies. Results of the published studies document the time efficiency of these procedures because in relatively short time we can collect a large amount of data from respondents. In our study, we dealt with analysis of data collected in this way referring to the frequency and intensity of the performed physical activity and we correlated them with health-related parameters of body composition.

Our findings were unexpectedly surprising because we did not confirm positive influence of performed physical activity on body composition parameters. On the contrary, in all observed parameters less physically active boys and girls reached better average results in relation to health indicators. There were found statistically significant differences comparing BMI and FFMI in girls and BFMI and WHR in boys.

More detailed analysis, based on percentage representation of students in individual categories, showed higher development of muscle mass in boys and girls who are more physically active.

As we mentioned previously the volume of performed physical activity was diagnosed using questionnaire. However, we recommend that in further work it would be appropriate to focus on monitoring of directly performed physical activity using accelometers that would help us to find out more relevant data. From our own experience we know that students who practiced physical activity less frequently used to augment the volume of physical activity in order to hide this fact. Therefore we believe that these tendencies could have negatively affected the results to some extent.

Moreover, it would be interesting to address the eating habits of children as they undoubtedly affect body composition and it is the increased energy output that results in increasing caloric intake which in not often nutritionally valuable in children. On the other hand, we can notice the fact that youth (especially girls) are influenced by the current trend and in order to maintain slimness they do not eat enough food.

Consuming way of life and low range of physical stimuli are just small part of negatives that lead to maladaptive processes of organism. Among these features, there is also decreased body composition quality that reflects on higher presence of fat tissue and lower presence of muscle tissue. Sedentary way of life without physical compensation increases importance of body composition changes monitoring in population.

Our research in this field contributed to the findings on the impact of physical activity on the level of body composition parameters. Such studies in this age category are absent in Slovakia. However, generalization of our results in Slovak conditions is not possible as the research was only carried out in Eastern Slovakia. It is desirable to conduct similar studies but with more sensitive selection of diagnostic methods and greater focus on the hidden factors which can play an important role in this age category.

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