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DIFFERENCES IN PHYSICAL FITNESS BETWEEN NORMAL-WEIGHT, OVERWEIGHT AND OBESE CHILDREN AND ADOLESCENTS

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ABSTRACT

The objective of the study was to investigate the relation between obesity and physical (motor) fitness of children and youth. In spring 2005, more than 80% of Slovenian schoolchildren population from 7 to 18 years participate in a national fitness evaluation system (Sport educational chart), similar to *Eurofit*. On the basis of body mass index and according to internationally recognized IOTF norms sample was divided into normal-weight, overweight and obese groups. Those groups were compared with MANOVA on 8 physical fitness items. The highest differences between groups were found in items requiring moving the whole body mass. In items involving only small body parts, differences between groups were small or even non-existent, suggesting motor abilities of obese children are not lower than those of normal population. At the end, suggestions for the physical activity for obese children are presented.

Key words: body mass index, obesity, fitness, children

INTRODUCTION

Overweight and obesity are health-related problems which have taken epidemic proportions in the last decades. WHO (2006) estimated in 2005 approximately 1.6 billion adults (age 15+) being overweight and at least 400 million adults being obese. Over 20 million children under age of 5 are already overweight. Over the last decade, the prevalence of obesity in Western and Westernizing countries has more than doubled (James, 2004). About 70% of obese adolescents grow up to become obese adults (Parsons, Power, Logan, & Summerbell, 1999).

There's a wide variety of definitions of child obesity, and no commonly accepted standard has yet emerged. The body mass index (weight/height^2) is widely used in adult populations, and a cut off point of 25 kg/m^2 and 30 kg/m^2 is recognized internationally as a definition of adult overweight and obesity (Malina & Katzmarzyk, 1999). International Obesity Task Force (IOTF) proposed age and sex specific cut off points from 2-18 years, which are internationally based and should help to provide internationally comparable prevalence rates of overweight and obesity in children (Cole, Bellizzi, Flegal, & Dietz, 2000). BMI was found both reliable and valid index of adiposity in children and adolescents (Pietrobelli et al., 1998; Dietz & Bellizzi, 1999).
Consequences of obesity are numerous. As well as increasing mortality, obesity is a risk factor for a range of chronic diseases, such as Type 2 (adult-onset) diabetes, Coronary heart disease, some types of cancer, osteoarthritis and back pain (Pi-Sunyer, 1993). There are also social and psychological consequences – including stigmatization, discrimination and prejudice (Cash, 2004; Goni & Zulaka, 2000; Lobstein, Baur, & Uauy, 2004). Some of obesity consequences – hyperinsulinaemia, poor glucose tolerance and a raised risk of type 2 diabetes, hypertension, sleep apnoea, social exclusion and depression – onset already in childhood, while other obesity related conditions onset mainly in adulthood (Lobstein, Baur, & Uauy, 2004).

The relations of obesity to physical activity and physical fitness are less known. It seems that physical activity is the common denominator for the treatment of low fitness and excess weight (Blair, 2004; Trost, Kerr, Ward, & Pate, 2001). Most of the studies focus on relation between obesity and cardiovascular fitness, confirming obese children are less fit then their normal weight peers, although most of the difference between them disappear after adjusting for body weight or fat-free mass (Treuth et al., 1998). Deforche et al. (2003) found obese Flemish Youth to had poorer performances on weight-bearing tasks, but did not have lower scores on other fitness components (*Plate tapping* and *Sit and reach* tests), measured by Eurofit physical fitness test battery (Eurofit Handbook, 1988). Inferior performances on tests requiring propulsion or lifting were found in other studies (Pate, Slentz, & Katz, 1989; Malina et al., 1995; Beunen et al., 1983; Minck et al., 2000). Similar results were found in Greek (Biskanaki et al., 2004) and German (Korsten-Reck et al., 2007) children with an exception of throwing of heavy object (medicine ball), were obese children perform better than their normal weight peers, if weight of the object is not adjusted for the body weight.

It is confirmed that obesity occurs when energy intake exceeds energy expenditure, suggesting proper diet and physical activity are the key strategy for controlling the current epidemic of obesity (Dehghan, Akhtar-Danesh, & Merchant, 2005). When controlling for body mass, obese children were found less physically active then their non-obese peers (Huttunen, Knip, & Paavilainen, 1986; Raudsepp & Jurimae, 1998). When physical activity was measured as the total energy expenditure no significant differences were found between obese and normal-weight youth (Bandini, Schoeller, & Dietz, 1990; Grund et al., 2000).

The purpose of the present study was to find the level and nature of differences between obese and normal weight children and adolescents in different aspects of physical fitness. The findings should serve as the basis for action both in tackling the obesity epidemic and constructing special programs which will take into account the level of physical fitness of obese youth.

METHODS

Sample

Crossectional sample (**Error! Reference source not found.**) consists of all pupils of primary and secondary schools in Slovenia, who participated in measurements for fitness evaluation system *Sport educational chart* (Strel et al., 1997) in 2005. 90% of population up to 15 years was included in the measurements, whereas the proportion of older pupils (16 to 18 years) is between 60-80%, depending on the type of high school (Strel, Kovač, & Rogelj, 2006). Measurements were held in April during normal physical education lessons in all Slovenian schools. Only healthy children who were not exempt from physical education for health reasons and whose parents gave their written consent to participate were measured.

Table 1: Size of subsamples in different age and sex groups

	age (years)											
Sex	7	8	9	10	11	12	13	14	15	16	17	18
Male	7668	8159	8235	8419	8375	8916	8557	9080	8392	6902	6735	5858
Female	7201	7617	7767	7828	7985	8181	7808	8170	7477	5865	5777	5414

Variables

Data from the *Sport educational chart* were used in the analysis. Test battery consists of three anthropometrical and eight motor tests (**Error! Reference source not found.**). All the tests have suitable measuring characteristics. The selection of motor tests is based on the model by Kurelić et al. (1975). The model is hierarchic and based on the functional mechanisms responsible for latent motor abilities. There are four dimensions at the lower level: the mechanism for movement structuring, the mechanism for synergy automation and regulation of the tonus, the mechanism for regulation of excitation intensity, and the mechanism for regulation of the duration of excitation. There are two dimensions at the higher level: the mechanism for the central regulation of movement and the mechanism for energy regulation. At the highest level the mechanism for the regulation of movement is called the general factor of motor behavior.

Table 2: Sample of variables

Test	Measured capacity	Measuring unit
Body height	Longitudinal dimension of the body	mm
Body weight	Volume of the body	kg
Upper-arm skin fold	Amount of body fat	mm
Arm plate tapping – 20 seconds	Speed of alternate movement	No. of repetitions
Standing broad jump	Power of legs	cm
Obstacle course backwards	Co-ordination of the whole body movement	Seconds
60-second sit-ups	Muscular endurance of the torso	No. of repetitions
Forward bench fold	Flexibility	cm
Bent arm hang	Muscular endurance of the shoulder girdle and arms	Seconds
60-metre run	Sprint speed	Seconds
600-metre run	General endurance	Seconds

Data analysis

The data were analyzed by the statistical package SPSS 15.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation). Multivariate analysis of variance (MANOVA) was used to test the differences between the weight category (normal, overweight, obese), gender and the age of pupils. The power of concurrent influence of BMI (weight category), sex and age on the dependent variables (fitness tests) was measured by Wilks' lambda; its statistical significance was tested by Bartlett's V transformation (Bray & Scott, 1985). The amount of explained variance for the entire system of dependent variables was estimated with a partial η^2 separately for all main effects (weight category, sex, age) and all their 2- and 3-way interactions. Univariate tests were also carried out for each dependent variable separately: F-tests for the entire model, for all main effects and all their interactions were used. The amount of explained variance was estimated with the adjusted R^2 for the entire system of predictors (all main effects and all interactions) and with a partial η^2 for individual predictors.

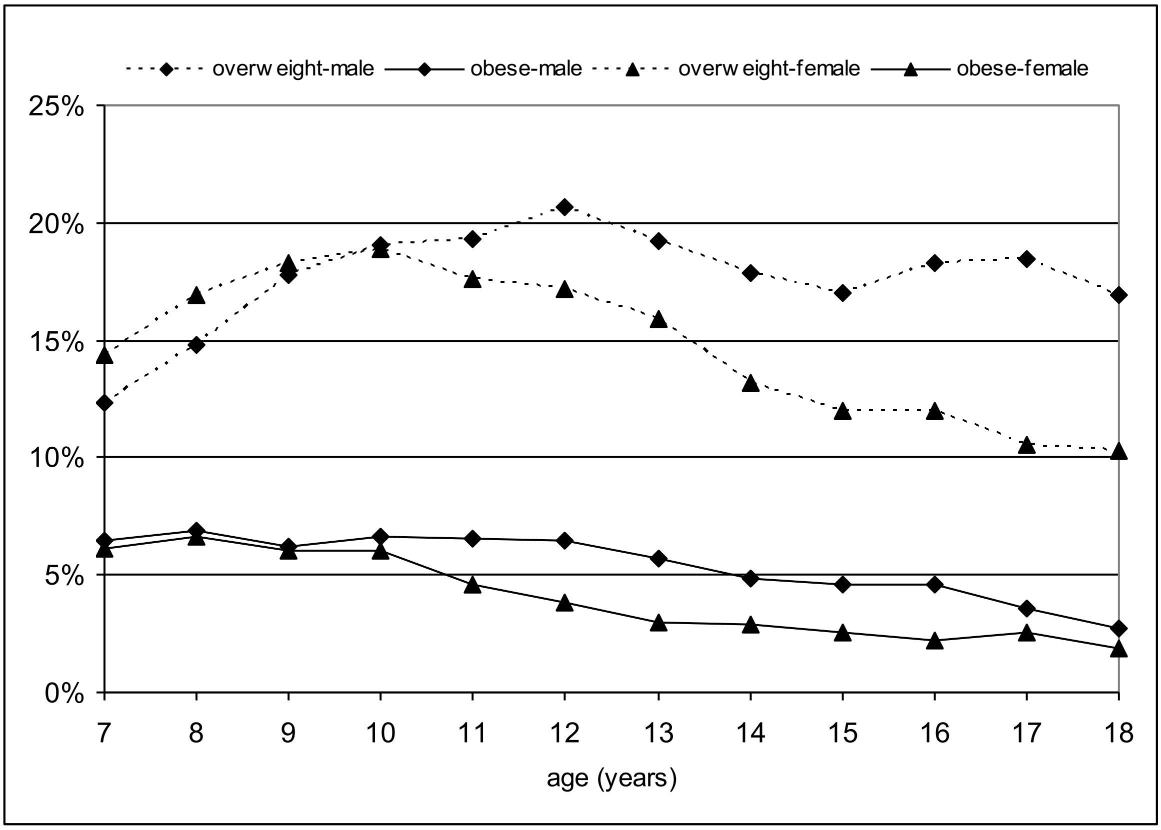
RESULTS

The proportion of overweight (excluding obese) pupils (

Figure 1) is rising till the early puberty, i.e. around 10 years in girls and 12 years in boys. After then proportion of overweight pupils is constantly falling in girls, whereas in boys there's a small raise after the age of 15.

Proportion of obese boys and girls is almost constant at around 6% from 7 to 10 years olds and afterwards gradually fall to the end of the observed period. Both obese and overweight proportion is higher in boys than in girls, although the difference is small at the early ages.

Figure 1: Proportion of overweight and obese pupils by age and sex



Differences between different weight categories in means of physical fitness tests (

Figure ***2***, Figure 3) depend greatly of the test observed, but are similar in boys and girls. Except for *Hand-tapping* and *Bend forward on bench*, were those differences are small, normal weight children achieve substantial better results than overweight children, where results of the later are substantially better than those of the obese children.

Figure 2: Means of physical fitness tests for different weight categories in boys

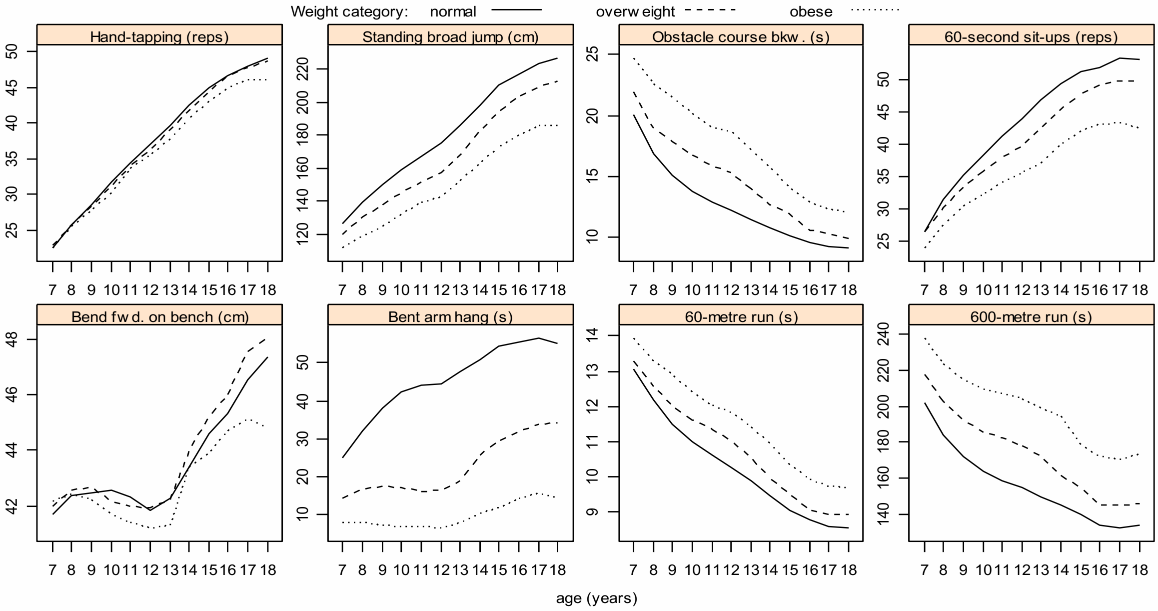
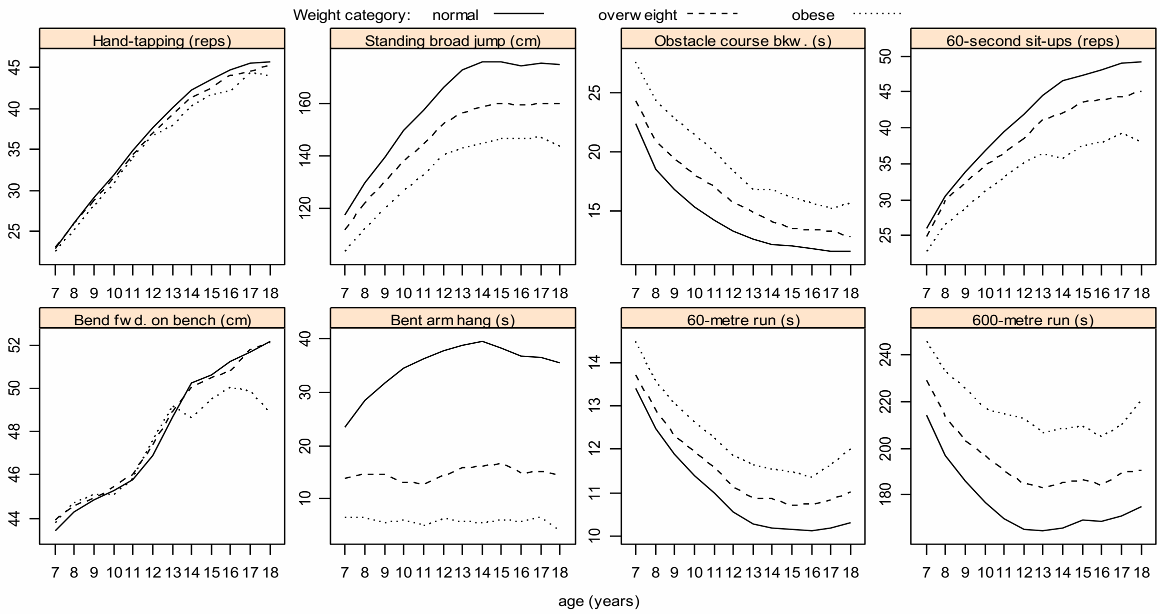


Figure 3: Means of physical fitness tests for different weight categories in girls



Multivariate analysis of variance (

Table ***3***) shows that weight category (BMI) has strong (partial eta squared η^2_{part}=12%) and statistical significant effect on block of fitness test variables. This effect is similar to that of the sex (η^2_{part}=12.2%) and higher then the effect of age (η^2_{part}=8.2%). Interaction effects are much smaller then those of the main factors. Most of the interaction between BMI and age (η^2_{part}=0.34%) is attributable to *Hand-tapping* and *Bent arm hang*. In *Hand tapping*, means of the different weight categories are almost equal, whereas in older age group results of obese pupils of both sexes and overweight girls are substantially worse than that of normal weight group. In *Bent arm hang* results of normal weight group, especially in girls, are raising at much higher rate then those of obese and overweight group.

Table 3: Multivariate test (Wilk's λ) and explained variance for the model effects

	Effect size (partial eta squared)					
Effect	λ	F	df1	df2	p	Partial η^2
BMI	0.77	3115	16	364614	<0.001	12.0%
age	0.51	1490	88	1195476	<0.001	8.2%
sex	0.88	3170	8	182307	<0.001	12.2%
age * BMI	0.97	29	176	1376869	<0.001	0.34%
sex * BMI	1.00	28	16	364614	<0.001	0.12%
age * sex	0.95	108	88	1195476	<0.001	0.65%
age * sex * BMI	1.00	3	176	1376869	<0.001	0.04%

Univariate tests of differences between the groups (Table 4) show that fitness test items should be arranged in 3 groups depending on effect of BMI: a) *Bent arm hang* with the strongest effect of BMI (η^2_{part}=14.6%), b) *Standing broad jump*, *Obstacle course backwards*, *60-metre run* and *600-metre run* with middle size effect of BMI (η^2_{part} from 7.5 to 10.7%) and c) items with small (*60-second sit-ups* with η^2_{part}=3.5%) or neglecting (*Arm plate tapping*, *Forward bench fold*) effect of BMI.

*Table 4: Effect sizes of main and interaction effects. All effects, except those marked with * are significant at 5% level.*

Effect	Effect size (partial eta squared)							
	Arm plate tapping	Standing broad jump	Obstacle course backwards	60-second sit-ups	Forward bench fold	Bent arm hang	60-metre run	600-metre run
BMI	.003	.102	.078	.035	.000	.146	.075	.107
age	.400	.255	.186	.142	.021	.007	.259	.093
sex	.001	.062	.013	.005	.024	.007	.035	.033
age * BMI	.001	.007	.005	.005	.000	.008	.002	.002
sex * BMI	.000	.001	.000*	.000*	.000*	.001	.000	.000
age * sex	.003	.032	.003	.002	.004	.003	.018	.011
age * sex * BMI	.000*	.000	.001	.000	.000	.000	.001	.001

DISCUSSION

About fifth of the population of the schoolchildren in Slovenia is overweight (incl. obese). This proportion is higher in boys than in girls. There is also a tendency of this proportion falling with age of girls, whereas proportion of overweight boys remains high throughout the observed period from 7 to 18 years of age. Overall obesity prevalence and relation of overweight proportion between boys and girls in Slovenia coincides with its geographical position in Europe. A review by Lobstein, Baur, and Uauy (2004) found the prevalence (percentage) of overweight (incl. obese) children aged around 7–11 years using the same IOTF cut-off points as in this study was higher in southern Europe (Italy 36%, Spain 34%, Greece 31%), and smaller in northern Europe (Holland 12%, Denmark 15%, Germany 16%). Among adolescents aged around 14–17 years the prevalence ranged from below 10% (Slovakia, Czech republic, Russia) to above 20% in some southern countries (Cyprus 23%, Greece 22%, Spain 21%).

The performance in almost all fitness tests measured in this study if substantially hindered (or at least is in negative correlation) with obesity – no matter of age or sex of children. The highest influence of obesity was found in tests requiring moving whole body (*Standing broad jump*, *Obstacle course backwards*, *60-* and *600-metre run*) or holding the whole body in a position (*Bent arm hang*). Smaller influence was found in test *60-second sit-ups*, which requires moving only of the upper body. Almost no differences between body weight categories exist in *Hand-tapping* which requires moving of only one (dominant) hand. In a test measuring flexibility, *Forward bench fold*, differences between weight categories are also small except for older boys and girls, where normal and overweight children perform substantially better then their obese peers.

These results is in agreement with other studies (Beunen et al., 1983; Malina et al., 1995; Minck et al., 2000; Deforche et al., 2003), which also found negative relationship between body mass and performance in tests requiring propulsion or lifting of that mass. Poor performance is these test is due to extra load of body fat, which is especially obvious in *Bent arm hang*, but probably also due to smaller amount of physical activity of obese children (Huttunen, Knip, & Paavilainen, 1986), especially in tasks, which may represent overload of joins of obese individuals (Hills, Hennig, Byrne, & Steele, 2002). In test requiring flexibility (*Forward bench fold*) and coordination with small body parts (*Arm plate tapping*) the small influence of obesity is also in agreement with other studies, mentioned above.

Low fitness of obese children in test items that require propulsion of lifting of the whole body on one side and average fitness of these children in items that don't require propulsion and lifting may lead to the conclusion that worse results in some components of physical fitness of obese children is *not* the consequence of their lower physical (motor) abilities, but merely the result of direct influence of excessive body weight and indirect influence of lower physical activity. Therefore it seems vital for obese children to involve them in proper diet and to motivate them to involve in physical (sport) activities. Although some studies have shown physical activity alone may reduce body fat in obese children, some other studies suggest better results should be expected when physical activity is combined with low calorie diet (Goran, Reynolds, & Lindquist, 1999).

Kind of physical activity should be carefully chosen, as to avoid joint overload and provide appropriate levels of energy expenditure. Among the traditional activities hiking, swimming and cycling seem best for this purpose. Other activities suitable for obese children and especially adolescents are fitness activities, which may include exercising on cardio-respiratory machines (stationary cycling, elliptical motion trainers, stair-climbing and rowing machines, treadmills etc.) and also middle intensity exercise on weight/resistance machines. Beside high energy expenditure while exercising these activities may also contribute to growing of the muscle body mass which in turn will raise also basal, sleeping and sedentary metabolic rates.

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