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Original research article

MORPHOLOGICAL CHARACTERISTICS AND MOTOR SKILLS AS PREDICTORS OF PHYSICAL ACTIVITY OF STUDENTS IN A PHYSICAL EDUCATION CLASS

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Abstract. *The aim of this research was to determine the influence of certain morphological characteristics and motor skills on the volume and intensity of activities in physical education (PE) classes. A total of 208 (107 boys and 101 girls) primary school children aged 10±1.4 years old participated in this study. Physical activity was estimated by a pedometer and pulse meter. The physical fitness of the children was estimated by 7 motor skills tests and morphological characteristic by bioelectrical impedance and an anthropometer. A multiple regression analysis indicates that both predictor models had a significant influence on physical activity during classes (p<0.01). For the group of boys, physical fitness had a greater prediction value while in for the girls it was the morphological characteristics. At the level of individual morphological variables, body weight and muscle mass as components have the greatest predictive power in both sexes. Explosive strength of the lower extremities, flexibility and the speed had the greatest prediction in the boys, as well as flexibility in the girls. Findings from the present study indicate that PE teachers could provide more activities which will result in significant improvements of physical fitness components and a healthy lifestyle in children.*

Key words: *Fitness, Morphological development, Younger school-age children, Primary school.*

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INTRODUCTION

Scientific research so far has undoubtedly indicated that physical activity contributes to the preservation of health and prevention of the onset of many diseases of the modern age, such as cardiovascular diseases, obesity, certain malignant diseases etc. (Castetbon & Andreyeva, 2012; Ogden, Carroll, Kit, & Flegal, 2012; Pinar, Ozdol, & Ozer, 2012). Special attention is paid to the fact that the increasing number of children and young adults are affected by insufficient physical activity (Goh, Podlog, Hannon, Brusseau, Webster, & Newton, 2014; Pate, O'Neill, & Mitchell 2010; Rey-López, Vicente-Rodriguez, Biosca, & Moreno, 2008; Silva & Santos, 2017). Causes of hypokinesia are numerous and complex (personal, family, social environment, etc.).

Physical activity is the key characteristic of a physical education (PE) class; through physical activity and in the context of physical activity, students learn to develop motor skills, learn about physical activity, get to know themselves and their abilities, communicate with other students and develop social skills. By exercising in class, the students can improve their motor abilities, and the performed physical activity represents a recommendation for minimum physical activity, which requires children and young people to be physically active at least 60 minutes a day (Corbin, Pangrazi, & Welk, 1994). The achievements of students in PE classes depend on numerous factors, and one of the most important ones is the time spent exercising (Pavlović, 2017; Šekeljić & Stamatović, 2014). Only when the students are active in class do they successfully acquire motor skills, develop motor abilities, gain positive experiences of exercising and develop the necessary self-confidence (Silverman, 2005).

The problem of insufficient physical activity of students in PE classes has been a burden to the PE curriculum for a long time. Previous studies have concluded that effective exercise in PE classes amounts to 15 minutes (Petrović, 2010), and in one of the recent studies where physical activity has been monitored by a valid observation instrument, the average active exercise time was 17.6 minutes (Marković, Bokan, Rakić, & Tanović, 2012), which is not sufficient to achieve a high volume and intensity of the curriculum and planned results. Insufficient physical activity of elementary school students has been noted in other countries as well, where it has been found that the students are active only 8.6% of the time of the total duration of a PE class, in a moderate intensity regime, which is significantly less than 50%, which is the recommendation of professional associations (Ridgers, Stratton, & Fairclough, 2006; Wadsworth, Rudisill, Hastie, Boyd, & Rodríguez-Hernández, 2014).

Many previous studies have shown that numerous factors (personal, social, behavioral etc.) correlate with the physical activity of children not only in their free time but also in a PE class (Bailey, Wellard, & Dismore, 2004; Carrol & Loumidis, 2001; Crocker, Eklund, & Kowalski, 2000; Cury et al., 1996; Đorđić & Tubić, 2008; Ferrer-Caja & Weiss, 2000; Harrison & Narayan, 2003). Among personal factors, morphological characteristics have been identified as a significant factor in the manifestation of physical activity of students in a PE class (Brusseaue et al., 2011; Pathare, Piche, Nicosia, & Haskvitz, 2016). In a recent study, nutritional status relationships (Body Mass Index, BMI), motor abilities and physical activities of younger school age students have been analyzed and it has been determined that BMI has a significant negative contribution to the physical activity of students (Wittmeier, Mollard, & Kriellaars, 2007). BMI can be said to indirectly affect the reduced level of physical activity of students in a PE class (Morrison et al., 2012), and that there is a negative correlation between BMI and motor skills. It is known that motor skills have a significant influence on physical activity in a PE class. However, in the study by Costa, Oliveira, Mota, Santos, & Ribeiro (2017), it has been found that the physical activity of the students in class was not affected by BMI, but by the level of motor skill performance and the class duration.

Motor skills and motor competence can also significantly influence the level of physical activity of the students in PE classes (Barnett, Ridgers, & Salmon, 2015; Hands, Larkin, Parker, Straker, & Perry, 2009; Morrison et al., 2012; Slykerman, Ridgers, Stevenson, & Barnett, 2016). Although children have sufficient motor skills and competencies for adequate participation in organized physical activities since the age of seven (Gabbard, 2012), some studies have argued though, that physical activity in class is at a low level (Hardy, Reiten-Reynolds, Espinel, Zask, & Okely, 2012; Spessato, Gabbard, & Valentini, 2013). However, there are studies (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006) that indicate that motor skills and motor competencies have no significant impact on physical activity. Different research results exist even in relation to sex, which show that there is a positive correlation between physical activity and motor skills and competencies only in boys, but not in girls (Cliff, Okely, Smith, & McKeen, 2009).

Taking into consideration the significance of the physical activity of students in a PE class and the relatively scarce and inconsistent results of the previous research, this study has been carried out with the aim to determine to what extent motor skills and morphological characteristics contribute to the volume and the intensity of the physical activity of students in a PE class.

METHODS

The sample of participants

The study included 208 students of the third and fourth grade of elementary school (age 10±1.4 years), of which there were 107 boys and 101 girls. All of the respondents regularly attended classes in schools, as well as PE classes three times a week. The classes were held according to the prescribed PE curriculum for the third and fourth grade elementary school students. The school authorities and parents were familiar with the objective and the content of the study and their written permission was obtained in accordance with the Convention on the Protection and Rights of the Child.

Measures

Martin's anthropometer was used for measuring body height, whereas for measuring body weight, a quality digital scale was used. The selected parameters of the body composition (muscle and mass component) were measured with the *InBody 230* body composition analyzer (Biospace Co., Ltd, Seul, Korea). *InBody 230* has been used in many studies of the body structure in children (Morrison, Shin, Tarnopolsky, & Taylor, 2015; Samaras et al., 2013; Wong et al., 2013; Young, Limbers, & Grimes, 2013).

A battery of motor tests, specially modified and validated for the school population (Bala, Stojanović, & Stojanović, 2007) was used to assess motor skills. For this research, the following tests were selected: for the whole body coordination and reorganization of stereotypes of motion - *Polygon backwards (0.1 s)*, for explosive strength - *Standing long jump (cm)* and a *20 m run (0.1s)*, for the static strength of the arms and shoulder belt - *Static hold in pull-up position (0.1 s)*, for the movement frequency - *Hand tapping (freq.)*, for the flexibility - *Wide-legged forward bend seated (0.1 cm)* and for the repetitive power of the torso - *Trunk elevation (freq.)*.

The physical activity of the students in a PE class was measured using the *Coach Gear* pedometer and the *Suunto Memory Belt* pulse meter. The intensity zones were determined based on the proven research practice (Fairclough & Stratton, 2005; Falgairette, Gavarry, Bernard, & Hebbelinck, 1996; Pate, Baranowski, Dowda, & Trost, 1996), so that three categories (zones) of the physical activities have been defined: Low intensity zone (Light Physical Activity, abbrv. **LPA =** resting pulse **+** x<25% values of the resting pulse); Medium intensity zone (Moderate Physical Activity, abbrv. **MPA** = resting pulse + 25% < x < 50% values of the resting pulse); High intensity zone (Vigorous Physical Activity, abbrv. **VPA** = resting pulse + x > 50% values of the resting pulse).

Data processing

The obtained data were processed using adequate statistical procedures in the SPSS program. Descriptive statistics for the analysis of the basic research results were first used, while the method of multiple regression was used to test the predictive power of the observed predictor variables, thus establishing the linear model of the criterion variables at the level of reliability p<0.01.

RESULTS

Table 1 shows the values of the descriptive statistics of predictors and criterion variables, separately for the subsamples of boys and girls. As it can be seen in the table, apart from the Static hold in pull-up position variable, there is a normal distribution of results in all applied variables, which is a prerequisite for further processing and analysis. The girls generally showed poorer results in almost all variables, except in the variable for the assessment of flexibility, where they performed better than boys. Based on the coefficient of variation, it can be concluded that the subsamples of boys and girls are the most homogenous when it comes to body height and body weight (CV% around 5%). The greatest individual deviations in both sexes were found in the strength of the arms and shoulder belt, as well as the whole body composition, which can be attributed to differences in lifestyles, i.e. the level of habitual physical activity and nutrition, and specifically, participation in activities which involve upper extremities (e.g. climbing trees, dead hanging, pushing, throwing, etc.).

Table 1 Descriptive statistics of predictors and criterion variables among the respondents

Variables	Subsamples	AM	SD	Min	Max	CV%	KS
Body height (cm)	Boys	143.63	7.78	126.21	159.24	4.69	0.20
	Girls	142.79	7.44	125.36	166.18	5.21	0.20
Body mass (kg)	Boys	38.39	8.06	24.60	65.50	51.57	0.06
	Girls	36.56	7.84	21.80	64.90	21.45	0.10
Body fat mass (%)	Boys	8.41	4.69	2.20	23.30	56.27	0.06
	Girls	9.00	4.69	0.90	31.30	52.06	0.06
Muscle mass (%)*	Boys	15.15	2.68	9.60	23.10	17.64	0.18
	Girls	14.26	2.62	8.70	23.40	18.37	0.16
Polygon backwards (s)*	Boys	23.55	8.08	11.20	50.60	34.12	0.06
	Girls	25.30	8.10	11.30	57.00	32.01	0.06
Standing long jump (m)	Boys	142.68	20.55	56.14	190.75	14.57	0.20
	Girls	134.13	19.11	91.14	190.27	14.24	0.20
20 m run (s)	Boys	4.30	0.43	3.59	6.32	9.65	0.06
	Girls	4.49	0.44	3.73	7.11	9.71	0.06
Static hold in pull-up position (s)*	Boys	13.02	9.84	0.00	48.91	87.87	0.01
	Girls	9.28	8.50	0.00	61.04	91.09	0.01
Hand tapping (number of taps)	Boys	42.07	8.99	17.00	56.00	23.25	0.07
	Girls	37.87	8.42	20.00	64.00	22.23	0.08
Wide legged bend seated (cm)*	Boys	51.39	9.32	27.50	82.00	18.41	0.20
	Girls	54.94	10.58	31.75	84.75	19.25	0.19
Trunk elevation (number of elevations)	Boys	31.74	7.17	10.00	45.00	24.12	0.18
	Girls	28.46	6.59	7.00	43.00	23.13	0.18
Physical activity volume (number of steps)*	Boys	2411.10	416.95	609.00	3346.00	18.79	0.09
	Girls	2224.10	345.43	1352.00	3008.00	15.53	0.08
VPA (min)*	Boys	23.57	5.67	8.11	34.51	21.17	0.08
	Girls	20.63	3.52	12.34	30.10	17.05	0.07

Legend: Min – minimum value; Max – maximum value; AM – arithmetic mean; SD – standard deviation; CV% – coefficient of variation; KS – Kolmogorov-Smirnov goodness of fit test; Skew – skewness; Kurt – kurtosis; VPA – high intensity zone; * - existence of statistically significant differences between groups (t-test; $p<0.01$)

The summarized results of a series of regression analyses are shown in Table 2. The predictive power of the two models (morphological characteristics and motor abilities), as well as individual predictors for predicting the volume and intensity of the physical activity of students in a PE class have been tested. In boys, motor skills are shown to be a better predictor of physical activity in a PE class. While in girls this is the case with morphological characteristics.

Table 2 Relations of predictor variables and physical activity of students in a PE class

	Physical activity volume		Physical activity intensity	
	Boys	Girls	Boys	Girls
1.Model: Morphological Variables	R^2 23.0% (20.4%) F(4)=8.79 p<.01	R^2 24.2% (21.3%) F(4.3)=10.59 p<.01	R^2: 19.5% (16.9%) F(4)=7.96; p<.01	R^2 20.1% (18.7%) F(4.1)=8; p<.01
	β	β	β	β
Body height	ns	ns	ns	ns
Body mass	*-1.07*	*-.44*	*-1.14*	*-.49*
Body fat mass	ns	ns	ns	ns
Muscle mass	*.95*	*.57*	*.93*	*.60*
2.Model: Motor Skills	R^2 38.0% (34.5%) F(7)=9.67 p<.01	R^2 21.7% (17.8%) F(6.5)=5.33 p<.01	R^2 29.7% (25.6%) F(6.4)=6,98; p<.01	R^2 19.9% (15.8%) F(5.9)=4,69; p<.01
	β	β	β	β
Polygon backwards	ns	ns	ns	ns
Standing long jump	*.27*	ns	*.20*	ns
20m run	ns	ns	ns	ns
Static hold in pull up position	ns	ns	ns	ns
Hand tapping	*.19*	ns	*.20*	ns
Wide legged bend seated	*.23*	*.24*	*.18*	*.19*
Trunk elevation	ns	ns	ns	ns

Legend: β - value of the standardized β (beta) coefficient; ns - relations without statistical significance

DISCUSSION

In this paper we propose the aim to determine the extent to which motor skills and morphological characteristics contribute to the volume and the intensity of the physical activity of students in a PE class. The paper presents results that the predictor system of motor skills in boys explains 38% (volume of the physical activity in class), 29.7%, respectively, (intensity of the physical activity in class) of the criterion variable. This system has a greater predictive power in comparison with morphological characteristics, which explain 23% variance in the volume of physical activity and 19.5% variance in the intensity of physical activity in a PE class. At the level of individual predictors, the most significant predictors of the physical activity in boys belong to the set of morphological variables (body mass, muscle mass), followed by motor variables of the long jump, wide legged forward bend and hand tapping. More muscular boys, with less body weight, who are more explosive, flexible and have a higher speed of alternative movements, were more physically active in a PE class.

On the other hand, motor abilities in girls are a weaker predictor of physical activity in a PE class (21.7% explained variance in volume, 19.9% explained variance in intensity of the physical activity, respectively), compared to morphological abilities (24.2%, 20.1%, respectively). In a subsample of girls, the most significant individual predictors are body weight and body mass just like in boys, but their beta coefficients are lower. When it comes to motor variables, only the variable of wide legged forward bend seated is significant for prediction of physical activity in girls in a PE class, which sets the flexibility as a significant factor. The girls who possessed greater flexibility were more active in a PE class, which is in agreement with previous research (Faigenbaum et al., 2015).

The obtained results can only partially be explained with the characteristics of the motor tasks. Higher levels of the motor skills facilitate motor skills acquisition in general and make the motor skill performance more effective, which is important for active play, sports and participation in a PE class. The finding that motor skills significantly determine physical activity of students and that they have a bigger impact than their morphological characteristics is in accordance with previous findings (Cantell, Crawford & Tish Doyle-Baker, 2008; Hands et al., 2009).

As it has already been pointed out, girls and boys with less body mass and with a higher percentage of muscle mass have achieved a higher volume and intensity of physical activity in a PE class. Increased body weight and balanced body mass, which are reflected in the increased voluminosity, have a negative impact on the volume and intensity of physical activity of students (Rezende et al., 2014; Tudor-Locke, Ainsworth, & Popkin, 2008; Zan, Hyunju, & Huiping, 2011), while a higher proportion of muscle mass contributes to more effective performance of the movement tasks and more engagement of the students in class. Total body mass and muscle mass represent an important framework of physical activity in a PE class (Fisher et al., 2005; Hands et al., 2009). In some previous study, higher body mass and body fat mass were associated with lower physical activity in girls in a PE class (Farr, Van Loan, Lohman, & Going, 2012). It is interesting that the Body fat mass variable in the already formed model of predictor variables did not represent a significant individual predictor of the criterion variables.

It is interesting to note that motor skills and morphological characteristics explain a higher percentage of variance of physical activity of students in a PE class expressed in volume, i.e. the number of steps taken, compared to the intensity which was measured by the heart rate. Also, the boys were more active than the girls in both indicators of physical activity, which confirms the results from the previous studies which identified girls as a specific target group when it comes to encouraging physical activity and active participation in a PE class (Hallal et al., 2012; Lenhart et al., 2012; Pearce, Basterfield, Mann, Parkinson, & Adamson, 2012; Trost et al., 2002). The level of participation of girls in physical activity, in addition to morphological characteristics, can be significantly influenced by perceptions of their own motor competences, self-respect and perceptions related to gender-appropriate physical activity (Carrol & Loumidis, 2001; Jaffee & Manzer, 1992; Jaffee & Ricker, 1993).

CONCLUSION

By encouraging a healthy lifestyle, which implies healthy nutrition and regular physical activity, we can contribute to establishing a healthy nutritional status and increasing the proportion of the muscle mass. Physical education plays an important role in creating an active lifestyle (Mooses et al., 2017), and on the other hand, children, who are not overfed and have a well-developed musculature, will be more active in a PE class. Higher activity of the students in class allows for greater teaching effectiveness, which represents a kind of vicious circle. Teachers and PE teachers are the key figures and the quality of the PE curriculum depends on them; therefore, it is important to prepare them and support them in the realization of the innovative PE, which puts a strong emphasis on the promotion of a healthy lifestyle (Haywood, 1991).

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MORFOLOŠKE KARAKTERISTIKE I MOTORIČKE SPOSOBNOSTI KAO PREDIKTORI FIZIČKE AKTIVNOSTI STUDENATA NA ČASU FIZIČKOG VASPITANJA

Imajući u vidu da je fizička aktivnost učenika na časovima fizičkog vaspitanja značajan pokazatelj njihove motivisanosti i kvaliteta nastave, sprovedeno je istraživanje sa ciljem da se utvrdi u kojoj meri morfološke karakteristike i motoričke sposobnosti doprinose predikciji obima i inteziteta fizičke aktivnosti učenika na času fizičkog vaspitanja. Istraživanjem je bilo obuhvaćeno ukupno 208 učenika trećeg i četvrtog razreda (uzrasta 10±1,4 godina) osnovne škole (107 dečaka i 101 devojčica). Fizička aktivnost je merena po obimu pedometrom Coach Gear i po intezitetu pulsmetrom Suunto Memory Belt. Motoričke sposobnosti su testirane baterijom testova po Bali i saradnicima, a morfološke karakteristike su merene antropometrom po Martinu i pomoću analizatora telesne kompozicije InBody 230. Podaci su obrađeni metodom višestruke linearne regresije. Dobijeni rezultati ukazuju da su oba modela prediktora statistički značajna (p<0.01), pri čemu su kod dečaka motoričke sposobnosti bolji prediktor fizičke aktivnosti nego morfološke karakteristike, dok je kod devojčica suprotno. Na nivou pojedinačnih morfoloških varijabli, telesna masa i mišićna komponenta imaju najveću prediktivnu moć kod oba pola. Motoričke sposobnosti eksplozivna snaga donjih ekstremiteta, gipkost i brzina pokreta imaju najveću predikciju kod dečaka, dok je to kod devojčica jedino gipkost. Nastavnici i učitelji mogu doprineti većoj fizičkoj aktivnosti učenika na času fizičkog vaspitanja usmerenim radom na poboljšanju motoričkih sposobnosti, edukacijom učenika o fizičkoj aktivnosti i zdravoj ishrani, te na promociji zdravog životnog stila, čije su ključne odrednice redovna fizička aktivnost i pravilna ishrana.

Ključne reči: *Fizička aktivnost, motoričke sposobnosti, morfološke karakteristike, mlađi školski uzrast*.