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Research article

BODY MASS INDEX AND MOTOR COORDINATION OF BOYS AND GIRLS AGED 7 TO 9

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Abstract. *The aim of this paper is to examine the differences in the overall level of motor coordination between groups of children with different nutritional status. In total, 418 participants of both sexes, aged 7-9, took part in the study. The participants were classified based on their nutritional status into one of four groups: underweight, normal weight, overweight, and obese, according to the International Obesity Task Force. The motor coordination of the participants was assessed using the KTK (Körpercoordination test für Kinder) battery of tests and total point scores were calculated for each age category. The Kruskal-Wallis test was used to examine the differences in the overall motor coordination between groups of participants. Statistical significance was set at the $p \leq .05$ level. The results revealed statistically significant differences in the overall level of motor coordination between all the examined groups of boys with different nutritional status aged 7, 8 and 9. The results of the Mann-Whitney test showed statistically significant differences between all three age groups of boys (7-, 8- and 9-year-olds) in favor of the normal weight groups. The Kruskal-Wallis test revealed no statistically significant differences in the case of the girls. The results of the Mann-Whitney test revealed statistically significant differences between all three age groups of girls (7-, 8- and 9-year-olds) in favor of the normal weight groups. The obtained results showed statistically significantly poorer motor coordination in boys and girls with higher values of body mass index compared to boys and girls with normal body weight across all age groups.*

Key words: *Body Mass Index, Motor Coordination, KTK battery of tests, Obesity*

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INTRODUCTION

Participation in various forms of physical activity is considered a significant factor of the proper physical (Obradović et al., 2011; Denker & Andersen, 2008; Ortega, Ruiz, Castillo, & Sjöström, 2008) and mental development of children (Gu, Chang, & Solmon, 2016; Fedewa & Ahn, 2013), and also a good predictor of health in later life (Cvejić, Pejović, & Ostojić, 2013). However, recent studies indicate that the number of children who meet the recommended minimum of physical activity is decreasing (Keane et al., 2017; Griffiths et al., 2013; Trembaly et al., 2011). What is more, studies also indicate that the number of obese children is dramatically increasing on a global level and threatens to reach pandemic proportions (Seidell, 2008; Kosti & Panagiotakos, 2006; Odgen et al., 2006). The latest results on the prevalence of obesity in children aged 6 to 8 on the territory of the Republic of Serbia point to the epidemic proportions of this problem (Djordjić et al., 2016). The current increase in the prevalence of excess body weight among the younger population puts children at risk of chronic diseases such as hypertension, high cholesterol levels, Type 2 diabetes, and development of cardiovascular diseases, which are all already associated with childhood obesity (Daniels, 2006). In addition, children who do not develop positive habits in terms of regular physical activity often perpetuate similar patterns of behavior in adulthood (Milanese, Bortolami, Bertucco, Verlato, & Zancanaro, 2010). Studies suggest that excess body weight has a negative impact on the level of physical activity of children as early as in the pre-school age. Obese children tend to be less active and achieve worse results when tested for motor abilities (Marmeleira, Veiga, Cansado, & Raimundo, 2017). This restricts the ability of obese children to acquire basic motor skills through which they are able to develop components of health-related fitness (Cvejić & Ostojić, 2018). Hence, the acquisition of motor skills is necessary for normal functioning later in life, during adulthood (Niederer et al., 2012). Previous studies indicate negative correlations between the body mass index (BMI) and overall motor coordination, as well as the fact that overweight and obese children are achieving lower values of overall motor coordination compared to those with normal body weight (Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; D'Hondt et al., 2011a; D'Hondt at al., 2011b).

Bearing in mind the above-mentioned, the aim of this paper is to examine the differences in the overall level of motor coordination between groups of children with different nutritional status.

METHODS

Participants

The research included 418 participants of both sexes aged 7 to 9. Table 1 shows the main characteristics of the sample of participants, i.e., groups formed according to their nutritional status and defined according to international normative tables, in percentiles (Cole & Lobstein, 2012). The study was a cross-sectional one. Written informed consents were obtained from the parents of all the children. The parents gave their consent for the children to participate in the study. All measurements and treatments were performed in accordance with the ethical standards laid down in the Declaration of Helsinki. The tests were conducted as part of the project "Bring sports to schools - Grow healthy", which is under implementation on the territory of the City of Šabac (Republic of Serbia).

Table 1 Classification of the participants based on nutritional status according to the IOTF†

Group	Girls n (%)	Boys n (%)	Total n (%)
1. Underweight†	16 (7.1)	7 (3.6)	23 (5.5)
2. Normal weight†	147 (65.3)	127 (65.8)	274 (65.6)
3. Overweight†	39 (17.3)	36 (18.7)	75 (17.9)
4. Obese†	23 (10.2)	23 (11.9)	46 (11.0)
Total	225 (100.0)	193 (100.0)	418 (100.0)

†International Obesity Task Force reference data

Instruments and Procedures

Motor coordination

To assess the overall motor coordination, a Körperkoordinations test (KTK) battery of tests was used, consisting of four subtests; 1) walking backwards three times along three different wooden beams, 2) single-leg hopping over a 5 cm high foam obstacle, 3) lateral jumping over a low obstacle within a 15-second time frame, 4) lateral movement across the floor using 2 wooden platforms for 20 seconds (Kiphard & Schilling, 1974). The battery of tests was customized for 5- to 15-year-olds, with high reliability (a reliability coefficient from 0.90 to 0.97 for the total battery of tests) and validity (r = 0.60-0.80 for the intercorrelation of KTK subtests) (D'Hondt et al., 2013; Lopes, Rodrigues, Maia, & Malina, 2011; Kiphard & Schilling, 1974).

Anthropometry

Body height and weight were measured using standardized procedures. Body height was measured using the "SECA 213" stadiometer, with an accuracy of 0.5 cm, while body weight was measured using "OMRON BF511" scales with an accuracy of 0.1 kg. The BMI expressed in units of kg/m^2 was calculated based on the above-mentioned and the participants were classified into categories according to percentile values: normal weight, overweight and obese.

The participants performed the tests barefoot, dressed in sportswear. Each of the tests was accompanied by specific instructions orally presented to each of the participants. Warming up and stretching prior to the start of the test was not allowed. However, trial tests were allowed for the KTK tests. The tests were performed in school gyms in the form of circuit exercises. The order of the tests was as follows: 1) Body height; 2) Body weight; 3) Walking backwards; 4) Lateral movement; 5) the Single-leg hop; 6) Lateral jumps. The tests were carried out by skilled timekeepers, and professors of sport and physical education. The participants were informed about the purpose and the technique of the tests and were given clear instructions on how to do the tests precisely, quickly, and consistently, in accordance with the factor being measured.

Statistical Analysis

Statistical data processing was carried out using SPSS, version 19 statistical package for Windows (Chicago IL). The Kruskal-Wallis test was used to examine the significance of differences in the overall motor coordination between groups of participants with a different nutritional status, whereas the Mann-Whitney test was used as a post-hoc test. Statistical significance was set at the $p \leq .05$ level.

RESULTS

The main descriptive indicators of anthropometric characteristics and overall motor coordination of students of both sexes are shown in Table 2 by age.

Table 2 Descriptive characteristics of girls and boys and the overall level of motor coordination by age

Girls (n=225)					Boys (n=193)				
Age	Weight (kg) Mean (SD)†	Height (cm) Mean (SD)	BMI‡ (kg m^{-1}) Mean (SD)	KTK§ (points) Mean (SD)	Age	Weight (kg) Mean (SD)	Height (cm) Mean (SD)	BMI (kg m^{-1}) Mean (SD)	KTK (points) Mean (SD)
7 (n=76)	28.6 (6.7)	126.2 (11.4)	19.4 (17.3)	88.6 (17.9)	7 (n=80)	28.3 (6.0)	128.3 (5.7)	17.0 (2.5)	91.2 (17.2)
8 (n=84)	30.2 (8.7)	132.8 (6.8)	17.0 (3.7)	89.6 (15.6)	8 (n=64)	32.4 (8.1)	134.1 (6.7)	17.8 (3.2)	92.5 (19.6)
9 (n=65)	35.8 (7.9)	141.5 (7.2)	17.7 (2.8)	86.9 (14.5)	9 (n=49)	35.5 (7.5)	141.1 (6.6)	17.7 (2.8)	91.5 (16.2)

†Standard Deviation; ‡Body Mass Index; §KTK test of motor coordination

Table 3 shows differences in the overall level of motor coordination between boys and girls with different nutritional status. The *Kruskal-Wallis* test showed statistically significant differences between groups of boys with different nutritional status: 7-year-olds (p = .02), 8-year-olds (p = .00), and 9-year-olds (p = .03). As for boys aged 7, the results of the *Mann-Whitney* test showed statistically significant differences between the group of students with normal weight and the group of overweight students (p = .00) in favor of the students with normal weight. As for boys aged 8, there is a statistically significant difference between the group of students with normal weight and the group of obese students (p = .00) in favor of the group of students with normal weight. What is more, among boys 8 years of age, statistically significant differences were also found between the group of overweight and the group of obese boys (p = .01) in favor of the overweight group. With respect to boys 9 years of age, a statistically significant difference was observed between the group of boys with normal weight and the group of overweight boys (p = .03).

Table 3 Differences in the overall level of motor coordination of boys and girls with different nutritional status

Age	Gender	Underweight‡ Mean (SD)§	Normal weight‡ Mean (SD) §	Overweight‡ Mean (SD) §	Obese‡ Mean (SD) §
7	Male	(n=2) 99.5 (24.7)	(n=54) 94.6 (16.4)*	(n=13) 79.5 (13.9)	(n=11) 86.5 (18.3)
8		(n=3) 100.3 (34.5)	(n=37) 96.9 (17.3)**	(n=17) 90.0 (19.1)**	(n=7) 68.3 (9.35)
9		(n=2) 76.5 (4.9)	(n=36) 95.5 (15.2)***	(n=6) 78.1 (18.2)	(n=5) 85.2 (11.5)
7	Female	(n=3) 94.3 (9.3)	(n=47) 91.55 (16.2)*	(n=14) 89.8 (16.8)	(n=12) 74.0 (21.4)
8		(n=9) 86.6 (23.3)	(n=55) 91.2 (14.3)	(n=14) 88.4 (13.3)	(n=6) 80.0 (19.3)
9		(n=4) 94.2 (20.3)	(n=45) 88.1 (14.4)***	(n=11) 86.5 (10.1)***	(n=5) 71.8 (13.8)

‡International Obesity Task Force reference data; §SD-Standard deviation; *statistically significant difference in relation to overweight boys (p <.01);* statistically significant difference in relation to obese girls (p <.01);** statistically significant difference in relation to obese boys (p<.01);*** a statistically significant difference in relation to overweight boys (p<.05);*** a statistically significant difference in relation to obese girls (p<.01)

The results of the *Kruskal-Wallis* test revealed no statistically significant differences between groups of girls with different nutritional status in any of the investigated age groups. However, the results of the *Mann-Whitney* test showed that among 7-year-old girls there were statistically significant differences between the group of girls with normal weight and the group of obese girls (p = .00) in favor of the group with normal weight. Furthermore, among girls 9 years of age there were statistically significant differences between the group of girls with normal weight and the group of obese girls (p = .03) in favor of the group with normal weight, as well as between the group of overweight and the group of obese girls (.04) in favor of the overweight group.

DISCUSSION

The motor skills of overweight children have yet to be more extensively documented. The available studies are primarily focused on gross motor skills; therefore, the primary aim of the present study was to determine whether there are differences between children with different nutritional status across an area of motor coordination evaluated by means of a complex battery of motor tests covering the entire range of motor skills. The prevalence of obesity and the existence of extreme obesity were studied in Serbian schools (Ostojić et al., 2011). The results of this study suggest that more than 28% of the total number of participants is either overweight or obese. One of the predictors of obesity is certainly a poor diet. Increasing obesity in children is supported by the fact that in schools they are served snacks prepared from white flour and additives (various pastries), and that they have easy access to various foods containing large amounts of sugar and fat (chips, various munchies, sweets, sweetened juices). In relation to motor coordination, the results obtained for boys indicate the existence of statistically significant differences

between boys with different nutritional status in all the examined age groups. Boys with a lower body weight index achieved better total results on tests assessing the overall motor coordination compared to boys with high body mass index values who belong to the overweight and obese groups. The results obtained for the girls indicate the existence of statistically significant differences between girls with normal weight and obese girls aged 7 and 9, in favor of the girls with lower body mass index values who belong to the normal weight group. The obtained results are consistent with previous studies that confirm the inverse relationship between the body mass index and motor coordination of the participants, as well as gross motor skills (Lopes, Malina, Maia, & Rodrigues, 2018; Marmeleira et al., 2017; Antunes et al., 2015; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Jones, Okely, Caputi, & Cliff, 2010; Morano et al., 2011). One of the key effects of obesity is a low level of physical activity and vice versa (Ostojić, Stojanović, Stojanović, Marić, & Njaradi, 2011; Ostojić, O'Neil, Calleja, Terrados, & Stojanović, 2010). Studies suggest that excess body weight contributes to a reduced level of physical activity as early as in the pre-school age (Niederer et al., 2012). It should be noted that the motivation of obese students to take-up a physical activity is influenced by various physical, social, and psychological factors (Sung, Yu, So, Lam, & Hau, 2005). Verbal criticism by parents and peers can also be a factor in the negative attitude of obese children towards exercise, consequently lowering their levels of physical activity (Faith, Leone, Ayers, Heo, & Pietrobelli, 2002). Parents should serve as the driving force for their children, encouraging them to participate in physical activities, because their relationship with their children, as well as their own level of physical activity, has an impact on their children's level of physical activity as well (Brzek et al., 2018). Being overweight in early school years may be an important factor in the occurrence of metabolic, digestive, respiratory, skeletal and psychosocial issues (Daniels, 2016); therefore, it is necessary to act as early as possible in order to neutralize such negative effects. The results obtained emphasize the necessity of developing strategies enabling intensification of physical activity and the adoption of basic motor skills through regular school activities as well as extracurricular activities from the earliest years at school. It should be kept in mind that well-designed advanced classes of physical education alone can increase physical activity among young people and should be widely implemented in schools. Moreover, it is necessary to raise awareness amongst schools and children about the importance of healthy eating habits and physical activity, along with changing nutritional patterns in schools. Young people with higher levels of motor skills are more physically active and are more likely to engage in different forms of physical activity than their peers with poorer motor skills (Boreham & Riddoch, 2001). Studies have shown that weight loss in obese children improves the results achieved on the KTK tests (D'Hondt et al., 2011a; D'Hondt et al., 2011b). There is a positive correlation between positive self-perception of motor potential and a higher level of physical activity and a negative correlation between the former and sedentary behavior patterns of children (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Taking into account the stated educational and health benefits, the basic motor skills of children should represent for them one of the essential means of prevention and correction of obesity.

CONCLUSION

In conclusion, the results indicate that more than 28% of the total participants in the study are either overweight or obese. The results obtained confirm the inverse relationship between BMI and motor coordination, which has already been confirmed by other studies. It is necessary to raise awareness amongst schools and children about the importance of healthy eating habits and physical activity.

Some study limitations should be noted. The impact of other possible contributing factors should be analyzed, such as the physical self-concept of students, the amount and intensity of physical activities at school and outside the school, socioeconomic status etc., in order to provide a more comprehensive understanding of the mechanisms of basic motor (in-)competence in the obese population of the young school age. In addition, BMI is not the most accurate predictor of body fat percentage; other weight-related variables affecting body weight need to be examined in order to understand the nature of this relationship. Furthermore, BMI does not take into account the individual nutritional status of a participant and data on the percentage of muscle and fat in the body could provide a somewhat different picture. A small sample could also further be reduced by gender classification.

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INDEKS TELESNE MASE I MOTORNA KOORDINACIJA DEČAKA I DEVOJČICA UZRASTA OD 7 DO 9 GODINA

Cilj ovog rada je da se ispitaju razlike na ukupnom nivou motorne koordinacije između grupa dece sa različitim nutritivnim statusom, U istraživanju je učestvovalo 418 dece oba pola, uzrasta od 7 do 9 godina. Ispitanici su klasifikovani na osnovu nutritivnog statusa u jednu od četiri grupe (pothranjena, sa normalnom telesnom masom, sa prekomernom telesnom masom i gojazna), prema Međunarodnoj radnoj grupi za gojaznost. Motorna koordinacija učesnika je procenjena korišćenjem KTK (Korpercoordination test fur Kinder) baterije testova, a ukupni broj bodova je izračunat za svaku uzrasnu kategoriju. Kruskal-Wallis test je korišćen za ispitivanje razlika u ukupnoj motornoj koordinaciji između grupa ispitanika. Statistička značajnost je određena na nivou $p \leq .05$. Rezultati Kruskal-Wallis-ovog testa pokazali su statistički značajne razlike u ukupnom nivou motorne koordinacije između svih ispitivanih grupa dečaka sa različitim nutritivnim statusom i uzrasta od 7 do 9 godina. Rezultati Mann-Whitney testa su pokazali statistički značajne razlike između sve tri starosne grupe dječaka (7-mo, 8-mo i 9-to godišnjaka) u korist normalnih težinskih grupa. Kruskal-Wallis-ovim testom nisu utvrđene statistički značajne razlike u kod devojčica. Rezultati Mann-Whitney testa otkrili su statistički značajne razlike između sve tri uzrasne grupe djevojčica (7-mo, 8-mo i 9-to godišnjaka) u korist normalnih težinskih grupa. Dobijeni rezultati pokazali su statistički značajno lošiju motoričku koordinaciju dečaka i devojčica sa višim vrednostima indeksa telesne mase u odnosu na dečake i devojčice s normalnom telesnom masom u svim uzrasnim grupama.

Ključne reči: *indeks telesne mase, motorna koordinacija, KTK baterija testova, gojaznost*