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Original Article

Physical fitness and parent-reported health status and leisure time activity of Polish boys and girls with abdominal and peripheral obesity

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Abstract
The study explores the physical fitness as well as the parent-reported leisure time activity and health status of children and youth aged 10-19 years with abdominal and peripheral obesity. The 2009 study involved 2,606 boys and girls from Eastern Poland. We calculated BMI and WHtR, based on which the participants were subdivided into groups with normal BMI, abdominal obesity, and peripheral obesity. Physical fitness was assessed using the Eurofit battery. Data regarding the subjects' leisure time activity and health status were collected from their parents in a survey. The statistical significance of the differences observed was assessed using Student's t-test (quantitative variables), the Kruskal-Wallis test (qualitative variables), and logistic regression. Boys and girls with abdominal and peripheral obesity achieved better results than those with normal BMI for arm strength, balance, and the 10 x 5 m shuttle run; similar observations were additionally made regarding girls for the tapping and sit-and-reach tests. However, obese subjects had lower results than non-obese peers in broad jump, sit-ups, and arm hang. No significant differences in physical fitness were found between groups with abdominal and peripheral obesity. The participants whose health status was evaluated the most poorly by parents were boys with abdominal obesity. Obese subjects participated in extracurricular sports activities less often than their normal-weight counterparts. No relationship was found between obesity type and physical fitness. The analysis of leisure time activity revealed differences between the groups analysed only with respect to their participation in extracurricular sports activity.
Keywords: adolescents, children, obesity, physical activity, physical fitness

Introduction

Obesity is currently considered to be one of the most frequently occurring non-infectious diseases which impair the function of the entire body. In terms of the distribution of adipose tissue, a distinction is made between general obesity, where fat tissue is evenly distributed across the entire body; peripheral or gynoid obesity, in which excess fat is accumulated in the gluteal-femoral region; and abdominal or android obesity, where fat is deposited centrally, in the region of the abdomen (Vague, 1956). Peripheral obesity and abdominal obesity have different metabolic features. Persons with abdominal obesity are characterised by increased triacylglycerols, increased LDL cholesterol, and reduced HDL cholesterol in the plasma. Abdominal obesity is definitely more often accompanied by hypertension, type 2 diabetes, impaired fibrinolysis, and atherosclerotic diseases than peripheral obesity. On the other hand, peripheral obesity is associated with reduced resting metabolic rate. In persons with peripheral obesity, metabolic rate does not change significantly when body mass is reduced, whereas those with the abdominal type respond with a considerable reduction in adipose tissue when the energy balance is negative (Després, 2006; Zhang, Rexrode, van Dam, Li & Hu, 2008; Griffith, Younk & Davis, 2010).

Abdominal obesity, along with its consequences, has been studied in children and adolescents (McCarthy, Jarret, Emmett & Rogers, 2005). The literature provides much information concerning the morphofunctional development of obese children, reporting, among others, that compared to their peers with normal body weight, these children have lower physical fitness and activity levels, accompanied by a faster rate of physical development (Deforche et al., 2009; Mota, Ribeiro, Carvalho, Santos, &Martins, 2009; Mota, Ribeiro, Carvalho,& Santos, 2010; Andreasi, Michelin, Rinaldi, & Burini, 2010; Kim, & Lee, 2009; Janssen et al., 2005). However, the above issues are rarely considered with respect to the type of fat distribution. Therefore, the main aim of the study was to analyse the physical fitness as well as parent-reported health status and leisure time activity of children and youth aged 10-19 years with abdominal and peripheral obesity.

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Material and methods

Subjects

The study was conducted in 2009, and it included children and youth from Eastern Poland aged 10-19 years. The subjects were selected for the study using a two-stage sampling system. In the first stage, we chose seven rural schools and seven urban schools, in which three stages of education of children and youth were implemented (primary, lower secondary, and upper secondary). In the rural schools, we planned to include all students aged above 10 years in the study, whereas in urban schools, two classes were randomly selected for each of the calendar ages considered in the study.

Approximately 75% of parents consented to their children's participation in the research. Among these children, 6% refused to take part in the study, and 8.7% did not participate since they were absent from school or had a medical certificate exempting them from attending physical education classes. The research involved 3,383 girls and boys, which accounted for 60.3% of the planned number of research participants. The current analysis included data collected for 2,606 persons, since those recorded for persons with under- and overweight were excluded. The research was carried out at the Faculty of Physical Education and Sport in Biała Podlaska (Grant No. DS.116), after receiving the approval of the Bioethics Committee of the University of Physical Education in Warsaw.

Anthropometric measurements

The subjects' physical development was assessed based on measurements of height, weight, and waist circumference. The measurements were carried out using devices commonly applied in anthropological studies: height was determined using a Sieber Hegner & Co anthropometer, weight was measured with an electronic CAS medical scale, and waist circumference was measured using an anthropometric band.

Anthropological parameters and division of subjects into groups

The values of Body Mass Index (BMI) were compared against the threshold values established by the International Obesity Task Force (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole, Flegal, Nicholls, & Jackson, 2007). This made it possible to divide the male and female participants into four groups: with underweight, with normal BMI, with overweight, and with obesity. The current analysis included only the results of obese subjects compared to those with normal BMI, whereas the results obtained for underweight and overweight persons were excluded from the analysis. Obese subjects were further divided into two groups using the waist-to-height ratio, WHtR (calculated by dividing waist circumference by height in cm). Persons who had an index of less than 0.5 were classified as having peripheral obesity, and those with an index equal to or higher than 0.5 were included in the group with abdominal obesity, in line with the recommendations of McCarthy, & Ashwell, (2006).

Physical fitness assessment

Physical fitness was assessed using the European Test of Physical Fitness battery (Eurofit, 1988). A cardiorespiratory endurance test was also carried out, but its results were not used in the analysis because few persons participated in it.

Diagnostic survey

A diagnostic survey was carried out using an original questionnaire designed for the purposes of the study. The survey made it possible to collect data regarding, among others, date of birth, gender, participation in physical education classes, leisure time activity (including the number of hours spent in front of the TV and computer) reported by the parents, as well as the subjective assessment of the children's health status made by the parents.

Statistical analysis

Normality of quantitative data distribution was assessed using the Shapiro-Wilk test. Depending on the type of data distribution, the statistical characteristics of measurable variables were presented as arithmetic averages and standard deviations or medians and ranges. The statistical characteristics of qualitative data were presented in the form of numerical and percentage distributions.

The results of the physical fitness assessment of subjects from the groups of girls and boys established based on BMI values (groups with normal BMI, abdominal obesity, and peripheral obesity) were normalised with respect to age. For this purpose, we subtracted the arithmetic mean for the test for a given age category from the results obtained by a particular subject in a given test, and the difference was divided by the standard deviation of the results of the test in that age category. This made it possible to add up normalised values for subjects of different calendar ages and calculate normalised values. The results of girls and boys with abdominal and peripheral obesity were compared against the normalised values obtained for subjects with normal BMI. The statistical significance of intergroup differences was evaluated using Student's t-test for independent samples.

The results for qualitative variables (health status, participation in physical education classes and extracurricular sports activity, and television and computer use) were compared using the Kruskal-Wallis test. We subjected the variables whose distributions differed significantly between groups ($p < 0.05$) and those for which intergroup differences were close to statistical significance ($p < 0.1$) to univariate logistic regression, calculating the odds ratio (OR) of their association with a given type of obesity with a 95% confidence interval (95% CI). The variables which were found to be significant predictors of the incidence of obesity in the univariate analysis ($p < 0.05$) were tested in multivariate models of regression analysis.

All the calculations were made using STATISTICA software version 10 (StatSoft).

Results

Table 1 shows the number of male and female participants of the study divided into groups based on their BMI. Persons who qualified as obese were divided into two groups, with peripheral and abdominal obesity, based on the WHtR index. Subjects with normal BMI were the most numerous, and those with peripheral obesity were the least numerous. In further analyses, only the results obtained for persons with peripheral and abdominal obesity were examined, with relation to the results of subjects with normal BMI.

Table 1. Number of boys and girls in groups established based on BMI

Group analysed	Boys		Girls	
	n	%	n	%
Underweight	115	6.54	147	9.05
Normal BMI	1272	72.35	1170	72.00
Overweight	282	16.04	233	14.34
Abdominal obesity	68	3.87	56	3.45
Peripheral obesity	21	1.19	19	1.17
Total	**1758**	**100.00**	**1625**	**100.00**

The lowest BMI, both in boys and in girls, was found in the group with normal weight. Clear differences were not found between persons with abdominal and peripheral obesity, as was also confirmed by statistical testing (Table 2).

Table 2. Mean BMI values of boys and girls

Group analysed	Boys					Girls				
	M	SD	H	p-value	Relation-ship	M	SD	H	p-value	Relation-ship
Normal BMI	18.71	2.50				18.73	2.60			
Abdominal obesity	27.69	3.45	231.71	0.001*	1-2** 1-3**	27.46	4.05	195.85	0.001*	1-2** 1-3**
Peripheral obesity	25.22	2.68				27.42	2.99			

* – statistically significant differences at $p < 0.05$; H – Kruskal-Wallis test value

** – statistically significant differences in post-hoc testing (1 – normal BMI, 2 – peripheral obesity, 3 – abdominal obesity)

Based on the results of the physical fitness test battery, boys with peripheral and abdominal obesity were found to have better outcomes in arm strength, balance, and the 10 x 5 m shuttle run. On the other hand, obese boys had lower results than their normal-weight peers in standing broad jump, sit-ups, and arm hang. An exploration of the physical fitness of boys with peripheral versus abdominal obesity revealed minor differences only for balance, sit-ups, and arm hang, but these differences were not statistically significant (Table 3, Fig. 1).

Table 3. Significance of intergroup differences in the physical fitness of boys and girls

Physical fitness test	1-2		1-3		2-3	
	t	p-value	t	p-value	t	p-value
Boys						
Hand grip	2.03	0.057	4.15	0.001*	−0.04	0.971
Balance	2.36	0.031*	6.05	0.001*	1.04	0.303
Tapping	0.50	0.623	0.98	0.330	0.02	0.986
Sit-and-reach	−1.11	0.281	1.44	0.155	1.56	0.122
Standing broad jump	−6.38	0.001*	−8.72	0.001*	−0.09	0.929
Sit-ups	−0.96	0.353	−3.81	0.001*	−0.57	0.573
Arm hang	−8.61	0.001*	−15.98	0.001*	−1.07	0.288
10 x 5 m run	4.92	0.001*	6.54	0.001*	−0.28	0.781
Girls						
Hand grip	1.98	0.064	4.30	0.001*	0.54	0.590
Balance	0.74	0.470	4.59	0.001*	1.69	0.095
Tapping	1.29	0.214	2.56	0.013*	0.02	0.984

Sit-and-reach	0.83	0.419	2.01	0.049*	0.68	0.496
Standing broad jump	−4.02	0.001*	−7.48	0.001*	0.46	0.649
Sit-ups	−2.48	0.031*	−4.31	0.001*	−0.64	0.524
Arm hang	−9.58	0.001*	−14.82	0.001*	0.34	0.738
10 x 5 m run	3.93	0.002*	5.47	0.001*	−0.20	0.840

* – statistically significant differences at $p < 0.05$; t – Student's t-test value
(1 – normal BMI, 2 – peripheral obesity, 3 – abdominal obesity)

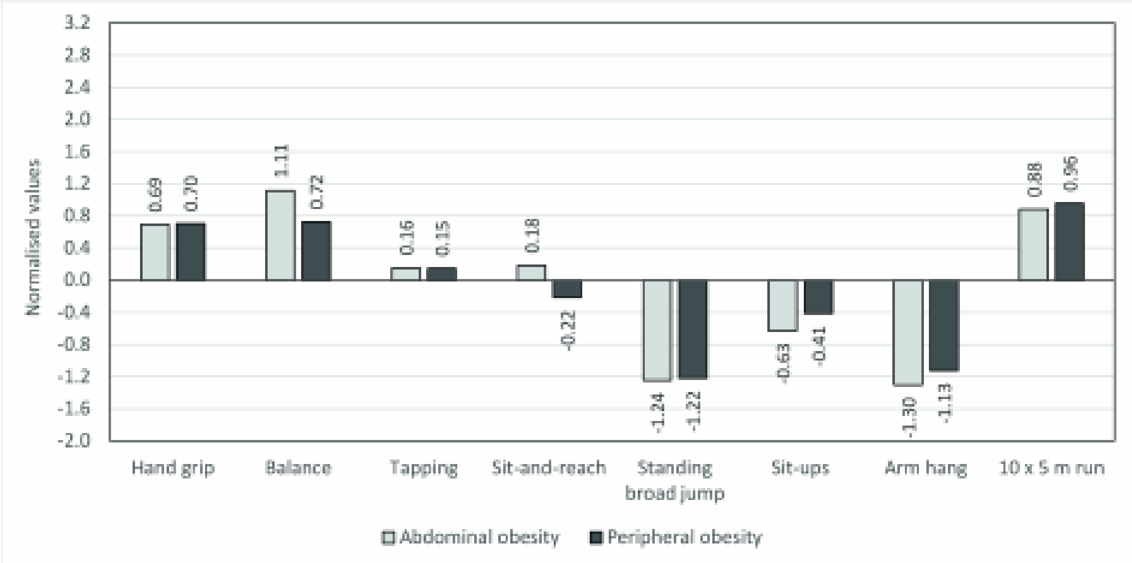

Figure 1. Physical fitness of boys with abdominal and peripheral obesity compared with subjects with normal BMI

The analysis of the results of the physical fitness test battery in girls showed considerable differences between subjects with normal BMI and those with peripheral and abdominal obesity. The relationships identified were similar to the ones found for boys. Regardless of the type of obesity, obese girls had better results in the 10 x 5 m shuttle run, arm strength, balance, tapping, and sit-and-reach tests. On the other hand, obese girls had lower results than their normal-weight peers in standing broad jump, sit-ups, and arm hang. A comparison of the physical fitness of girls with peripheral and abdominal obesity revealed the greatest – though non-significant – differences for balance and sit-ups (Table 3, Fig. 2).

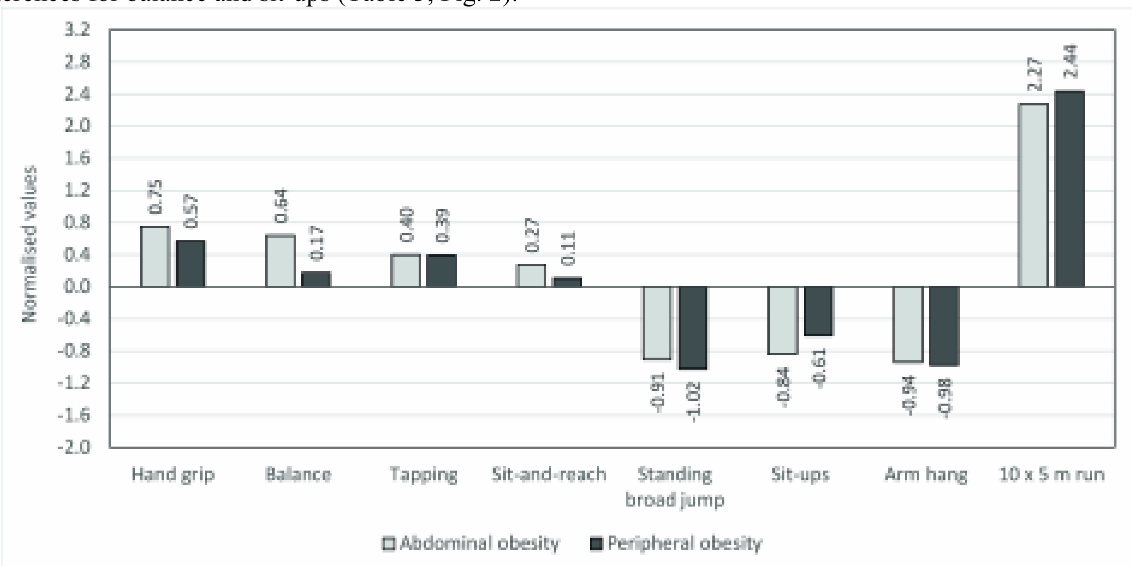

Figure 2. Physical fitness of girls with abdominal and peripheral obesity compared with subjects with normal BMI

The study also examined the subjective assessment of the subjects' health status and leisure time activity carried out by their parents. Most parents of male subjects viewed their children's health status as good, and most parents of female subjects saw their children's health status as very good. The greatest number of "neither good nor bad", "bad", and "very bad" responses were given with respect to boys with abdominal obesity. The only statistically significant differences in parent-reported health status were observed between boys with normal BMI and those with abdominal obesity (Table 4).

Table 4. Parent-reported health status and leisure time activity of boys

Variable	Normal BMI	Peripheral obesity	Abdominal obesity	H	p-value	Relation-ship
	%	%	%			
Health status						
Neither good nor bad, bad, or very bad	5.3	0.0	15.7			
Good	53.1	71.4	62.8	12.09	0.002*	1-3**
Very good	41.6	28.6	21.6			
Participation in PE classes	97.3	100.0	94.1	2.19	0.334	-
Participation in extracurricular sports activity	53.9	41.7	38.8	4.89	0.087	-
Hours spent practising sports outside PE lessons						
Up to 1 hour/week	26.3	25.0	36.2			
1-3 hours/week	45.5	33.3	55.3	7.81	0.020*	1-3**
More than 3 hours/week	28.2	41.7	8.5			
TV or computer use (summer)						
Up to 1 hour/day	34.0	35.7	41.2			
1-3 hours/day	54.2	57.1	47.1	0.84	0.658	-
More than 3 hours/day	11.8	7.1	11.8			
TV or computer use (winter)						
Up to 1 hour/day	19.5	7.1	21.6			
1-3 hours/day	59.4	78.6	52.9	0.15	0.926	-
More than 3 hours/day	21.1	14.3	25.5			

* – statistically significant differences at $p < 0.05$; H – Kruskal-Wallis test value
** – statistically significant differences in post-hoc testing (1 – normal BMI, 2 – peripheral obesity, 3 – abdominal obesity)

Table 5. Parent-reported health status and leisure time activity of girls

Variable	Normal BMI	Peripheral obesity	Abdominal obesity	H	p-value	Relation-ship
	%	%	%			
Health status						
Neither good nor bad, bad, or very bad	1.2	7.1	2.1			
Good	7.2	7.1	6.4	3.39	0.184	-
good	91.5	85.7	91.5			
Participation in PE classes	96.2	92.9	93.8	1.18	0.553	-
Participation in extracurricular sports activity	46.3	35.7	21.7	11.14	0.004*	1-3**
Hours spent practising sports outside PE lessons						
Up to 1 hour/week	39.1	38.5	42.9			
1-3 hours/week	44.8	61.5	52.4	1.77	0.414	-
More than 3 hours/week	16.1	0.0	4.8			
TV or computer use (summer)						
Up to 1 hour/day	39.9	35.7	31.9			
1-3 hours/day	50.7	42.9	59.6	1.31	0.519	-
More than 3 hours/day	9.5	21.4	8.5			
TV or computer use (winter)						
Up to 1 hour/day	27.3	21.4	29.8			
1-3 hours/day	57.7	50.0	55.3	1.26	0.531	-
More than 3 hours/day	14.9	28.6	14.9			

* – statistically significant differences at $p < 0.05$; H – Kruskal-Wallis test value
** – statistically significant differences in post-hoc testing (1 – normal BMI, 2 – peripheral obesity, 3 – abdominal obesity)

In the analysis of data collected regarding the subjects' participation in physical education classes, the greatest number of absentees was found among persons with abdominal obesity in the group of boys and those with peripheral obesity in the group of girls (Tables 4-5). The study also analysed information regarding participation in extracurricular sports activity and the amount of time spent engaging in this activity. The group which performed this activity the most often was boys and girls with normal BMI, and the group who practised them the least often was subjects with abdominal obesity; however, intergroup differences were statistically significant only in girls. The research participants most often spent 1 to 3 hours per week engaging in extracurricular sports activity.

When it comes to time spent in front of the TV screen or computer monitor, no major differences were observed between the groups examined. In each of the groups, the greatest percentage of students used a TV and computer from 1 to 3 hours per day on average, regardless of the time of the year (Tables 4-5).

Univariate logistic regression analysis showed that for boys, the variables which were associated with the incidence of abdominal obesity were health status (OR = 0.52, CI = 0.35-0.77, $p < 0.001$) and time spent on extracurricular sports activity (OR = 0.61, CI = 0.45-0.85, $p < 0.003$). After subjecting these variables to multivariate regression analysis, we found that only the time spent on extracurricular sports activity was an independent and significant predictor of the abdominal obesity in the group of boys (OR = 0.69, CI = 0.49-0.97, $p < 0.033$).

In girls, only differences with respect to participation in extracurricular sports activity between subjects with normal BMI and those with abdominal obesity were statistically significant. The results of univariate (OR = 0.32, CI = 0.16-0.66, $p < 0.002$) and multivariate (OR = 0.39, CI = 0.19-0.81, $p < 0.012$) regression analysis showed that avoiding physical activity in one's leisure time was significantly associated with abdominal obesity.

Discussion

The increased prevalence of overweight and obesity in children and adolescents is mainly related to poor nutrition and low physical activity; all this contributes to a decrease in physical fitness. Many authors have reported lower physical fitness in children with high BMI values compared to peers with normal body weight (Lee, & Arslanian, 2007; Stratton, et al., 2007). Tokmakidis, Kasambalis, & Christodoulos (2006), who examined a group of 8- to 10-year-old Greek children with normal BMI, overweight, and obesity, found that children with normal BMI had the best results in fitness tests assessing explosive strength, trunk strength, agility, and cardiorespiratory endurance. The poorest results were obtained by obese children, and the second-best ones were achieved by overweight children. The differences between Greek children with various amounts of body fat were statistically significant in all tests apart from the one measuring agility, which is in line with the findings of other studies (Klein, et al., 2004; Fogelholm, Stigman, Huisman, & Metsämuuronen, 2008) and of the current study. Deforche et al. (2009) explored the correlations between balance and BMI in boys aged 8-10 years. A significantly lower level of this motor skill was found in overweight children. Deforche et al.'s findings do not, however, correspond with our observations. The obese boys and girls who participated in our study obtained better results in this test than normal-weight subjects. This can be explained by the fact that adequate balance requires appropriate development of the central nervous system, the sensory organs (in particular the organ of balance), as well as the skeletal and muscular systems. In obese children, these and other body systems develop faster, since they enter puberty earlier (Wang, 2002; Dai, et al., 2014).

A high BMI value has a negative influence on the explosive strength of the lower extremities, which has been reported, among others, by Fogelholm et al., (2008); Brunet, Chaput, & Tremblay, (2007), Castro-Piñero et al., (2009) and Halme, Parkkisenniemi, Kujala, & Nupponen, (2009), as well as being found in the current study. Similar relationships have been observed in analyses of functional strength and speed (Brunet, et al., 2007; Hulens, et al., 2001; Ara, et al., 2004).

On the other hand, these associations were reversed for arm strength: it was persons with high body mass indices who had good results in this respect in the current study. Similar relationships were observed in the research by Deforche et al., (2003) and Ervin, Fryar, Wang, Miller, & Ogden, (2014). This can be explained by the fact that higher weight in school-age boys and girls is associated not only with higher fat mass, but also with greater muscle growth and development; thus the biological development of children with high BMI is more advanced. This better development of children with greater fat mass could also explain why obese children achieved higher results in the agility test in our study. Agility involves motor components that require the central nervous system to exercise effective coordination, which is necessary to combine different types of movements into a single complex movement, and to switch quickly from one movement to another.

Many authors also discuss the relationships between physical fitness and abdominal obesity, which is considered to be more dangerous for health than the peripheral type due to a higher risk of metabolic syndrome (Cavalcanti, et al., 2010; Kim, et al., 2016; Kim, & Lee, 2009; Galaviz, et al., 2012). However, we have not found any research conducted in recent years that would examine differences in the physical fitness of persons with peripheral and abdominal obesity, which was the main aim of the current study. This study did not show major or statistically significant differences in physical fitness between subjects with these two types of obesity. Minor differences in the results were only found in balance and sit-ups, and additionally in arm hang in boys. When it comes to a comparison of the results of the two groups with different types of obesity and the group with normal BMI, greater differences, which were more frequently statistically significant, were found for boys and girls with abdominal obesity than those with peripheral obesity.

One of the reasons for the lower physical fitness of the boys and girls with obesity, apart from their somatic features, could have been their low level of physical activity. The results of the current study unequivocally showed that persons with obesity participated less frequently in extracurricular sports activity than their peers with normal body weight, which corresponds with the findings of other authors (Mota, Ribeiro, Carvalho, & Santos, 2010; Butte, Puyau, Adolph, Vohra, & Zakeri, 2007; Dencker, et al., 2006). It is impossible, however, to make direct comparisons between the results of these authors and the findings of the current study due to differences in the methods applied in assessing physical activity. Yu et al. (2002) evaluated energy expenditure associated with physical activity using heart rate monitoring. Analysing the results of obese and non-obese children and youth aged 6-18 years, the authors found that persons with normal weight spent approximately 30% more time engaging in physical activity during the day than obese persons did. The group of obese subjects, on the other hand, spent 51% more time on sedentary activity. Accelerometer research carried out by Hughes, Henderson, Ortiz-Rodriguez, Artinou, & Reilly (2006) also found that obese children had a lower level of physical activity; however, no differences were observed for sedentary activity between the groups analysed. The authors mentioned above noted differences in the time dedicated to physical activity of particular intensities. Obese persons spent somewhat less time engaging in vigorous activity (16 minutes less on average). Similar results, also in an accelerometer study, were obtained by Page et al., (2005) in 10-year-old children. Time spent performing activity of moderate to high intensity was slightly shorter in obese persons (BMI > 99 percentile) compared to non-obese persons. Ekelund et al., (2002), who used the doubly labelled water method as well as an accelerometer, did not find differences in total energy expenditure during physical activity is obese and non-obese persons, even though physical activity was lower in the former.

In the current study, we also noted that time spent watching TV or using a computer by boys and girls with abdominal and peripheral obesity did not differ significantly between the groups analysed and was similar to the group with a normal BMI level, regardless of whether it was summer or winter. Meanwhile, many authors suggest that sedentary activity, including the use of a TV or computer, are some of the most popular forms of leisure activity among obese children (Davison, Marshall, & Birch, 2006; Fulton et al., 2009). Engaging in such sedentary activity instead of active leisure can further increase obesity. According to Dennison, Erb, & Jenkins (2002), in persons aged 12-17 years, each additional hour spent watching television during the day increases the risk of obesity by 2%. For this reason, it is crucially important to encourage obese and overweight children to change their lifestyle by reducing the number of hours they spend in a passive manner in favour of increased physical activity.

Conclusion

The study has not found statistically significant differences in the physical fitness of boys and girls with peripheral and abdominal obesity.

The analysis of the subjects' leisure time activity revealed differences between the groups only with respect to their participation in extracurricular sports activity.

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