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# The Percentage of Body Fat in Children and the Level of their Motor Skills

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**ABSTRACT**

*The aim of this study was to determine the prevalence of overweight and obesity among primary education pupils and to identify differences in motor skills between normal weight, excessive and obese pupils. Partial aim was to determine differences in motor status of girls and boys and their anthropometric characteristics (Body Mass Index, body fat percentage). The study was conducted in two primary schools in Zagreb, Ivan Goran Kovačić and Davorin Trstenjak. Total of 333 pupils, aged 7–11, were measured (178 boys and 155 girls). Four anthropometric and seven motor variables were used to analyze differences in motor abilities of children. Children were divided into three groups within gender based on their body fat measures. We established a statistically significant difference in motor abilities between groups of subjects in three subsamples ($1^{st}$–$2^{nd}$ class girls and $3^{rd}$–$4^{th}$ boys and girls). Children with normal weight have better results in explosive strength, coordination, static strength of arm and shoulder than children who are overweight and obese. The differences are not observed in motor variables where body weight is not a requisite for efficient execution of movement. Differences in motor skills by gender showed that boys are better in coordination, speed of the simple movements, explosive and repetitive strength, and girls are better in flexibility. The conclusion of this study confirmed the existence of differences in the development of motor skills in children with normal body weight compared to children who are overweight or obese. These facts prove that excessive body weight has negative repercussions on motor performance.*

***Key words:*** *pupils, obesity, percentage body fat, motor skills*

## Introduction

According to World Health Organization[1], in 2012 there were over 40 million overweight or obese children aged up to 5 years. Because of the increasing trend in the number of overweight and obese children, more and more attention was given on monitoring of body composition from an early age[2]. Due to the increase in body fat more children suffer from diseases that once were identified with adults. So kids now have type 2 diabetes, high cholesterol[3], cardiovascular diseases[4], and chronic diseases[5]. Obesity has become enormous health problem and it is crucial to monitor child's body composition in order to prevent future health problems[6].

More than half of the waking hours children spend sitting[7] and less than 20% of them comply with the relevant instructions on spending at least 60 minutes every day in moderate to vigorous activities[8]. Considering that the level of physical activity is declining[9,10], the results also show a decreasing level of motor skills[11]. However, it has been proven that mastering basic motor skills are necessary for the normal functioning[12], but not only that, motor skills are basis for an active lifestyle[13]. Children with better motor skills are also more physical active than children with lower motor skills[14]. Many studies have shown that overweight and obese children have poorer performance of motor skills[15–17].

Spessato at al.[18] proved that children with higher motor competence were more active in physical education class than children with low and moderate motor competence. Martins at al.[19] in their research proved that the gross motor function was negatively associated with BMI changes and Lopes et al.[20] also proved that motor coordination in children have inverse relationship with BMI. D'Hondt at al.[21] in their study found that the differences in the tests for gross motor coordination increase over the years between normal weight and overweight/obese children. Đokić and Međedović[22] in there study showed that overweight and obesity influence on motor skills. Overweigh was negatively correlated with explosive strength and obesity was negatively correlated with strength of the arm and shoulder muscles.

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Due to overcome sedentary lifestyles, the number of overweight children is increasing every day while their level of physical activity and motor skills declines. As has been shown that the percentage of body fat is closely linked to the level of motor skills, the aim of this study was to determine the prevalence of overweight and obesity among primary education pupils and to identify differences in motor ability between normal weight, excessive and obese pupils. Partial aim is to determine differences in motor status of girls and boys and their anthropometric characteristics (body mass index-BMI, body fat percentage-%BF).

## Materials and Methods

The study was conducted in two primary schools in Zagreb, Ivan Goran Kovačić and Davorin Trstenjak. Total of 333 pupils were measured (178 boys and 155 girls). Four subsamples defined by age were formed for the purposes of this research. Subsample of subjects from 1st and 2nd class consisted of 79 boys, mean age 8.25±0.78 years and 78 girls, mean age 8.29±0.70 years. Subsample of subjects from 3rd and 4th class consisted of 99 boys, mean age 10.34±0.69 and 77 girls, mean age 10.14±0.64. The sample of variables consists of motor skill tests: polygon backward – coordination, forward bend on a bench – flexibility, hand tapping 15" – speed of simple movement, standing long jump – explosive leg strength, bent arm hang – static strength, sit ups – repetitive strength and high jump – explosive leg strength. The measurement was conducted in the second month of the school year 2013/2014 in the morning. All anthropometric measurements were performed according to the instructions of International Biological Program-IBP[23]. Signatures of parents who approved the participation of their child in this study were collected, and the study was conducted in accordance with the Code of Ethics for Research with Children[24]. We estimated body fat percentage from the sum of sub-scapular (subsc) and triceps (tric) skinfold (mm) according to the Slaughter equations[25]. The amounts of body fatness and of fat-free mass were also calculated (in kg). Body mass index was obtained by the BMI formula:

$$\frac{\text{kg}}{\text{m}^2} = \frac{\text{weight}(\text{kg})}{\text{height}(\text{m})^2}$$

The classification of subjects according to the percentage of body fat was made by McCarthy and associates[26] with defined percentile curves specific to children's age and gender (normal weight 2–85 percentiles, overweight 85–95 percentiles and obese over 95 percentiles).

## Statistics

Data analysis was performed with the program STATISTICA (data analysis software system), version 7.1. Basic descriptive parameters were calculated for all variables: the arithmetic mean (AM) and standard deviation (SD). The significance of differences between the descriptive parameters of the subsamples defined by gender was calculated by t-test. Likewise, differences of anthropometric measures between formed subsamples according to the nutritional status were determined by t-test. Canonical discriminant analysis was used to determine differences of motor variables between the three groups of subjects. Statistical significance of differences was tested at a significance level of $p<0.05$.

## Results

Descriptive parameters of anthropometric measures, motor abilities and their differences by gender and age are initially shown in the results. At the end are the results of the difference between pupils according to the established percentage of fat.

Table 1 shows the descriptive parameters for boys and girls divided into two subsamples according to age, and the total sample of pupils who participated in the study. Results of anthropometric measures for the total sample obtained by t-test show significant differences in body weight in favor of boys who are almost 2 kg heavier than girls. In the area of motor skills, boys had a significantly ($p<0.05$) better results in variables polygon backwards, hand tapping 15", standing long jump and sit ups while girls had significantly better results in variable forward band on a bench. Boys of 1st and 2nd grade had better results in polygon backwards, standing long jump and high long jump than girls. Other results also show higher scores for boys except variable forward bend on the bench. There is no statistically significant difference between boys and girls in anthropometric measures. Results in subsamples of the 3rd and 4th grades show a statistically significant difference ($p<0.05$) in BMI and body weight, where boys have more than 3 kg compared to girls. In the case of motor skills, significant differences appear only in the variable forward band on a bench where the girls had significantly higher scores than boys. Unusual result appeared in variable bent arm hang, where the girls had a score 16.14±13.78 seconds as compared to boys 15.52±13.48.

Looking at the descriptive parameters in Table 2 for the boys who were divided into two subsamples by age and by level of nutrition, it is evident that there are numerical differences between the results of their anthropometric characteristics and motor skills. Results of anthropometric measures obtained by t-test in a sample of first and second grade boys show significant differences in body weight in favor of boys with normal level of nutrition. The boys who were classified in the group of overweight have nearly 4 kg more, and boys who were classified in the obese group have 7 kg more than boys with normal weight. Identical results appear in the variables % BF and BMI. Body height in all three groups is at the same level. In the group of older boys (3rd and 4th grade) body height showed significant differences in favor of boys who are overweight or obese. The results show a difference in body weight where overweight boys weigh almost 7 kg more than boys with normal weight, while the differences between obese boys and normal weight is up to 17 kg. Also, the results of % BF showed a rapid increase between groups in nearly 10% of

**TABLE 1**
DESCRIPTIVE STATISTICAL PARAMETERS OF THE ANTHROPOLOGICAL CHARACTERISTICS OF THE PUPILS FROM 1ST TO 4TH GRADE

| | Total (N=333) | | 1st–2nd Grade (N=157) | | 3rd–4th Grade (N=157) | |
|---|---|---|---|---|---|---|
| | Boys N=178 | Girls N=155 | Boys N=79 | Girls N=78 | Boys N=99 | Girls N=77 |
| | $\overline{X}$±SD | | $\overline{X}$±SD | | $\overline{X}$±SD | |
| Height-cm | 137.59±9.28 | 135.81±9.17 | 130.57±6.55 | 129.93±6.73 | 143.12±7.14 | 141.77±7.29 |
| Weight-kg | 34.90±9.21* | 32.99±7.45 | 29.31±5.13 | 29.84±6.20 | 39.41±9.32* | 36.18±7.27 |
| Body fat (%) | 21.61±8.55 | 21.26±6.70 | 18.81±7.02 | 20.90±7.11 | 23.79±9.02 | 21.62±6.27 |
| BMI | 18.20±2.92 | 17.69±2.50 | 17.12±1.93 | 17.52±2.49 | 19.05±3.28* | 17.87±2.51 |
| Polygon backward | 20.72±6.59* | 24.66±8.16 | 22.96±6.61* | 28.40±7.31 | 18.95±6.04 | 20.92±7.24 |
| Forward bend on a bench | 19.93±7.55 | 22.13±7.10* | 21.37±7.18 | 22.05±6.89 | 18.79±7.68 | 22.21±7.35* |
| Hand tapping 15" | 23.04±4.18* | 21.99±4.25 | 20.18±2.89 | 19.64±3.39 | 25.32±3.62 | 24.38±3.68 |
| Standing long jump | 132.14±21.03* | 121.88±21.18 | 124.38±17.03* | 111.42±16.61 | 138.33±21.93 | 132.34±20.13 |
| Bent arm hang | 13.00±11.99 | 12.06±12.29 | 9.84±8.92 | 7.98±8.97 | 15.52±13.48 | 16.14±13.78 |
| Sit ups | 30.16±9.43* | 27.67±9.36 | 25.23±8.19 | 22.82±8.61 | 34.04±8.50 | 32.47±7.43 |
| High jump | 22.23±5.07 | 21.20±4.98 | 21.72±5.32* | 19.59±4.72 | 22.64±4.84 | 22.82±4.72 |

*Statistically significant at p<0.05

**TABLE 2**
DESCRIPTIVE STATISTICAL PARAMETERS FOR 1ST – 2ND AND 3RD – 4TH GRADE BOYS

| | Normal weight | | Overweight | | Obese | |
|---|---|---|---|---|---|---|
| | Boys N=52 | Boys N=49 | Boys N=11 | Boys N=27 | Boys N=14 | Boys N=23 |
| | 66% | 50% | 14% | 27% | 17% | 23% |
| | 1st – 2nd | 3rd – 4th | 1st – 2nd | 3rd – 4th | 1st – 2nd | 3rd – 4th |
| | $\overline{X}$±SD | | $\overline{X}$±SD | | $\overline{X}$±SD | |
| Height-cm | 129.40±5.79 | 140.98±6.61 | 132.44±7.69 | 144.54±6.07*e | 131.48±8.61 | 146.00±8.17*f |
| Weight-kg | 27.41±3.43 | 33.64±4.97 | 31.36±4.19*a | 40.42±5.51*e | 34.46±7.08*b | 51.02±9.33*f/g |
| Body fat (%) | 14.89±3.32 | 16.43±3.29 | 22.57±2.38*a | 26.13±2.60*e | 30.41±4.72*b/c | 36.74±5.29*f/g |
| BMI | 16.71±1.29 | 16.84±1.34 | 17.83±1.18*a | 19.30±1.83*e | 19.71±1.79*b/c | 23.68±2.75*f/g |
| Polygon backward | 22.80±6.48 | 16.64±3.85 | 21.82±2.91 | 18.55±5.68 | 23.69±8.80 | 24.34±7.06 |
| Forward bend on a bench | 21.19±7.67 | 19.65±7.79 | 20.97±6.75 | 19.69±7.69 | 22.36±6.49 | 15.90±6.99 |
| Hand tapping 15" | 20.04±3.03 | 25.78±3.72 | 19.82±1.54 | 25.85±3.54 | 20.93±3.34 | 23.74±3.15 |
| Standing long jump | 126.91±16.27 | 143.74±210.95 | 126.97±14.89 | 139.44±22.53 | 116.45±18.46 | 125.51±15.88 |
| Bent arm hang | 11.64±9.84 | 21.17±14.84 | 7.99±5.16 | 14.09±9.93 | 5.04±5.52 | 5.17±5.16 |
| Sit ups | 26.38±7.98 | 35.53±7.41 | 26.82±8.21 | 36.70±7.45 | 20.36±7.49 | 27.74±9.04 |
| High jump | 22.39±5.33 | 24.07±4.44 | 21.59±4.17 | 22.52±4.67 | 20.68±5.15 | 19.74±4.71 |

*=statistically significant at p<0.05, a=normal-overweight; b=normal-obese; c=overweight-obese 1th–2th class; e=normal-overweight; f=normal-obese; g=overweight-obese 3th–4th class

the value. Statistically significant differences also occur in the variable BMI. In the area of motor variables, descriptive parameters showed no nominally significant results in boys of first and second grade. In boys of third and fourth grade, differences are more pronounced. Numerical differences appear in variables backward polygon, standing long jump and bent arm hang, while the differences are less visible in variables forward bend on a bench and hand tapping 15".

Results in Table 3 indicate that girls, who were divided into two subsamples by age and by level of nutrition, have numerical differences between the results of their anthropometric characteristics and motor skills. Anthropometric measures obtained by t-test in the first and second grade on a sample of girls show significant differences in body height in favor of girls who fall into the obese group. Girls who are classified among overweight group have nearly 6 kg more, and obese girls group have 18 kg more than girls

**TABLE 3**
DESCRIPTIVE STATISTICAL PARAMETERS FOR 1ST – 2ND AND 3RD – 4TH GRADE GIRLS

| | Normal weight | | Overweight | | Obese | |
|---|---|---|---|---|---|---|
| | Girls N=49 | Girls N=55 | Girls N=19 | Girls N=15 | Girls N=10 | Girls N=7 |
| | 63% | 71% | 24% | 20% | 13% | 9% |
| | 1st – 2nd | 3rd – 4th | 1st – 2nd | 3rd – 4th | 1st – 2nd | 3rd – 4th |
| | $\overline{X}$±SD | | $\overline{X}$±SD | | $\overline{X}$±SD | |
| Height-cm | 128.46±6.79 | 140.85±7.26 | 131.48±6.81 | 144.08±6.83 | 134.19±3.52*b | 146.06±7.98*f |
| Weight-kg | 26.87±4.27 | 33.20±5.51 | 32.48±5.40*a | 42.27±5.72*e | 39.38±3.05*b/c | 46.57±4.55*f |
| Body fat (%) | 16.69±3.24 | 18.59±3.35 | 24.36±1.56*a | 26.26±1.99*e | 34.94±5.57*b/c | 35.52±5.01*f/g |
| BMI | 16.18±1.43 | 16.62±1.38 | 18.68±1.85*a | 20.31±1.83*e | 21.87±1.32*b/c | 22.44±1.30*f/g |
| Polygon backward | 26.93±6.55 | 19.92±6.35 | 29.72±7.38 | 24.80±10.04 | 32.94±8.94 | 20.52±4.32 |
| Forward bend on a bench | 21.88±7.20 | 22.72±7.29 | 22.61±4.89 | 22.44±6.21 | 21.80±8.97 | 17.71±9.51 |
| Hand tapping 15" | 19.57±3.26 | 24.35±3.87 | 19.74±3.25 | 24.53±2.90 | 19.80±4.52 | 24.29±4.11 |
| Standing long jump | 115.34±17.01 | 136.52±20.12 | 107.42±14.48 | 125.00±18.13 | 110.17±12.01 | 115.24±9.50 |
| Bent arm hang | 10.39±10.23 | 19.62±14.22 | 4.32±4.26 | 9.65±7.72 | 3.36±3.60 | 2.24±1.29 |
| Sit ups | 22.73±8.86 | 32.62±7.74 | 22.67±6.84 | 32.33±6.38 | 23.50±10.87 | 31.57±8.04 |
| High jump | 20.54±4.96 | 23.66±4.76 | 18.21±4.29 | 21.23±4.72 | 17.65±3.11 | 19.79±1.80 |

*Statistically significant at $p<0.05$; a=normal-overweight; b=normal-obese; c=overweight-obese 1th–2th class; e=normal-overweight; f=normal-obese; g=overweight-obese 3th–4th class

of normal weight. Also, the results of % BF show significant differences where obese girls have 18% more body fat that the girls with normal body weight. BMI results show significant differences between this three analyzed groups.

In the group of older girls (3rd and 4th grade) body height showed significant difference in favor of girls who belong to the obese group. Results of body weight showed a significant difference where overweight girls have nearly 9 kg more than normal weight girls. The differences between obese and normal weight girls are approximately 13 kg. The results of % BF also show differences between groups. Girls in overweight and obese group have 8% and 17% higher values. Statistically significant differences also occur in the variable BMI.

In the area of motor variables among girls from the 1st and 2nd grade, descriptive parameters indicate that the largest differences in results occur with variables bent arm hang and high jump. Results in variables forward bend on a bench and hand tapping 15" have very similar values. Differences in girls of 3rd and 4th grade are somewhat more pronounced. Numerical differences appear in variables backward polygon, standing long jump and bent arm hang, while the differences are less visible in variables forward bend on a bench and hand tapping 15".

**TABLE 4**
DISCRIMINANT ANALYSIS FOR SAMPLES OF 1ST – 2ND GRADE BOYS IN THE SPACE OF MOTOR ABILITIES ACCORDING %BF

| | Eigenvalue | Canonical R | Wilks' Lambda | $\chi^2$ | df | p-level |
|---|---|---|---|---|---|---|
| 0 | 0.26 | 0.45 | 0.76 | 19.12 | 14 | 0.1603 |
| 1 | 0.04 | 0.19 | 0.96 | 2.68 | 6 | 0.8481 |

Results of canonical discriminant analysis (Table 4) showed no statistically significant discriminant functions in system of motor variables. The lack of significant differences in levels of motor skills between boys of 1st and 2nd grade according to their degree of nutritional status was determined at a significance level of $p<0.05$.

Canonical discriminant analysis of the system of motor variables (polygon backward, forward bend on the bench, hand tapping 15", standing long jump, bent arm hang, sit ups and high jump) in 1st and 2nd grade girls (Table 5) isolated two canon ical functions of which one is statistically significant with $p=0.0027$. Factor structure of that function shows the dominance of variables bent arm hang (–0.55) and standing long jump (–0.51), while the direction of the variables correlation and projection of canonical discrimination function centroid indicates the dominance of these variables in girls with normal body weight. With the rise of obesity results values of this instrument are declining. A similar less prominent situation is with the variable backward polygon (0.48) where girls with an increased percentage of body fat had significantly worse results. The differences don't appear in the variables forward bend on a bench and hand tapping 15". The positive sign at the variable polygon backward is the result of a negative value i.e. lower score is better.

Canonical discriminant analysis of the system of motor variables (polygon backward, forward bend on the bench,

**TABLE 5**
DISCRIMINANT ANALYSIS IN THE SPACE OF MOTOR ABILITIES THE STRUCTURE OF THE DISCRIMINANT FUNCTION AND CENTROIDS OF GROUPS FOR SAMPLE OF 1ST – 2ND GRADE GIRLS

| | Eigenvalue | Canonical R | Wilks' Lambda | $\chi^2$ | df | p-level |
|---|---|---|---|---|---|---|
| 0 | 0.48 | 0.57 | 0.66 | 29.03 | 14 | 0.0104 |
| 1 | 0.03 | 0.17 | 0.97 | 1.91 | 6 | 0.9278 |

| Variable | Discriminant function structure | |
|---|---|---|
| | 0 | 1 |
| Polygon backward | 0.43 | 0.36 |
| Forward bend on a bench | –0.02 | –0.05 |
| Hand tapping 15" | 0.01 | 0.15 |
| Standing long jump | –0.51 | –0.11 |
| Bent arm hang | –0.55 | 0.65 |
| Sit ups | 0.03 | 0.14 |
| High jump | –0.38 | |
| Centroids | | |
| G_1:1 | –0.49 | 0.05 |
| G_2:2 | 0.53 | –0.26 |
| G_3:3 | 1.35 | 0.26 |

hand tapping 15", standing long jump, bent arm hang, sit ups and high jump) in the older boys (3rd and 4nd grade) (Table 6) also isolated two canonical functions of which one is statistically significant with p=0.0000. Factor structure of that function shows the dominance of variables polygon backward (0.80) and bent arm hang (–0.73). Direction of variable correlation and centroid canonical discrimination function projection indicates the dominance of these variables in normal weight boys. With the rise of obesity, result value of this instrument is declining. Also, the similar situation but with a slightly less pronounced results is in variables sit ups (–0.54) and high jump (–0.52). The positive sign at the variable polygon backward is the result of a negative value i.e. lower score is better.

Looking at the results in Table 7 it is evident that canonical discriminant analysis of the motor variables system, at girls in older age groups (3rd and 4th grade), isolate two canonical function of which one is statistically significant with p=0.0000. Factor structure of that function shows the dominance of variable bent arm hang (–0.73). Also, the variable standing long jump (–0.57) shows that girls with normal body weight have a significantly better result. Direction of the variables correlation and centroid canonical discrimination function projection indicates the dominance of this variable in children with normal body weight. With the rise of obesity result value of this instrument is declining.

**TABLE 6**
DISCRIMINANT ANALYSIS IN THE SPACE OF MOTOR ABILITIES THE STRUCTURE OF THE DISCRIMINANT FUNCTION AND CENTROIDS OF GROUPS FOR SAMPLE OF 3RD – 4TH GRADE BOYS

| | Eigenvalue | Canonical R | Wilks' Lambda | $\chi^2$ | df | p-level |
|---|---|---|---|---|---|---|
| 0 | 0.55 | 0.59 | 0.60 | 47.69 | 14 | 0.0000 |
| 1 | 0.08 | 0.27 | 0.93 | 7.21 | 6 | 0.3016 |

| Variable | Discriminant function structure | |
|---|---|---|
| | 0 | 1 |
| Polygon backward | 0.80 | –0.21 |
| Forward bend on a bench | –0.27 | 0.27 |
| Hand tapping 15" | –0.31 | 0.34 |
| Standing long jump | –0.48 | 0.14 |
| Bent arm hang | –0.73 | –0.22 |
| Sit ups | 0.80 | –0.21 |
| High jump | –0.27 | 0.27 |
| Centroids | | |
| G_1:1 | –0.59 | –0.17 |
| G_2:2 | 0.02 | 0.46 |
| G_3:3 | 1.24 | –0.18 |

**TABLE 7**
DISCRIMINANT ANALYSIS IN THE SPACE OF MOTOR ABILITIES THE STRUCTURE OF THE DISCRIMINANT FUNCTION AND CENTROIDS OF GROUPS FOR SAMPLE OF 3RD – 4TH GRADE GIRLS

| | Eigenvalue | Canonical R | Wilks' Lambda | $\chi^2$ | df | p-level |
|---|---|---|---|---|---|---|
| 0 | 0.42 | 0.54 | 0.63 | 32.60 | 14 | 0.0033 |
| 1 | 0.12 | 0.33 | 0.89 | 8.02 | 6 | 0.2366 |

| Variable | Discriminant function structure | |
|---|---|---|
| | 0 | 1 |
| Polygon backward | 0.31 | –0.55 |
| Forward bend on a bench | –0.22 | –0.41 |
| Hand tapping 15" | 0.01 | –0.05 |
| Standing long jump | –0.57 | –0.19 |
| Bent arm hang | –0.73 | –0.19 |
| Sit ups | –0.06 | –0.05 |
| High jump | –0.46 | –0.08 |
| Centroids | | |
| G_1:1 | –0.40 | 0.04 |
| G_2:2 | 0.84 | –0.52 |
| G_3:3 | 1.29 | 0.82 |

## Discussion

Aim of this study was to determine the differences in motor skills between pupils with normal body weight compared to pupils who are overweight or obese. The level of body weight in subjects was determined by the percentage of body fat. Slaughter equation based on skinfold on the shoulder and upper arm was used to determine the percentage of body fat. Values have shown that between 9% and 13% of girls are considered obese, which is less than obese boys where the data range from 17% for pupils aged 7–9 years and 23% for pupils 10–11 years old. The results are different than most studies where is proven that girls are more prone to higher BMI and percentage of body fat[27–30]. The results showed that there was no statistically significant difference in motor skills in boys aged 7–9 years who are classified according to body weight. The reason for this lies in the fact that motor skills are still not sufficiently developed at younger pupils and mechanical factor has an impact on test performance. At the results for the girls of the same age, it is evident that those who have a normal body weight had significantly better results in variables bent arm hang (–0.55) for the assessment of static strength and standing long jump (–0.51) for the evaluation of explosive power. For the standing long jump test, the differences are expected because the muscles of the lower extremities are vital in supporting and initiating additional adipose tissue[31]. Results of discriminant analysis in boys aged between 10 and 11 years old showed statistically significant differences in favor of boys with normal body weight. Boys who have a normal body weight showed significantly better results in the area of coordination, static strength and explosive and repetitive strength. Similar results in tests that require moves opposite of gravity have been obtained in other studies[32–36]. Pupils who are obese have significantly poorer results, as evidence that among boys aged 10 to 11 years differences in the level of motor skills are closely associated with an increased percentage of body fat. Pupils who have more fat tissue showed significantly lower results in the performance of motor tests in which limiting factor in the performance of motion is increased body weight[20, 21, 37, 38]. Among girls between 10–11 years old, statistically significant differences were also confirmed in favor of girls with normal body weight. The girls with a normal body weight have significantly better results in the area of static strength, explosive power and coordination than overweight and obese girls. Such results also support other studies[20,36,39].

From the results it is evident that level of motor skills in obese pupils is declining and they achieved significantly lower scores than their peers with normal body weight. This claim has been confirmed by many other studies[32,37,40–42]. The differences are not observed in the area of motor variables where body weight is not a prerequisite for efficient execution of movement (hand plate tapping – the speed of simple movements and forward bend on a bench – flexibility). Overweight pupils achieved almost the same or better results in a test that measure the ability of this motor skill, and the reason probably lies in the fact that in this test, there is no movement of the lower extremities and trunk, so it is not necessary to move their mass of bodies in space, but the task performed only with upper extremities. Similar results were obtained in other studies[16,43–45]. Also in girls is noticeable that there is no difference in the repetitive strength i.e. when performing the sit ups test.

Results of anthropometric characteristics show that boys who belong to the overweight or obese group have a significantly increased percentage of body fat (%BF), higher BMI and significantly bigger weight. More differences in this area are visible in older pupils. Differences were observed between the groups of overweight and obese, where obese pupils have significantly higher values of anthropometric characteristics. Results in girls show similar values. Those girls who have increased body weight or are obese, have a significantly higher results in body weight, BMI and % BF. Comparing the results between the subsamples defined by gender, the differences in space of anthropometric characteristics and motor skills were determined. In the total sample, it is evident that boys compared to girls have a significantly higher body weight, and had a significantly better coordination, speed of simple movements, and explosive and repetitive strength. Gallota et al.[46] also found that boys in prepuberty have better results in explosive strength than girls. Girls have significantly better results in flexibility[47]. Observing the results of the subsamples by age and gender, it is evident that between 7–9 years, boys have better results in the coordination and explosive strength. Similar results in their study were obtained by Spessato at al.[48] and Wrotniak at al.[49] while Prskalo et al.[50] found no differences between girls and boys in the area of motor skills. Results in subjects aged 10–11 years showed differences in favor of girls in flexibility[51,52]. Also, the boys of this age have significantly higher levels of body weight and BMI. Research of Prskalo et al.[53] showed a statistically significant gender dimorphism in % BF in favor of girls, while this study found no differences in % BF between girls and boys between the ages of 7 and 11. Relatively unusual results for examined age appeared in static strength where the girls had numerically higher scores (16.14 seconds) in test bent arm hang than boys (15.52 seconds). These results are explained by the fact that the sample was focused only on two primary schools in Zagreb.

The results of many studies showed a clear improvement in motor skills after school interventions for physical activity increase, which confirms that regular participation in physical activities is associated with health benefits, and motor development of overweight children[16, 21, 39, 46]. Daily physical exercise has a high impact on the development of motor skills that have major implications for human health. Only sufficiently developed motor skills can largely be one of the prerequisites of good health[54]. Creating a habit of daily physical exercise is very important in maintaining the human health and these habits can and must be created in children's childhood[45]. Children who have developed a higher level of motor skills in childhood have a large prediction to be physically active in adolescent years[49,55,56].

Limitations of this study primarily relate to the sample of subjects which is limited only on two primary schools in Zagreb. Also, the number of subjects is relatively limited in case of forming subsamples defined by age, so the probability of results error is more likely. The number of investigated motor variables proved to be very limited because one variable for each motor skill was used. In some future researches a larger sample of subjects and tests are necessary to verify the motor skills.

The strength of this study lies in the fact that the anthropometric characteristics were objectively measured, and the subjects were classified according to the recommended percentile values in three levels of nutrition according to the %BF. The results are a good foundation for the expansion of research projects which will aim to stop the obesity epidemic that has engulfed the population of children.

## Conclusion

Conducted research shows that there is a link between body composition and amount of body fat and the level of motor skills. Based on the current assumptions, the results of this study confirmed the existence of differences in the development of motor skills in children with normal body weight compared to children who are overweight or obese. These facts prove that excessive body weight has negative repercussions on motor performance. Continuous and daily physical exercise stimulates the development of motor skills and a period at young age is a starting point for quality development of motor skills. Creating a habit of daily physical exercise at a young age typically continues into adulthood as a regular activity.

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## POSTOTAK MASNOG TKIVA I RAZINA MOTORIČKIH SPOSOBNOSTI UČENIKA

## S A Ž E T A K

Cilj istraživanja bio je utvrditi prevalenciju prekomjerno teških i pretilih učenika primarne edukacije te utvrditi razlike u motoričkim sposobnostima između normalno teških, prekomjerno teških i pretilih učenika. Parcijalni cilj bio je utvrditi razlike u motoričkom status i antropometrijskim karakteristikama (indeks tjelesne mase, postotak masnog tkiva) po spolu. Istraživanje je provedeno u dvije škole primarne edukacije u Zagrebu, Ivan Goran Kovačić i Davorin Trstenjak. Ukupno je izmjereno 333 učenika (178 dječaka i 155 djevojčica) u dobi od 7 do 11 godina. Za utvrđivanje razlika u motoričkim sposobnostima korištene su 4 varijable antropometrije i 7 varijabli motorike. Djeca su podijeljena u tri grupe unutar spola na temelju mjera masnog tkiva. Utvrđena je statistički značajna razlika u području motoričkih sposobnosti između grupa ispitanika u tri subuzorka (djevojčice 1–2 razred i dječaci i djevojčice 3–4 razred). Djeca normalne tjelesne težine imala su bolje rezultate u eksplozivnoj snazi, koordinaciji, statičkoj snazi ruku i ramena nego prekomjerno teška i pretila djeca. Razlike nisu uočene u varijablama u kojima tjelesna masa nije preduvjet za uspješno izvršenje pokreta. U području motoričkih sposobnosti dječaci su bolji od djevojčica u koordinaciji, brzini jednostavnih pokreta, eksplozivnoj i repetitivnoj snazi, dok su djevojčice bolje u fleksibilnosti. Može se zaključiti da je ovim istraživanjem potvrđena razlika u razvoju motoričkih sposobnosti kod djece s normalnom tjelesnom masom u usporedni s prekomjerno teškom i pretilom djecom. Navedene činjenice dokazuju da prekomjerna tjelesna težina ima negativne reperkusije na motoričke sposobnosti.