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# Differences in Motor and Cognitive Abilities of Children Depending on Their Body Mass Index and Subcutaneous Adipose Tissue

**Patrik Drid, Sandra Vujkov, Damjan Jakšić, Tatjana Trivić, Dragan Marinković and Gustav Bala**

University of Novi Sad, Faculty of Sport and Physical Education, Novi Sad, Serbia

**A B S T R A C T**

*The aim of the present study was to analyze differences in motor and cognitive abilities of children depending on their value in quantitative indicators of Body Mass Index (BMI) and subcutaneous fatty tissue. The study sample consisted of overall 910 boys and girls, aged 11 to 14, all from elementary schools in Vojvodina (Serbia). Six anthropometric, eight motor and one cognitive variable were analyzed to identify quantitative and qualitative differences in motor and cognitive functioning of children. Children were divided into three groups within gender based on their body mass index calculated and subcutaneous fatty tissue measured. The results obtained from the study indicate the existence of differences in motor and only partly in intellectual abilities between groups of subjects. The greatest differences between the clusters were found in the level of coordination of the entire body, and the static strength of arms and shoulders.*

***Key words:*** *obesity, Raven's Progressive Matrices, motor functioning*

## Introduction

Overweight and obesity represents a modern disease that had spread world-wide in the past few decades as a product of a modern lifestyle with an increased lack of physical activity. To date, there are many ways to define obesity, one of which says that obesity represents an increasing proportion of body fat to total body weight by over 30% in women and 25% in men[1]. This abnormal accumulation of fat is a result of increased energy intake and/or reduced energy consumption. This may cause many health-related problems and diseases, and is present in childhood as well as in adults. Obesity, as a medical and social problem of the humankind, is widely researched. The statistics of a current state regarding this problem are concerning, especially with increasing number of children that are considered to be overweighed or obese in developed countries[2]. In the United States obesity occurs in 18.8% of children with an average age of 12, while in Switzerland this percentage is much lower – 6.5[3]. In the EU countries, 38.2% of school age children are overweight and of these, 10% are obese[4]. In Serbia, 7.3% of children and adolescents aged 6–14 years are reported as obese[5].

To date, there are very convincing evidence that the prevalence of childhood overweight and obesity has stabilised in the last decade[6–9]. Research of Péneau et al.[6] shows that the overall trend in prevalence of overweight children between 1996 and 2006 was stable for population aged from 6 to 15. However, health experts and researchers talk about a pediatric 'obesity epidemic' with exponentially increasing rates of obesity and overweight. Although levels of Australian pediatric overweight remain high, the prevalence of overweight and obesity seems to have flattened and have not followed the anticipated exponential trajectory[8]. In addition, the prevalence of overweight among adolescents and US children increased between 1980 and 2004[9]. Therefore, it can be noticed that obesity and excessive weight are more pronounced in economically developed areas as well as in urban populations[4].

Factors that cause overweight and obesity are not merely simple events; they are mainly a large number of mutually intertwined different factors (*i.e.* genetic, physiological, endocrine, psychological, sociological and others). They can be distinguished by a sedentary lifestyle,

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which is observed more at children, and represents one of the key factors of obesity. Excess weight is related to many medical problems such as cardiovascular problems, high cholesterol, diabetes (type II), hypertension, orthopedic abnormalities, gastrointestinal problems and even cancer[10–12]. Furthermore, an elevated body mass index (BMI) can be a serious risk factor for stroke and dementia in adults[13–15]. Moreover, depression and its symptoms have been indicated as a future leader of affective disorder in young people, and Erickson et al.[16] has shown that it might be a consequence of obesity, primarily in women. In addition, authors suggests that overweight girls, in relation to overweight boys, manifest more depressive symptoms than their normal-weight peers do.

Body mass index (BMI), is one of the most common and widely used Somatic Index in evaluating overweight and obesity. It is commonly used in adults, whereas its adequacy in use for children and youth is still being explored[17]. The concept of BMI is based on the assumption of proportionality between body mass and squared body height, which mainly depends on body proportions, and is not the same for adults and with children (with regards to growth and development). Although the correlation of BMI with body fat was found significant, one should be careful in coming to conclusions regarding BMI as a predictor of body fat content[17]. It has been proved that the emergence of obesity and excessive amounts of adipose tissue has a negative impact on cognitive, motor, emotional, and social development of children. Cognitive and intellectual abilities of children in particular and later as adolescents and elderly, during the acquisition and development are adversely affected by obesity[10]. Some recent studies suggest a negative relations between obesity and cognitive abilities, in particular, two studies indicating cognitive deficits in young adults with elevated BMI[18,19].

Obesity is a chronic disorder that has multiple causes[2]. Overweight and obesity in childhood has proven to have significant impact on both physical and psychological health. In addition, psychological disorders such as depression occur with increased frequency in obese children. Unlike other studies, in aspect of gaining new information, authors tried to apply different methodology that involves not only calculated BMI for defining overweight and obese children, but skinfolds as well. Therefore, the aim of this study was to analyse differences in motor and cognitive abilities of children depending on their value in quantitative indicators of BMI and subcutaneous adipose tissue.

## Materials and Methods

### *The sample of subjects*

The sample of subjects was drawn randomly from a number of elementary schools in Vojvodina (Serbia), a total of 910 children aged 11–14 (413 boys and 497 girls). All subjects and their parents were fully informed about the nature and demands of the study and all parents voluntarily gave their informed consent for their child, to participate in the study, which was approved by the University's Ethical Advisory Commission in accordance with the Helsinki Declaration. All measurements and tests were carried out in the morning (from 8:00 to 12:00 h) by the same-trained measurers, who used the same measuring instruments and protocols. Decimal age of subjects was calculated according to the International Biological Programme (IBP) and treated the children's age on the day of measurement and testing.

### *Measures and tests*

#### Anthropometric evaluation

Evaluation of anthropometric characteristics was carried out by the International Biological Programme (IBP), and the sample consisted of: Body height, Body weight, Abdominal skinfold, Subscapular skinfold, Triceps skinfold, Body mass index. Body weight and body height were measured without shoes and body mass index (BMI) was calculated (kg/m$^2$). »Over-weight« and »obesity« were defined using the age- and sex-specific criteria of the International Obesity Task Force (IOTF)[20]. Three skinfolds were measured with modified Lohman et al.[21] procedure: Abdominal skinfold: a vertical fold is raised 5cm laterally at the level of the umbilicus; Subscapular skinfold: an angular fold taken at the 45 degree angle 1–2 cm below the inferior angle of the scapula; Triceps skinfold: a vertical fold on the posterior midline of the upper right arm, halfway between the acromion and the olecranon processes, with the arm held freely to the side of the body. For all skinfolds, the average of three measurements at each site was being used for analysis. The children's age is presented in decimals, which represents the period between the date of birth and the date of measuring and testing of every child, transformed into a corresponding result according to the IBP.

#### Motor performance evaluation

The battery of eight motor tests used in this research estimates the effectiveness of the following functional mechanisms: movement structuring, tonus and synergetic regulation, regulation of excitation intensity and regulation of excitation duration[22]. Motor abilities of boys and girls were estimated by these motor test battery: – functional coordination: Obstacle course backwards, Slalom with 3 balls; – frequency of simple movements: Arm plate tapping; – flexibility: Forward bend from straddle sitting position; – power (explosive strength): Standing broad jump; – muscular endurance (isometric strength): Bent-arm hang; – muscular endurance (isotonic strength): Crossed arm sit-ups. – speed of running: 20-m dash.

A short description of the motor tests follows. Every child was given an opportunity to rehearse the test before registering the results. In this way, more adequate and reliable results were obtained.

1) Obstacle course backwards. The child has to walk backwards on all fours and cover the distance of 10 m, climb the top of Swedish bench and go through the

frame of the bench. The task is measured in tenths of a second.

2) Slalom with 3 balls. On command »GO« the child rolls three balls between cones and cover the distance of 10 m. After he/she passes the last of five cones, the child turns around it continuously rolling the balls around the cones toward the start line. The task is completed when the child rolls all three balls over the start line. The score is the length of time required to complete the task, measured in tenths of second.
3) Arm plate tapping. For fifteen seconds the child has to tap alternately two plates on the tapping board with his dominant hand, while holding the other hand in the centre between two plates. The result is the number of alternate double hits.
4) Forward bend from straddle sitting position. The child sits on a floor, leaning against the wall, in straddle position and bows forward as deep as possible. A straight angle ruler lies down in front of the child and he/she reaches the scale with cm as far as he/she can. The result is the depth of the reach measured in cm.
5) Standing broad jump. The child jumps with both feet from the reversed side of Reuter bounce board onto a carpet, which is marked in cm. The result is the length of the jump in cm.
6) Crossed-arm sit-ups. The child lies on his/her back with knees bent and arms crossed on the opposite shoulders. He/she rises into a seated position and returns into the starting position. The instructor's assistant holds the child's feet. The result is the number of correctly executed rises to the seated position (no longer than 60 seconds).
7) Bent arm hang. The child under-grips the bar and holds the pull-up as long as he/she can (chin above the bar). The result is the time of the hold measured in tenths of a second.
8) 20 m dash. On command »GO«, the child that stands behind the start line has to run 20 m as fast as he/she can, to the end of track (20 m). Children run in pairs. The score is the time of running, measured in tenths of second.

Cognitive Functioning Evaluation

The Raven's Standard Progressive Matrices (RSPM) assessed cognitive abilities. RSPM represents multiple-choice tests and in each test item, a candidate is asked to identify the missing segment required to complete a larger pattern. Many items are presented in the form of a 3×3 or 2×2 matrix, giving the test its name. There are five sets (A to E) of 12 items each (e.g. A1 – A12), with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyze information.

### *Statistical procedures*

Since the variables such as body height, body weight, BMI, abdominal, subscapular and triceps skinfold, come from various metric spaces, their standardization was necessary. The groups within both genders were determined using measures of squared Euclid's distance index based on body weight and adipose tissue, with Ward's hierarchical method of cluster analysis.

Differences between distinguished taxonomic groups in motor variables and variable for the assessment of general cognitive ability were determined using multivariate analysis of variance (MANOVA), and univariate analysis of variance (ANOVA). Post-hoc Scheff's procedure was applied to analyze differences between pairs of groups.

All data were analysed using IBM SPSS Statistics (version 19.0) program for Windows.

## Results

Overall sample of subjects was divided into two groups by gender (413 boys and 497 girls) and, within gender, into three groups with different characteristics using Ward's hierarchical clustering procedure presented in Table 1 and 2.

Group A for boys is characterised by a minimum values of body height, body weight, BMI and average values of subcutaneous fatty tissue. Group B is characterised with highest values of body height, average values of BMI and lowest values of subcutaneous fatty tissue, whereas group C is characterised with highest values of

**TABLE 1**
BASIC PARAMETERS OF TAXONOMIC GROUPS – BOYS

| Variable | A (N=190) | | B (N=161) | | C (N=62) | |
|---|---|---|---|---|---|---|
| | X | SD | X | SD | X | SD |
| Body height (cm) | 154.74 | 8.84 | 169.06 | 9.65 | 159.98 | 11.29 |
| Body weight (kg) | 45.00 | 10.88 | 54.85 | 9.88 | 65.67 | 17.04 |
| Abdominal skinfold (mm) | 12.57 | 7.03 | 10.12 | 4.44 | 32.43 | 4.77 |
| Subscapular skinfold (mm) | 7.62 | 2.95 | 7.01 | 1.83 | 22.55 | 7.17 |
| Triceps skinfold (mm) | 10.58 | 3.91 | 8.56 | 2.94 | 21.78 | 5.24 |
| Body mass index (kg/m$^2$) | 18.58 | 3.00 | 19.04 | 2.05 | 25.29 | 3.41 |
| Age (decimal years) | 12.85 | 0.66 | 13.17 | 0.73 | 12.75 | 1.20 |

**TABLE 2**
BASIC PARAMETERS OF TAXONOMIC GROUPS – GIRLS

| Variable | A (N=259) | | B (N=210) | | C (N=28) | |
|---|---|---|---|---|---|---|
| | X | SD | X | SD | X | SD |
| Body height (cm) | 159.40 | 9.13 | 164.32 | 7.84 | 163.26 | 8.88 |
| Body weight (kg) | 45.06 | 7.51 | 57.58 | 7.67 | 71.55 | 11.97 |
| Abdominal skinfold (mm) | 11.51 | 3.49 | 19.98 | 4.38 | 31.61 | 5.23 |
| Subscapular skinfold (mm) | 7.53 | 1.61 | 11.70 | 3.24 | 25.85 | 5.45 |
| Triceps skinfold (mm) | 10.25 | 2.33 | 15.04 | 3.73 | 24.64 | 5.65 |
| Body mass index (kg/m$^2$) | 17.60 | 1.61 | 21.26 | 1.83 | 26.72 | 3.19 |
| Age (decimal years) | 13.08 | 1.02 | 13.48 | 1.12 | 13.26 | 1.15 |

body weight, subcutaneous fatty tissue and BMI and average body height.

Group A in girls is characterised by a minimum values of body height, body weight and BMI and subcutaneous fatty tissue. Group B is also characterised with highest values of body height, average values of body height and BMI, whereas group C is characterised with highest values of body weight, subcutaneous fatty tissue and BMI.

Differences between the formed groups in the field of motor abilities were determined using multivariate and univariate analysis of variance, while the differences between pairs of group's was defined with post-hoc Sheff's test. All results are shown in Tables 3 and 4.

The presented results in Table 3 indicate that in entire system of variables, as well as individual variables, there were significant differences between taxonomic groups of boys. Second taxon differed significantly in all variables over the first and third, a difference between the first and third taxon was in favour of the first one in the next variables: Obstacle course backwards, Slalom with three balls, Standing broad jump, Crossed-arm sit-ups, Bent arm hang and 20 m dash. All differences were significant.

The obtained results in the multivariate space of variables for girls showed that there were statistically significant differences between the groups (Table 4). Statistically significant differences between groups were found in all variables except the Raven variable. Comparing pairs of groups, A to C significantly differed in the variables Obstacle course backwards, Standing broad jump, Crossed-arm sit-ups, Bent-arm hang and 20-m dash, respectively, and compared to group B only in Bent-arm hang variable. Group B was significantly better than group A in the variables Slalom with three balls, Arm plate tapping, Forward bend from straddle sitting position and compared to group C in all variables except the Raven variable.

## Discussion

The purpose of this study was to analyse differences in motor and cognitive abilities of 11–14 years old children depending on their value in quantitative indicators of BMI and subcutaneous adipose tissue. The presented

**TABLE 3**
DIFFERENCES BETWEEN TAXONOMIC GROUPS OF BOYS

| Variable | A X (SD) | B X (SD) | C X (SD) | f | p |
|---|---|---|---|---|---|
| Obstacle course backwards (s) # | 14.55 (3.66)$^{cc}$ | 12.92 (2.88)$^{aa\ cc}$ | 19.14 (5.85) | 59.36 | 0.00 |
| Slalom with 3 balls (s) # | 35.62 (7.24)$^{c}$ | 30.81 (6.11)$^{aa\ cc}$ | 38.15 (6.82) | 34.83 | 0.00 |
| Arm plate tapping (freq.) | 28.14 (4.69) | 31.03 (4.84)$^{aa\ cc}$ | 28.24 (4.56) | 17.92 | 0.00 |
| Forward bend from straddle sitting position (cm) | 42.59 (8.64) | 47.56 (9.33)$^{aa\ cc}$ | 43.00 (8.96) | 14.49 | 0.00 |
| Standing broad jump (cm) | 177.35 (21.70)$^{cc}$ | 203.13 (22.57)$^{aa\ cc}$ | 157.45 (23.37) | 111.15 | 0.00 |
| Crossed-arm sit-ups (freq.) | 40.27 (7.96)$^{cc}$ | 45.20 (6.74)$^{aa\ cc}$ | 34.81 (9.45) | 43.48 | 0.00 |
| Bent-arm hang (s) | 36.91 (24.18)$^{cc}$ | 52.93 (22.07)$^{aa\ cc}$ | 11.60 (10.61) | 82.24 | 0.00 |
| 20-m dash (s) # | 4.11 (0.33)$^{cc}$ | 3.81 (0.29)$^{aa\ cc}$ | 4.38 (0.43) | 74.43 | 0.00 |
| Raven (points) | 41.49 (8.75) | 43.93 (9.64)$^{aa\ cc}$ | 41.27 (10.26) | 3.49 | 0.03 |
| F=17.61 P=0.00 | | | | | |

Scheffe's post hoc test: $^{aa}$ ≤ 0.01 statistical significance relative to A; $^{cc}$ statistical significance ≤ 0.01 compared to C; $^{b}$ ≤ 0.05 statistical significance relative to B; # – variables with the inverse metrics

**TABLE 4**
DIFFERENCES BETWEEN TAXONOMIC GROUPS OF GIRLS

| | A | B | C | f | p |
|---|---|---|---|---|---|
| | X (SD) | X (SD) | X (SD) | | |
| Obstacle course backwards (s) # | 15.56 (3.46)[cc] | 16.14 (4.58)[cc] | 22.52 (7.72) | 32.30 | 0.00 |
| Slalom with 3 balls (s) # | 38.66 (7.09) | 36.82 (7.29)[cc a] | 41.52 (7.97) | 6.98 | 0.00 |
| Arm plate tapping (freq.) | 30.52 (4.34) | 31.77 (4.66)[a c] | 29.52 (3.68) | 6.10 | 0.00 |
| Forward bend from straddle sitting position (cm) | 59.28 (12.56) | 62.33 (11.96)[a c] | 57.19 (10.48) | 4.58 | 0.00 |
| Standing broad jump (cm) | 177.10 (19.74)[cc] | 177.94 (21.78)[cc] | 151.70 (22.51) | 19.72 | 0.00 |
| Crossed-arm sit-ups (freq.) | 39.62 (7.79)[c] | 40.23 (8.36)[c] | 36.19 (8.35) | 3.02 | 0.05 |
| Bent-arm hang (s) | 36.78 (18.88)[bb cc] | 24.91 (15.90)[cc] | 7.17 (8.42) | 52.45 | 0.00 |
| 20-m dash (s) # | 4.21 (0.32)[cc] | 4.20 (0.36)[cc] | 4.51 (0.38) | 9.90 | 0.00 |
| Raven (points) | 42.76 (13.62) | 41.80 (16.16) | 46.19 (7.91) | 1.15 | 0.32 |
| | F=11.17 P=0.00 | | | | |

Schaffe's post hoc test: [a] statistical significance of ≤ 0.05 compared to A; [bb] ≤ 0.01 statistical significance relative to B; [cc] statistical significance ≤ 0.01 compared to C; [c] the statistical significance of ≤ 0.05 compared to C; # – variables with the inverse metric

results indicate the existence of differences in motor, and partly in the intellectual abilities between groups of subjects divided based on BMI and subcutaneous adipose tissue. This difference was more pronounced with boys compared to girls. Boys with higher BMI and substantial amount of subcutaneous adipose tissue generally performed weaker in the motor tests, which is in line with some previous studies[23]. This difference was most pronounced in the mechanism for the regulation of excitation intensity (explosive strength of legs), as well as in static force of arms and shoulders indicating that boys with higher BMI and amount of subcutaneous adipose tissue have less explosive and static power. Explosive strength measured by Standing broad jump test unambiguously imply that a higher body mass index and amount of subcutaneous adipose tissue lead to poorer performance in this test. Muscles involved in this movement require greater explosive power, which was not pronounced with increased BMI for both genders. Similarly, girls showed the greatest difference in coordination and static strength of arms and shoulders. Short-term maintenance of the body in a static position, such as hang, is typical for children with higher body mass index and amount of subcutaneous adipose tissue, because of their body weight. Some researchers have found that there was a negative correlation between BMI and motor abilities, where obese children showed poorer performance on age-appropriate field based tests[24]. D'Hondt et al.[25] concluded that childhood obesity is associated with lower total Movement Assessment Battery for Children[20]. In addition, obese children also displayed less of general motor skill performance that required endurance and strength. Furthermore, flexibility was in a significant negative correlation with increased BMI, as compared to children with normal body weight[26–31]. By analysing the association between motor coordination (MC) and BMI across childhood and early adolescence, Lopes et al.[23] revealed that MC is inversely associated with BMI, and that the strength of the inverse relation increases during childhood in both genders. Obese and overweight children showed markedly worse motor coordination levels[23]. According to Colella et al.[32], overweight children reported larger body-dissatisfaction scores, lower self-efficacy scores, and poorer performance on weight-bearing tasks than non-overweight peers. Fogelholm et al.[33] observed that overweight in 15 to 16 year-old boys and girls were negatively associated with cardiorespiratory fitness, abdominal muscle endurance, explosive power, speed and agility. In most tests, even highly active overweight individuals could not reach better than average fitness levels. The study of Bovet et al.[34] was restricted to the 4599 students aged 12 to 15. They reveal that a strong inverse relationship between overweight and performance of several standardized tests of physical fitness at adolescents in a country in the African region. Two variables that evaluate the level of coordination showed that boys with higher body mass index and amount of subcutaneous fat were significantly inferior to other taxonomic groups of boys, indicating markedly poorer motor coordination for overweight and obese boys compared to normal weight boys. Accordingly, girls with normal to moderate BMI and subcutaneous fat performed complex coordination task significantly better too, which indicates better ability in reorganization of movement stereotypes. Furthermore, the group with moderate BMI and subcutaneous fat, achieved better results in second coordination test to the group of girls with higher BMI and subcutaneous fat ($p = 0.01$), whereas differences between girls with normal to moderate BMI and subcutaneous fat were statistically significant to a less severe criterion ($p = 0.05$). In addition, results in research for coordination and obesity for children indicate contradictory findings of several authors. Kiphard and Schilling[35] reported that obese children showed significantly weaker coordination than normally nourished children, and Adam et al.[36] suggest that the correlation between BMI and coordination was not statistically significant. Overall, these results agree with most other results that demonstrate an inverse relationship between childhood body weight and various measures of motor coordination (i.e., process and product movement assessments)[37–39]. Unlike the motor variables, intelligence did not significantly differ between the selected groups of girls, whereas the assessment of intelligence with boys showed that group B achieved significantly best results in RP Matrices. If we observe other research of correlation between intelligence and obesity, it is interesting to notice that a comprehensive and extensive research[40] concludes that a lower IQ score in childhood is linked to obesity and being overweight later, particularly more prevalent with women. In addition, a statistically significant correlation was found between cognitive ability and BMI, when subjects showed significantly lower results in cognitive tests than children of normal nourishment[41]. Intelligence was measured using the Intelligence Scale for Children (WISC). In this study, the sample also showed a significant difference between subjects who were obese from those who were not[42]. Physical activity levels are significantly lower among overweight children than their lean counterparts are. Furthermore, children's motivation to participate in physical activity is influenced by their perceived and actual competence and their parents' perceptions of their competence. Overweight children have also reported lower perceived physical competence than non-overweight children[43], whereas, the correlation of cognitive and motor sphere is shown to be much more distinct in pre-pubertal and even more in pubertal children[44,45].

Even though, the cross-sectional nature of the results does not allow us to make causal inferences regarding the relationships between BMI, motor performance and intelligence, results obtained in this study gives us preliminary picture of the current state regarding the overweight and obesity issue in Serbia. In addition, BMI is not the most accurate predictor of body fat percentages but is widely abused as an indicator of body fat because of its simplicity of use[46]. Furthermore, it should be taken into consideration that with the growth and development period of children, BMI is very artificial value representing no true body proportions.

However, this research also has its practical implication. Observations given in this study highlights the potential importance of promoting use of physical activity in children for more efficient prevalence of childhood overweight and obesity. It can be significantly influenced on biological growth and development of child's body with correctly applied training of high intensity, especially in long terms of application[47–48]. Therefore, continued development of motor abilities and implementation of moderate physical activity on a daily basis should be a strategy goal of childhood interventions in order to promote long-term overweight and obesity prevention.

## Conclusion

Obtained results reported in this cross-sectional study support the majority of results indicating negative correlation of BMI and subcutaneous adipose tissue with motor performance. Overweight and obese children showed, in general, worse motor coordination performance for both genders, whereas the difference in cognitive assessment appeared only with boys.

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*G. Bala*

*University of Novi Sad, Faculty of Sport and Physical Education, Lovćenska 16, Novi Sad, Serbia*
*e-mail: gustavbala@yahoo.com*

## RAZLIKE U MOTORIČKIM I KOGNITIVNIM SPOSOBNOSTIMA DJECE U ZAVISNOSTI OD INDEKSA TJELESNE MASE I POTKOŽNOG MASNOG TKIVA

### S A Ž E T A K

Cilj ovog istraživanja je bio da se utvrde razlike u motoričkim i kognitivnim sposobnostima djece u zavisnosti od kvantitativnih pokazatelja Indeksa Tjelesne Mase (ITM) i potkožnog masnog tkiva. Uzorak ispitanika je sačinjavalo 910 djevojčica i dječaka iz osnovnih škola sa područja Vojvodine, uzrasta 11–14 godina. Analizirano je šest antropometrijskih, osam motoričkih i jedna kognitivna varijabla s ciljem utvrđivanja kvantitativnih i kvalitativnih razlika u prostorima motoričkog i kognitivnog funkcioniranja djece. Djeca su podijeljena na dva subuzorka na osnovu spola, a unutar subuzorka su podijeljeni u tri grupe na osnovu preračunatog ITM-a i izmjerenog potkožnog masnog tkiva. Rezultati dobiveni u ovom istraživanju ukazuju na postojanje razlika u motoričkom, i djelomično u kognitivnom prostoru između grupa ispitanika. Najveća razlika između taxona se pokazala u području koordinacije cijelog tijela i statičke snage ruku i ramenog pojasa.