Original Article

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Effect of different sports activities on body composition in pubescent girls

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Abstract

Introduction: The purpose of the study was to determine the effects of different sports on body fat and lean body mass in pubescent girls. *Material and Methods:* The sample of 40 girls (12 ± 1.2 years of age) were divided into 4 groups: 10 volleyball players, 10 basketball players, 10 swimmers, and 10 girls formed the control group. Body height was measured using portable stadiometer. We used InBody 230 to measure body mass, body mass index, fat mass, lean mass, visceral fat, and sum of skeletal muscles. The measured variables were evaluated using the Body-vision program and Statistica 12.0 cz. For normal distribution we used Shapiro-Wilk normality test. The differences between the groups were determined by Kruskal-Wallis test, $p<0.05$. *Results:* We found statistically significant differences in fat mass between the groups of swimmers and the control in the body fat (10.62%; p= 0.033) and fat mass in upper limbs (1.42 kg; p= 0.027). Statistically significant difference was found between the group of swimmers and volleyball players in the lower limbs fat mass (2.43 kg; p= 0.045). Furthermore, statistically significant difference in lean mass was found between the volleyball players and the control in the weight of the lower limbs muscle mass (3.59 kg; p= 0.047). *Conclusions:* Our findings show that sports such as volleyball, basketball, and swimming provide appropriate development of lean mass in pubescent girls. We may conclude that pubertal girls practicing sports have lower body fat mass and higher lean body mass compared to youth who do not practice sports.

Keywords: fat mass, lean mass, bioimpedance analysis, physical activity, children, obesity

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INTRODUCTION

Overweight and obesity pose a serious public health challenge in contemporary society. The obesity trend is particularly alarming in children and adolescents [1], furthermore, declining physical activity and related negative health outcomes are the most significant among young people, especially women [2, 3]. The annual rate of increase in the prevalence of childhood obesity has been growing steadily, and the current rate is 10 folds higher than it was in the 1970s. This reinforces the adult epidemic and creates a growing health challenges for the next generation, as obesity in childhood affects obesity in adulthood [4]. Obesity determines different risks in the biological, psychological and social sphere [5]. It leads youth to isolation, self-esteem reduction, thus affecting the personal, family and academic performance [6]. The costs of children obesity for the family, the society and the health system has become quite significant [7, 8]. Physical activity in childhood acts as prevention of obesity in later years in life [9]. Restrepo-Calle [10] states that physical activity has positive effect on body composition and lean body mass, increase energy consumption and helps maintain lean body mass. Performing continuous and regular physical activity causes changes in body composition [11]. People who perform physical activity regularly, have a lower percentage of body fat mass than people who are not physically active [12].

As a result, health institutions should increase interest in youth lifestyle and its consequences. Health problems can be identified in relation to body fat, lean mass, or muscle mass and changes associated with different types of exercise [13]. The BMI has been considered as the best anthropometric indicator to diagnose overweight and obesity in 2-18 year old children [8]. The body composition can be measured using indirect technology, like for example the DSC-BIA-bioelectrical impedance, through InBody 230 body composition analyzer. Which represents a noninvasive and quick method that provides immediate results, requires minimal collaboration of subjects, is ideal for routine practice and field research [14, 15]. As we know, the sport sector is diverse and each sport has varied effects on the development of the body composition of athlete. There are different physical requirements on the athletes in each sport [16]. For instance, swimming improves aerobic capacity, flexibility, strength, coordination, and muscle tone of the whole body [17]. Swimming is specific in that it takes place in water, which shows specific characteristics. The characteristics of water environment (temperature and resistance) may aid in decreasing or maintaining children’s body fat values within the normal range. Pubertal girls who participate in swim training on a regular basis have lower body fat percentages than those who do not engage in any sports activities, or those who engaged in another type of sports activity [18, 19].

On the other hand, physical activity in ball games such as basketball and volleyball show different specifics because these games are played on dry land. Ball games such as basketball are distinct in intensity, distance, and the length of training load [20]. Where change of direction, acceleration and abrupt stops are required, force and speed reactions of lower limbs is needed [21]. In volleyball we can observe very quick changes of direction on the ground and in the air with repeated short jumps and short change of position [22].

Studies dealing with body composition in ball games showed that girls who play basketball have higher volume of fat mass, total lean mass, and segmental lean mass than girls who do not play any sports. In volleyball, girls who played volleyball had lower fat mass and higher lean mass than their physically inactive counterparts [18, 23]. However, study of body composition in kids’ athletes is important not only for recognizing young talent but also for their optimal development [24].

This can help us to assess educational and training programs in different contexts (e.g. school, training process, competition etc.). In that context, the aim of our paper was to determine the effect of 3 distinct sports (volleyball, basketball and swimming) on the accumulation of adipose tissue and lean body mass in pubescent girls.

MATERIAL AND METHODS

Participants

Our participants were pubescent girls who attended elementary school Ing. O. Kožucha in Spišská Nová Ves and sports clubs (ŠKP Košice - swimming, VK Spišská Nová Ves - volleyball, ŠKBD Spišská Nová Ves - basketball). Forty girls aged 11 to 13 years (12 ± 1.2 years) were divided into 4 groups (volleyball, basketball, swimming, and control group), taking into account their physical activity levels. All girls doing sports in sports clubs and the girls from the control group were selected non-randomly. All girls attended elementary schools in the Košice region. The girls included in the control group did not take part in any out-of-school sports activity, except for 2 hours of physical education classes per week. Compared with the experimental group, we used the control group to determine the effect of physical activity levels on body composition parameters. The characteristics of the particular groups are presented in Table 1.

The girls from the experimental group were personally asked questions about their exercise habits and physical activity levels. Only girls who engaged in a minimum of 3 hours of training per week and 12 months of sports activity were included in the experimental group. The girls who did not attend all training sessions were excluded from the study.

Table 1 Descriptive characteristics of 4 groups of pubescent girls

	Swimming *n*=10		Volleyball *n*=10		Basketball *n*=10		Control group *n*=10	
	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values
Age (year)	12.60 ± 0.69	-	12.47 ± 0.46	-	12.67 ± 0.74	-	12.06 ± 0.40	-
Height (cm)	157.12 ± 10.30	-	165.90 ± 10.30^{4}	-	157.12 ± 9.98	-	153.60 ± 8.32	-
Body mass (kg)	45.50 ± 9.59	normal	53.72 ± 6.63	normal	48.55 ± 10.56	normal	46.84 ± 13.83	low
BMI (kg/m^2)	18.24 ± 2.02	normal	19.47 ± 2.02	normal	19.21 ± 2.06	normal	19.61 ± 4.60	normal
Years of training	3.80 ± 0.42	-	3.40 ± 0.52	-	3.50 ± 0.53	-	-	-
Weekly training hours	8.00 ± 0.00	-	6.00 ± 0.00	-	7.50 ± 0.00	-	1.50 ± 0.00	-

Data adjusted by height. Differences concerning the ^{1}swimming, ^{2}volleyball, ^{3}basketball, ^{4}control groups, $p<0.05$.
Abbreviations: X – average; SD standard deviation; BMI = body mass index; BIA standard - bioelectrical impedance values (program Body-vision)

Parents of children and participants were informed about the aim of our study, as well about possible risks and benefits at the beginning of the program. Parents of all girls provided their written informed consent prior to the study. At the start of the program significant differences was found in the body height between volleyball players and the control ($p= 0.016$). Volleyball players were on average 12.3 cm taller than girls from the control (Table 1).

Data collection

To measure body height (cm), we used a portable stadiometer (Seca 213, Germany). To measure body composition, we used the InBody 230 body composition analyzer, which may function independently (only with the printer) or using the Lookin'Body PC software, which provides instant overview about the outcomes in tables and graphs. By the means of, InBody 230 and Looking Body software, we obtain: body mass (kg); body mass index (kg/m^2); fat mass (kg; %); fat mass arms, trunk and legs (kg); lean mass (kg); muscle mass arms, trunk and legs (kg); bone mineral content (kg), visceral fat (cm^2); skeletal muscle mass (kg). The measurement using the InBody 230 analyzer is based on the direct segmental measurement bioelectrical impedance analysis method, the so-called DSM-BIA. The measurement consists of 10 impedance measurements by using two different frequencies (20kHz, 100kHz) at each of 5 segments (right and left arm, trunk, right and left leg) using the tetrapolar 8-point tactile electrodes. InBody 230 analyzer was calibrated by the manufacturer. Measurements were conducted in early September in the morning hours. Participants were informed in advance to abstain from food and to not drink at least two hours before the measurement. The participants stood barefoot on the InBody 230 device, wore only T-shirt and shorts. To complete measurement of one participant took about 4 minutes. To ensure validity and reliability of the measurement, all measurements were conducted using the same device and the same support staff.

Pubertal age

There are a number of unequal biological changes typical for this age period. More specifically, there are major changes in the internal environment of the pubescent body. We can observe acceleration of growth (weight and height) and increment of muscle strength [25].

Data analysis

We used descriptive methods to provide basic characteristics of groups that participated in the research. Body composition data were evaluated using the Body-vision program and Statistica 12.0 CZ. Body-vision program, which is supplied with the InBody 230 body composition analyzer, provides detailed information on the body composition of a human body. The body composition parameters include total body water, intracellular water and extracellular water, proteins, minerals, fat mass, and body weight. To process the body composition data, we used the Statistica 12.0 CZ statistical software. This software is a complex analytical tool for data processing in all fields of human activity by providing a wide selection of advanced techniques for research purposes. To evaluate normality of data distribution, we used the Shapiro-Wilk test. Differences between groups were determined using the Kruskal-Wallis ANOVA, and the probability was set at $p < 0.05$.

RESULTS

Fat mass

Fat mass results indicate that the highest values measured among the four groups of girls were achieved by the control group (25.77 ± 9.54 %; 12.84 ± 7.18 kg).Body-vision software assesses fat mass parameters on a 3-degree scale: low, normal, and high. The girls from the control group had high volume of fat mass.

The difference in fat mass between control group and the group of swimmers was approximately 10%, two-fold in kilograms. The differences between the control group and volleyball and basketball players, respectively, equaled 5.1 to 5.4%, which accounted for 1.8 to 2.73 kg. The differences in fat mass between the control group and the sports groups were statistically significant only between swimmers and the control group (10.62%; $p = 0.033$).

Differences in the values of total fat mass and percentage body fat between the athletes and their physically inactive counterparts were found in particular between swimmers (individual sport) and volleyball and basketball players (team sports) accounting for 5.3-5.5 %, 3.6-4.3 kg. The Body-vision software showed that swimmers' fat mass values were low and volleyball and basketball players' values were normal. There were no statistically significant differences in total fat mass and percent body fat between the sports groups and the control group.

The control group also showed highest values of segmental fat (arms, trunk, and legs). Greatest differences were found between the control group and swimmers (fat mass arms 1.42 kg, fat mass trunk 2.99 kg a fat mass legs 6.73 kg). There were slighter differences between the control group and groups of volleyball and basketball players, respectively, in fat mass arms by 0.5 kg, fat mass trunk by 0.8-1.4 kg, and fat mass legs by 4.0-4.1 kg. Statistically significant difference in the segmental mass between the control group and the sports groups were found only for fat mass arms ($p= 0.027$) between swimmers and the control group.

The values of segmental fat showed that greatest differences between sports groups were found between swimmers and the groups of volleyball and basketball players. The differences in fat mass arms, fat mass trunk, and fat mass legs, were 0.9 kg, 1.6 - 2.2 kg and 2.4 kg, respectively. The difference in the segmental fat mass between volleyball players and basketball players was minimal. Statistically significant differences in the segmental fat mass were found only between swimmers and volleyball players ($p= 0.045$).

The girls from the control group had the highest values of visceral fat. Despite higher values when compared with the sports groups, Body-vision software showed that these values were normal. The greatest difference (27 cm^2) was found between the control group and the group of swimmers. The difference between the groups of volleyball players and basketball players was 18 cm^2. The differences in the visceral fat between the control group and sports groups was statistically insignificant.

The highest difference in visceral fat (9 cm^2) between sports groups was found between the swimmers and volleyball and basketball players, respectively. Body-vision software showed that the visceral fat mass of sports groups was low. There were no statistically significant differences in visceral fat mass between sports groups (Table 2).

Table 2 Fat mass in the 4 groups of pubescent girls

	Swimming n=10		Volleyball n=10		Basketball n=10		Control group n=10	
	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values
Percent body fat (%)	15.15 ± 5.42[4]	low	20.42 ± 5.44	normal	20.68 ± 4.66	normal	25.77 ± 9.54	high
Total fat mass (kg)	6.70 ± 2.54	low	11.01 ± 3.39	normal	10.31 ± 3.92	normal	12.84 ± 7.18	high
Fat mass arms (kg)	0.43 ± 0.13[4]	-	1.35 ± 0.50	-	1.34 ± 0.47	-	1.85 ± 0.98	-
Fat mass trunk (kg)	2.85 ± 1.24	-	5.05 ± 1.97	-	4.47 ± 2.27	-	5.84 ± 4.03	-
Fat mass legs (kg)	1.23 ± 0.26[2]	-	3.66 ± 0.91	-	3.60 ± 1.13	-	7.69 ± 5.00	-
Visceral fat (cm^2)	34.36 ± 14.02	low	43.15 ± 22.05	low	42.50 ± 19.44	low	61.43 ± 34.75	normal

Data adjusted by height. Differences concerning the [1]swimming, [2]volleyball, [3]basketball, [4]control groups, $p<0.05$.
Abbreviations: X – average; SD standard deviation; BIA standard - bioelectrical impedance values (program Body-vision).

Lean mass

Lean mass results indicate that the lowest values measured among the four groups of girls were achieved by the control group (34.00 ± 7.99 kg). The greatest difference in lean mass (8.8 kg) was found between the control group and the group of volleyball players. There was a minimal difference between the control group and group of swimmers. The differences in total lean mass between the control group and the sports groups were statistically insignificant.

The assessment of total lean mass was found between the sports groups and the groups of swimmers and volleyball players (6.9 kg) and between the groups of volleyball and basketball players (4.6 kg). The differences in total lean mass between the sports groups were statistically insignificant.

As for the segmental lean mass, the control group showed the lowest values of muscle mass trunk (14.67 ± 3.31 kg) and the second lowest in muscle mass arms (2.91 ± 1.01 kg) and legs (9.95 ± 2.95 kg). The greatest difference in the segmental lean mass (arms, trunk, and legs) was found between the control group and the volleyball players (muscle mass arms 1.2 kg, muscle mass trunk 3.9 kg, muscle mass legs 3.6 kg). The differences in the segmental lean mass between the control group and the sports groups were statistically significant only in muscle mass legs between the volleyball players and the control group ($p= 0.047$).

The values of segmental lean mass for sports groups showed differences between the group of swimmers and the groups of volleyball and basketball players, respectively. The difference in muscle mass arms, trunk, and legs ranged from 1.7-2.4 kg, 0.1-2.4 kg, and 6.6-8.2 kg, respectively. There was only a slight difference between volleyball players and basketball players (muscle mass arms 0.7 kg, muscle mass trunk 2.3 kg, muscle mass legs 1.7 kg). There were no statistically significant differences in total lean mass between the sports groups.

Skeletal muscle results indicate that the lowest values measured among the four groups of girls were achieved by the control group (18.06 ± 4.78kg). Body-vision software showed that the values of skeletal muscle mass found for the control group were low. The greatest difference in the skeletal muscle mass (5.2 kg) was found between the control group and the volleyball players. Slight differences were found between the control group and swimmers (3.1 kg) and between the control group and basketball players (2.6 kg). There were no statistically significant differences in skeletal muscle mass between the control group and the sports groups.

The values of skeletal muscle mass showed differences between sports groups, especially between groups of basketball players and volleyball players and swimmers. The difference between groups varied from 0.5 to 2.6 kg. Body-vision software showed that the values of skeletal muscle mass were normal. The differences in skeletal muscle mass between the sports groups were statistically insignificant (Table 3).

Table 3 Lean mass in the 4 groups of pubescent girls

	Swimming n=10		Volleyball n=10		Basketball n=10		Control group n=10	
	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values	X ± SD	BIA values
Total lean mass (kg)	35.87 ± 6.87	-	42.8 ± 5.83	-	38.24 ± 7.40	-	34.00 ± 7.99	-
Muscle mass arms (kg)	1.71 ± 0.46	-	4.08 ± 0.83	-	3.41 ± 0.97	-	2.91 ± 1.01	-
Muscle mass trunk (kg)	16.20 ± 2.99	-	18.61 ± 2.51	-	16.28 ± 3.24	-	14.67 ± 3.31	-
Muscle mass legs (kg)	5.30 ± 1.34	-	13.54 ± 1.95[4]	-	11.85 ± 2.70	-	9.95 ± 2.95	-
Skeletal muscle mass (kg)	21.13 ± 6.15	normal	23.28 ± 3.39	normal	20.66 ± 4.36	normal	18.06 ± 4.78	low

Data adjusted by height. Differences concerning the [1]swimming, [2]volleyball, [3]basketball, [4]control groups, $p<0.05$.
Abbreviations: X – average; SD standard deviation; BIA standard - bioelectrical impedance values (program Body-vision).

DISCUSSION

The main focus of our paper was to compare the body fat and lean body mass in the pubescent girls who were practicing 3 different sports with girls who do not engage in any sports. Subsequently we determined the effects of various sports activities on the development of body composition. The research on the effects of physical activity on body fat and lean mass in children and adolescents who participating in various sports (health perspective) is not extremely large. However, body fat accumulates when the energy content of the food and drinks consumed exceeds the energy expended by an individual's metabolism and physical activity. Since both intake and output contribute to weight gain, it is often difficult to identify either excess intake or physical inactivity as the sole and clearly demonstrable factor responsible for an individual's or a society's obesity problem [26].

Several aspects of the social environment (such as school policies or the media) and the built environment (such as transport and urban design) can in some way influence physical activity choices. For example, some schools are placing more emphasis on academic tasks, often at the expense of time for physical education and other forms of physical activity. In addition, in free time during the day, activities involving exercise are increasingly competing with sedentary activities such as television watching (in younger classes) or computer use. Moreover, participation in some traditional sports has decreased recently, in part owing to demographic changes and the increase in the variety of sports disciplines. Commercial fitness clubs and activities have developed, but their accessibility may be limited in some areas or else, for some population groups. Physical activity is of benefit for all body types and body weight as it reduces the likelihood of cardiovascular diseases, hypertension and type 2 diabetes. Beneficially influences fat and carbohydrate metabolism, enhancing insulin sensitivity and improving blood lipids. Moreover, can increase muscle mass, even when the change in weight is small or nonexistent [27].

The steady rise of obesity in children and adolescents emphasizes the need for new, integrated approaches to its diagnosis and therapy. When diagnosing obesity and choosing methods for its correction, it is fundamentally important to use reliable methods of estimating the amount of adipose tissue. Using the body mass index is not always sufficient, since it does not provide complete information on quantitative content in the body weight of the patient's body. For these purposes in clinical medicine use of bioimpedance analysis to assess the indicators, which characterize the basal metabolism, active cell mass, fat and lean body mass and total water content in the body. Quite interesting is the use of the bioimpedance method in the pediatric age group for accurate evaluation of body composition of children of various ages and body weight that will allow for dynamic control of all types of metabolism to evaluate the effectiveness of the observation and treatment of patients with overweight and obesity [28], therefore, we decided to apply the bioimpedance method in this study.

Presented outcomes pointing to the conclusion, that the girls from the control group had higher values of body fat than their physically active counterparts. The same conclusions were drawn by Abbott and Davies [12], who studied the relationship between physical activity and childhood obesity, and the correlations between the level of physical activity, BMI and body fat mass. Children who are physically inactive have higher body fat percentages than those who participate in physical activity at least 3 times per week [29], which is consistent with our research findings. The amount of body fat decreases linearly with the results of physical abilities even in children with normal body composition [30]. Children who are overweight before the age of 8 are likely to have more severe obesity as adults [31]. The causes of this trend in the last 10-15 years should be attributed to the lifestyle changes, reduced levels of physical activity and a greater amount of energy intake. Both in industrialized societies and in the developing world, there is a common trend of body fat increment especially in young segment of the population [32]. The lowest values of total lean mass and skeletal muscle mass were found for the control group. This may be attributed to the fact that the girls from the control group did not engage in sufficient levels of physical activity (45 minutes of physical activity twice per week) as compared with the sports groups (1 hour of physical activity six to eight times per week). However, is should be noted that the levels of muscle mass in male and female children increase with physical activity as well as during adolescence [33]. Therefore, both children and their parents should become familiar with the benefits of physical activities performed either in the water or on dry land.

This finding may be caused by the fact that the group of swimmers are physically active in the water environment, which induces greater expenditure of energy at the intensity that is the same as with dryland exercise. This may be explained by the fact that the thermal conductivity of water is 23 to 28 times higher than that of air [34]. Loss of body temperature in children is higher than in adults. Therefore, the appropriate temperature for swim training should range from 26° to 27° [35]. In addition to energy expenditure, another factor that has effect on the movement in water is the water density, which is 800 to 1000 times higher than the density of air [36]. Therefore, the above-mentioned factors including water density may cause lower values of total fat mass in the group of swimmers.

This is consistent with the results presented by Stanforth et al. [19] and Ubago-Guisado et al. [18], who found that swimmers have lower body fat (%) than basketball and volleyball players, showing there were no statistically significant differences in fat mass between the sports groups. However, the study by Valente-dos-Santos et al. [37] showed that swimmers had lower fat mass values than the groups of volleyball players, and the differences between groups were statistically significant ($p>0.01$).

As reported for fat mass, the lowest values of lean mass were found among the group of swimmers, and their total lean mass was slightly higher than that of basketball group. The greatest differences were recorded in muscle mass arms and legs between the groups of swimmers and volleyball and basketball players. The differences found may be caused in particular by the specific characteristics of the sports. Similar findings were reported by Bavios et al. [38]. In volleyball and basketball, players use their arms to control the ball and their legs to maintain stability in the basic stance or at takeoff (more explosive sport produces greater muscle mass development, especially in the legs [39, 22]. In another study [23] was found that basketball players between the age 18 and 25 years had a higher percentage of lean mass than subjects who does not play basketball. Similarly, athletes whose performance rely on jumping ad throwing have stronger and bigger upper bodies [40]. The comparison of the body composition between volleyball and basketball players shows that volleyball players are taller [18, 38]. We can utter that more research is needed to clarify complex issue's related to causation of overweight in young cohorts and its influence on the health of individual and society as a whole [41, 42].

On the very end we can conclude, that the adolescent overweight and obesity in school age is becoming epidemic. Increasing physical activity participation and decreasing sedentary life should be the focus of strategies aimed at preventing and treating overweight and obesity in youth.

CONCLUSION

The aim of the study was to determine the effect of 3 distinct sports (volleyball, basketball and swimming) on the accumulation of adipose tissue and lean body mass in pubescent girls. We may conclude that physical activity in pubescent age, depending on the type of sport, has a positive effect on the body composition, more specifically on body fat and lean body mass in comparison with those who do not participate in physical activity on a regular basis. The results have shown that swimming is associated with low degree of adiposity, which proves the beneficial effect of physically activity on health, diabetes, obesity, and illness in adulthood.

This may be a good argument for parents, teachers, coaches, doctors, and other professionals to promote participation in sport and physical activity for the young people on a regular basis. We believe that people who suffer from weight management problems should engage in water-type physical activities that may be perceived as health-promoting.

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