ORIGINAL ARTICLE

Nutritional and motor ability status of first- and second- grade students

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Abstract

Nutritional status is a relevant indicator of optimal growth and development, as well as the health status of children. Since nutritional status can influence the expression of children's motor capacities, a study has been carried out in order to examine differences in motor abilities of children in relation to their nutritional status. The sample included 300 first- and second-grade students (132 boys, 168 girls). Students' motor literacy and motor ability status was evaluated by reduced version of "EUROFIT" test battery, while nutritional status was evaluated based on the body mass index. IOTF criteria were used in order to assign participants into four distinctive groups – underweight, normal weight, overweight and obese. Differences between groups in motor ability status were tested by Kruskal-Wallis and Mann-Whitney tests. No significant differences were found between groups of a different nutritional status in most of the motor abilities, suggesting that BMI does not represent a high-quality predictor of motor abilities of children of lower elementary school grades.

Keywords body mass index • motor ability status • nutritional status • overweight • obesity

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Introduction

Obesity has reached exceptionally high levels globally. Nearly two billion adults are overweight adults, with 650 million of them being clinically obese. According to recent data around 41 million children under the age of 5 are overweight or obese (WHO, 2016). Newer studies corroborate the fact that the number of obese children continues to grow (Biehl et al., 2013).

Study carried out by the Public Health Institute of Republic of Serbia (Results of the National Health Survey of Serbia: 2013 year, 2014) showed that there has been an increase in the prevalence of obese children (4.9%) in the year 2013, in comparison to the year of 2006 (2.6%).

Overweight children and adolescents are more susceptible for developing both short-term and long-term, physical, social, psychological and academic problems (Johnson & Wardle, 2005; Lawler & Nixon, 2011). Obesity in childhood can result in the formation of cardiovascular diseases, increase of cholesterol level, hypertension and dyslipidemia (Krebbs & Jacobson, 2003). Obesity negatively influences the endocrine system by causing disturbances in glucose and insulin metabolism (Pinhas-Hamiel et al., 1996; Sinha et al., 2002). In addition, obesity can be harmful to children's mental health, since obese children are at increased risk for depression and negative self-image (Strauss, 2000). Chronic diseases affecting adult population might stem from childhood, while physical activity level during childhood influences the health status during later stages of life (Harro & Riddoch, 2000; Thomas, Baker, & Davies, 2003).

Study that has examined the relationship between physical activity levels and the body mass index of children aged 7-10, identified the association between low physical activity and high body mass index in children, and this association seemed to be increasing with age (Brunet, Chaput, & Tremblay, 2007). Obesity in childhood is a strong predictor of adulthood obesity (Stettler & Iotova, 2010).

Biological development of a child manifests itself through a set of sequential and predictive changes in the physical domain, as well as in the sphere of motor ability development. Nutritional status represents one of the strongest predictors of the child's overall health and well-being, its capacities for regular and healthy growth and development (Lobstein, Baur, & Uauy, 2004). Great number of authors have examined the relationship between obesity and motor abilities in children of different age groups, and the obtained results consistently point out to the negative relationship between obesity and motor abilities level (Armstrong, M. I. Lambert, & E. V. Lambert, 2017; Ceschia et al., 2017; Gulías-González et al., 2017; Häcker, Bigras, Henderson, Barnett, & Mathieu, 2017; Karppanen, Ahonen, Tammelin, Vanhala, & Korpelainen, 2012).

Research by Trost, Kerr, Ward and Pate (2001) which examined physical activity levels of obese and non-obese children, showed that on a daily level obese child have lower amount of total accelerometer counts, moderate and vigorous physical activity, and fewer bouts of moderate to vigorous physical activity (MVPA) than their non-obese peers. The researchers explain the results by following: lower level of physical activity self-efficacy, physical inactivity of parents and an underdeveloped awareness of the entire community about the benefits, importance and significance of physical activity. Higher physical activity level is positively correlated with motor dexterity in children, while reduced physical activity level is negatively correlated with motor dexterity (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006).

Obese children are socially marginalized, have a decreased level of self-confidence, and more often suffer different forms of peer abuse and violence (Janssen, Craig, Boyce, & Pickett, 2004; Strauss & Pollack, 2003) in comparison to their normal weight counterparts, which can lead to a decreased level of physical activity, and can negatively affect their overall motor ability status.

Previous research indicates that nutritional status is very important prerequisite for healthy development, including motor development, during childhood. Since there is an obvious lack of research analyzing the relationship between nutritive and motor status of children in Serbia, a study has been carried out with the main goal to examine the differences in motor abilities of students in relation to their nutritional status.

Method

A cross-sectional study was conducted in September, 2015 in three different elementary schools, which all participated in a project "Let's get sports back to schools" in the city of Šabac.

Participants. Three hundred (N=300) 1st and 2nd graders (7-8-year old), of both genders, participated in this study. Basic characteristics of participants are shown in Table 1. Three groups were formed based on the participants' nutritional status, which was determined by International Obesity Task Force body mass index (BMI) cut-offs (Cole & Lobstein, 2012).

Table 1. Basic sample characteristics (N = 300)

	Boys (*n* = 132)	Girls (*n* = 168)	Total (*n* = 300)
Underweight	17 (12.88%)	25 (14.88%)	42 (14.00%)
Normal weight	83 (62.88%)	107 (63.69%)	190 (63.33%)
Overweight	20 (15.15%)	24 (14.29%)	44 (14.67%)
Obese	12 (9.09%)	12 (7.14%)	24 (8.00%)

Measures. A reduced "EUROFIT" test battery was used to evaluate motor ability status. The battery combines validated health and skill-related fitness tests (Committee of Experts on Sports Research, 1988), of which the most reliable and convenient tests were selected:

Standing Long Jump. This test evaluates leg explosive strength. The participant jumps by using two-foot take off from a reversely positioned spring board, and lands on a mat, as far as possible. The landmark of landing and take-off have to be in the same plane and level. The participants perform two consecutive jumps, and the longer jump is registered. The distance is measured with a measuring tape from the take-off position to the landing position.

Plate Tapping. This test evaluates the speed of alternating movement of the dominant hand. Equipment required includes the following: a desk with two discs (20 cm diameter), placed so that distance between their centers is 60 cm; a rectangle (10 x 20 cm) placed on an equal distance between two discs; and a stopwatch. The aim of this test is to perform 25 single-handed (whether left or right will be used, is up to the participant to decide) cycles of movement (one cycle consists of touching the opposite disc and returning the same hand to the starting position) in the shortest possible time period.

Sit-Ups. This test measures muscular endurance of abdominal and hip flexor muscles. Participant tries to perform as many sit-ups as possible in 30 seconds, starting from a supine position with legs bent at 90 degrees and ending in a seated position with elbows touching the knees (1 repetition). Finger are interlocked behind the head (palms of the hand placed on the back of the head).

10x5m-Shuttle-Run. This tests estimates running speed and agility. Participant starts from a standing start, behind the starting line, and waits for an audio signal upon which he initiates the test. The participant tries to run as fast as possible towards the opposite line (5 meters apart from the starting line) and return to the starting line, crossing both lines with both of his feet. This is repeated five times at a maximum running speed.

Sit-and-Reach. This test measures flexibility of lower back and hamstring muscles. The participant starts from a seated position, with legs extended, and soles of his feet touching a Swedish box (or any suitable wooden box). The aim of this test is to bend forward and reach as far as possible with one's fingers, while maintaining the proper posture. Equipment needed: sit-and-reach box (35 x 45 x 32 cm) with the ruler surpasses the edge of the box by 15 cm. The scale (ruler) should be in the range of 0 to 50 cm. For easier statistical analysis of the obtained data, 20 cm has been added to the initial results.

Anthropometric characteristics included body height and body weight.

Body height was measured to the nearest 0.1 cm with the portable "Seca 213" stadiometer. During the measuring procedure, the participant stands barefooted. Body weight was measured to the nearest 0.1 kg by digital scale "OMRON BF511". The scale was positioned on a flat, hard and solid surface. The participants were measured wearing minimal amount of clothing.

Body mass index (BMI) was used to assess nutritive status of the participants. BMI was calculated from weight (in kilograms) divided by the height squared (in square meters). For nutritive status classification, International Obesity Task Force (IOTF) cutoff points were applied (Cole & Lobstein, 2012).

Procedure. The participants performed motor tests dressed in sports attire. The tests were performed in school gyms using station format. Trained and experienced examiners (PE teachers) conducted the testing. The participants were well informed about the purpose and the technique of tests. All parents signed the informed consent for their child's participation in the study, and they were told that the children can withdraw from the test at any moment if they are feeling uncomfortable for some reason.

Data analysis. Normality of distribution has been tested with the Kolmogorov-Smirnov (K-S) method. Differences in motor abilities between groups of different nutritional status were analyzed by Kruskal-Wallis test, while the Mann-Whitney test was used for post-hoc analysis. The margin for the level of significance has been set at $p \leq 0.05$. SPSS 20.00 package for Windows has been used for data analysis.

Results

Descriptive statistics of used variables, as well as results of testing gender differences is shown in Table 2. Testing the normality of the distribution with the K-S test has showed that there are statistically significant deviations from the normal distribution in the variable Sit-and-Reach in both genders, while among girls these deviations are present in variables

Plate Tapping and 10x5m-Shuttle-Run. Due to the inability to normalize the data, for further analysis non-parametric techniques for data processing have been used. Gender differences in motor abilities were tested by Mann-Whitney test. The test identified significant gender differences in 10x5m-Shuttle-Run and Sit-and-Reach tests. In agility test boys had better results, while girls were more successful compared to boys in the flexibility test.

Table 2. Descriptive statistics and gender differences in motor tests

Variable	Boys (n = 132)		Girls (n = 168)	
	M ± SD	K-S (p)	M ± SD	K-S (p)
Plate Tapping (s)	19.34±3.42	0.20	19.35±4.89	**0.000**
Standing Long Jump (cm)	114.31±21.96	0.20	110.45±22.38	0.200
Sit-Ups (n/30 s)	15.30±5.65	0.20	14.58±4.48	0.094
10x5m-Shuttle-Run (s)[a]	26.02±3.22	0.20	26.91±3.36	**0.037**
Seat-and-Reach[a] (cm)	16.17±5.92	**0.00**	19.02±6.45	**0.000**

Legend: [a] – significant difference between boys and girls (p = 0.01), detected by Mann-Whitney test; K-S - Kolmogorov-Smirnov test.

Results of testing the differences in motor abilities between boys of different nutritional status, by Kruskal-Wallis test, are shown in Table 3. As it can be seen, no significant differences were detected in any of the observed variables across all groups.

Table 3. Differences in motor ability tests between boys of different nutritional status

Variable	Underweight	Normal weight	Overweight	Obese
	AS±SD	AS±SD	AS±SD	AS±SD
Plate Tapping (s)	19.16±3.00	19.24±2.97	20.30±5.04	18.70±3.74
Standing Long Jump (cm)	120.06±18.49	115.43±22.95	110.30±20.54	105.08±20.14
Sit-Ups (n/30 s)	15.71±4.63	16.13±5.72	13.75±5.86	11.58±4.48
10x5m-Shuttle-Run (s)	25.43±3.00	26.20±3.51	24.99±1.89	27.33±2.70
Seat-and-Reach (cm)	16.71±4.37	16.71±5.99	14.45±6.33	14.50±6.52

Differences in motor ability tests between underweight, normal weight, overweight and obese girls are presented in Table 4. Results of the Kruskal-Wallis test indicate that there are statistically significant differences in Standing Long Jump and 10x5m-Shuttle-Run tests. As for the pairs of groups, Mann-Whitney showed that in both tests, statistically significant differences are present between normally nourished girls and obese girls, consistently in favor of normally nourished girls

Table 4. Differences in motor ability tests between girls of different nutritional status

Variable	Underweight	Normal weight	Overweight	Obese
	AS±SD	AS±SD	AS±SD	AS±SD
Plate Tapping (s)	21.86±7.84	18.57±3.44	19.57±5.90	20.71±4.18
Standing Long Jump (cm)	106.04±29.09	114.79±19.53[a]	105.50±20.86	90.92±21.79
Sit-Ups (n/30 s)	13.72±4.97	15.04±4.50	14.54±3.87	12.33±3.87
10x5m-Shuttle-Run (s)	27.26±3.06	26.43±3.38[a]	27.66±2.93	28.94±3.82
Seat-and-Reach (cm)	17.68±6.52	19.50±6.08	18.79±7.91	18.08±6.75

Legend: [a] – statistically significant difference in comparison to obese girls ($p \leq 0.01$).

Discussion

The study was conducted in order to examine differences in motor abilities between children of different nutritional status, since there is a lack of this kind of research in Serbia. Participants were divided in four groups according to BMI: underweight, normal weight, overweight, and obese, while. In addition, gender subsamples were formed in order to examine gender differences in motor abilities.

It turned out that girls are more flexible, while boys showed better results in running speed/agility test (Table 2). Girls of younger school age, generally have higher level of flexibility levels in comparison to boys of the same age group (Beunen, Malina, Renson, & Van Gerven, 1988). This might be explained by the fact that activities which predominantly affect the flexibility levels, such as dancing, figure skating or synchronized swimming, are traditionally seen as feminine activities, and thus more girls choose to participate in them in comparison to boys. Nevertheless, participation in programs for developing flexibility is a far stronger predictor of flexibility levels than gender (Haywood, 2014). Previous studies also shown that boys achieve better results in tests of speed, explosive strength and cardio-respiratory endurance (Gulías-González, Sánchez-López, Olivas-Bravo, Solera-Martínez, & Martínez-Vizcaíno, 2014; Tomkinson et al., 2017). On the other hand, gender differences in motor ability tests are relatively small during pre-pubescent years, and a complete understanding which factors and in what magnitude influence these differences in motor abilities of children haven't yet been fully clarified (Malina & Bouchard, 1991).

As far as the relationship between motor abilities and nutritional status is concerned, statistically significant differences in explosive strength and running speed/agility have been noticed in girls (Table 4). In both cases, normal weight girls were significantly more successful than their obese counterparts. Previous studies which examined the association between nutritional status and motor abilities of obese and normal weight girls, have also identified such differences in motor tasks such as running, jumping and isometric holds (static endurance), all in favor of normal weight girls (Malina et al., 1995; Malina & Katzmarzyk, 2006). On the contrary, in the subsample of boys, no significant differences have been observed between groups in relation to nutritional status (Table 3). Altogether, the results suggest that there are no statistically significant differences in most of the examined motor tests in relation to children's nutritional status. These results are in concordance with previous research which pointed out that body mass index isn't a good predictor of motor ability in children (Fjørtoft, 2000; Milanese, Bortolami, Bertucco, Verlato, & Zancanaro, 2010).

Even though no other significant differences have been detected, it can still be said that obese participants, regardless of gender, in almost all of the examined variables achieved the weakest results, which indicates a tendency of lower motor functioning within obese children population. These findings are in agreement with most of the previous research which examined relationships between nutritional and motor status of elementary school students (Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Wrotniak et al., 2006). Yet, in children from South Africa, aged 7 – 14, an increase in body mass index has a positive correlation with the standing long jump (Monyeki, Koppes, Kemper, & Monyeki, 2005), probably due to the fact that among the underweight population body mass index can be interpreted as an indicator of muscle mass. Bearing in mind previous research, it can be said that individual variability within the normal range of BMI does not significantly affect the results of children in motor ability tests, while it does have a significant effect in extreme populations such as underweight and extremely obese individuals (Milanese et al., 2010).

Worse results of overweight and obese students in all motor ability tests can be explained by the fact that greater body mass acts as an inertial load which should be transferred during the execution of motor tasks (Astrand, Rodahl, & Stromme, 2003). Excessive body weight negatively correlates with performance in motor tasks such as running, jumping and torso flexion, in which the body weight is working against gravity. Some other factors that contribute to lower results in motor abilities of obese children should also be taken into consideration. Lack of motivation and reduced participation in physical activity programs are frequently present in obese children. Lack of motivation for physical activity participation among obese children is partially attributed to "learned and acquired helplessness", where any level of physical activity is perceived as a hard work. Therefore, the main focus of interventions aiming to obese children should be acquiring and improving basic motor skills with constant verbal encouragement, more so than on highlighting the importance of sport competition (McWhorter, Wallmann, & Alpert, 2003).

Besides nutritional status, some other factors, out of the scope of this study (e.g. heredity, general health, SES), may influence motor functioning of children, and should be taken into consideration when analyzing the results. In addition, limitations of the study design, as well as of instruments used for nutritive and motor status assessment, could have affected the results, and this should be carefully considered in future research.

Bearing in mind that motor efficacy of children enables efficient participation in physical and everyday activity, and that increased body mass index might negatively influence their motor functioning, maintenance of optimal body structure in extremely sensitive period of childhood must be prioritized in both education and health sectors.

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