The Relationship of Body Mass Index and Motor Abilities of Eight Grade Students

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POVEZANOST INDEKSA TJELESNE MASE I MOTORIČKIH SPOSOBNOSTI UČENIKA OSMIH RAZREDA OSNOVNE ŠKOLE

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ABSTRACT

The aim of this research was to examine the connection of body mass index of eighth grade students and their results in motor abilities test, with the purpose of gaining insight in which tests is that connection more or less expressed, or there isn't any. The sample of subjects consisted of 66 male and 64 female students from four elementary schools from the Varaždin city area, who attended eighth grade in the school year of 2018/2019 For data analysis, the results of the final testing of motor abilities were used. The sample of variables consisted of six motor tests and two anthropometrical measures, student's age and their body mass index. For all 10 variables the basic descriptive parameters were calculated (arithmetic mean, standard deviation, minimum and maximum), both for female and male students. Further data processing was done by linear regression analysis – 6 x regression analysis for each motor ability. The results of the regression analysis in male students showed statistically significant connection of body mass index and four variables (standing long jump, shuttle run with carrying objects, sit and reach and pull-up hold), while in female students the connection was significant only in two variables (standing long jump and pull-up hold). Overweight and obesity of children and adolescents is a growing phenomenon all over the world. Motor abilities are an important indicator of physical activity and one of the possible indicators of the level of fitness. Overweight and obesity, as well as underweight, negatively influence the condition and development of motor abilities, and the role of Physical education classes are of great importance in prevention and promotion of healthy living habits of students.

Key words: *exercise, body weight, activity*

INTRODUCTION

In Croatian elementary and high schools students are systematically monitored in anthropological characteristics twice a year through initial and final testings. According to Findak and Prskalo (2004), anthropological characteristics are defined as „organized systems of all traits, abilities and motor information and their mutual relations, which include anthropometric features, motor, functional and cognitive abilities, conative features and social status." There are many definitions of motor abilities, which are the subject of this research. Prskalo (2004) defines them as „latent motor structures responsible for practically infinite number of manifested motor reactions, and they can be evaluated and described. Jurko et al (2015) state in their book that motor abilities are present in performance of all kinds of motor movements, and the motor abilities tests serve for their determination.

There are many factors that influence the level of physical fitness of children and adolescents and understanding of their connection is of great significance, given that the level of physical activity is an important protective factor of later health problems (Gísladóttir, et al., 2019; Ortega, et al., 2008, Robinson, et al., 2015). Previous evidence suggest a positive association of motor abilities and a number of health indicators like the level of physical activity, cardiorespiratory fitness, muscle strength, muscle endurance and healthy body weight (Robinson, et al., 2015). Also, according to Gísladóttir et al (2019), motor abilities are one of the possible predictive factors of physical fitness level because they are an important sign of participation in physical activities of children and adolescents. The authors say that children and adolescents with low level of motor abilities tend to be less physically active, they are less likely to include in sports and they have lower level of physical fitness compared to their peers with higher level of motor abilities. Because of the mentioned, it is necessary to systematically observe the level of motor abilities of children and adolescents in schools, in order to notice irregularities in their development in time and to intervene accordingly.

Nowadays we are witnessing an increase in the trend of reduced movement of children and adolescents, their participation in physical activities, irregular diet and accordingly an increase of overweight and obesity. That the stated is a worldwide public health problem isn't the news. The most common cause of overweight in children and adolescents is excessive calorie intake without their adequate consumption through physical activity, claim Kansra, Lakkunarajah and Jay (2021) in their research. They point out the connection of overweight and different comorbidities like type two diabetes, hypertension, non-alcoholic fat liver disease, obstructive sleep apnea, and those are only some of them.

The stated diseases were once connected with an adult population, but today they also often appear in younger population. Body mass index is a simple and cheap way of body composition assessment, or level of nutrition, and there are research that point to its association with the amount of fat tissue, and future health risks (Adab, Pallan, & Whincup, 2018; Kansra, et al. 2021). Unlike body mass index calculation of adults, which is standardly obtained by the ratio of body mass and the square of height, for children and adolescents the procedure is somewhat different. Body mass index of children and adolescents aged 5 to 19 is associated with their age and sex, and it is determined by the percentile curves and standard deviation according to the recommendations of World Health organization (Kansra, et al., 2021; Mračević,

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2020; WHO, 2022). The connection of motor abilities and body mass index were the subject of many prior research (Cheng, et al., 2016; Greier, & Drenowatz, 2018; Houtari, Heikinaro-Johansson, Watt, & Jaakkola, 2018). The results in one of them suggests that higher body mass index in earlier childhood reduces the level of motor abilities five to ten years later (Cheng, et al., 2016). Research conducted on children from 5th to 8th grade showed the existence of synergistic connection between body weight and motor abilities, where the excess body weight resulted in weaker development of motor abilities, while losing the excess body weight enabled previously obese students to catch up with their normal weight peers (Greier & Drenowatz, 2018).The association between basic motor knowledge and body mass index was proven by Houtari et al (2018) on the sample of subjects 15 and 16 years of age, measured in years 2003. and 2010. It was found that basic motor knowledge have a significant effect on body mass index of both sexes.The goal of this research was to examine the connection of body mass index of eighth grade students and their results in motor abilities test, with the purpose of gaining insight in which tests is that connection more or less expressed, or there isn't any.

METHODS

Sample of subjects

The sample of subjects consisted of 66 male and 64 female students from four elementary schools from the Varaždin city area, who attended eighth grade in the school year of 2018./2019. All the students attended Physical education classes regularly and were of good health status.

Sample of variables

For the purpose of this research the results of the final motor abilities testing of eighth grade students were used. Ten variables were examined out of which six belonged to standard motor abilities tests for elementary schools (Neljak, et al., 2011), two were anthropometric variables (height – HGT and body weight -BW), student's age (exact age at the time of testing) and body mass index – BMI. Tests for measuring motor abilities were: hand tapping (HT – number of repetitions) for measuring the frequency of movement, standing long jump (SLJ – cm) for measuring explosive leg power, shuttle run with carrying objects (SRCO – sec) for testing agility, sit-ups (SU – number of repetitions) for testing repetitive trunk power, sit and reach (SAR – cm) for measuring flexibility of hamstrings and lower back, and pull-up hold (PUH – sec) for testing static arm and shoulder strength.

Testing protocol

The final testing of students' motor abilities was conducted as a part of regular Physical education class in the main part of the class, after the preparation part that consisted of general physical warm up for activities that follow. The testing was announced two weeks before. Eighth grade students don't have prior attempts in tests due to good familiarity to all of them, since they are systematically performed from the fifth grade.

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Data processing

All data were processed by the program package Statistica for Windows and the alpha level of the statistical tests was set at .05. For all 10 variables the basic descriptive parameters were calculated (arithmetic mean, standard deviation, minimum and maximum), both for female and male students. Further data processing was done by linear regression analysis – 6x regression analysis for each motor ability. Body mass index was calculated for each individual student in regard to their birth year and moth by an online BMI calculator for children and adolescents according to the guidelines of the World Health Organization (Pliva health, 2022).

RESULTS

The results of descriptive statistics for male and female students are shown in tables 1. and 2. The number and percentage of students categorized according to their body mass index and nutrition level, are shown in table 3. Consolidated results of 6 regression analysis are shown in tables 4. and 5.

Table 1. *Results of descriptive statistics for male students*

Variable	N	AM	MIN	MAX	SD
HGT	66	169.750	148.500	190.500	8.603
BW	66	64.962	35.500	107.000	17.975
HT	66	35.439	20.000	47.000	4.798
SLJ	66	195.227	95.000	250.000	31.298
SRCO	66	10.306	8.500	14.720	1.298
SU	66	52.985	30.000	82.000	10.313
SAR	66	51.258	30.000	70.000	7.117
PUH	66	33.818	1.000	80.000	22.002
age	66	13.477	-14.100	15.800	6.077
BMI	66	22.242	14.200	33.400	4.842

N: number of subjects; AM: arithmetic mean; Min: minimum value; Max: maximum value; SD: standard deviation; HGT: height; BW: body weight; HT: hand tapping; SLJ: standing long jump; SRCO: shuttle run with carrying objects; SU: sit-ups; SAR: sit and reach; PUH: pull-up hold; BMI: body mass index

Table 2. *Results of descriptive statistics for female students*

Variable	N	AM	MIN	MAX	SD
HGT	66	169.750	148.500	190.500	8.603
BW	66	64.962	35.500	107.000	17.975
HT	66	35.439	20.000	47.000	4.798
SLJ	66	195.227	95.000	250.000	31.298
SRCO	66	10.306	8.500	14.720	1.298
SU	66	52.985	30.000	82.000	10.313
SAR	66	51.258	30.000	70.000	7.117
PUH	66	33.818	1.000	80.000	22.002
age	66	13.477	-14.100	15.800	6.077
BMI	66	22.242	14.200	33.400	4.842

N: number of subjects; AM: arithmetic mean; Min: minimum value; Max: maximum value; SD: standard deviation; HGT: height; BW: body weight; HT: hand tapping; SLJ: standing long jump; SRCO: shuttle run with carrying objects; SU: sit-ups; SAR: sit and reach; PUH: pull-up hold; BMI: body mass index

Table 3. *Number and percentage of male and female students according to the category of body mass index (WHO, 2022)*

Variable	N	AM	MIN	MAX	SD
HGT	66	169.750	148.500	190.500	8.603
BW	66	64.962	35.500	107.000	17.975
HT	66	35.439	20.000	47.000	4.798
SLJ	66	195.227	95.000	250.000	31.298
SRCO	66	10.306	8.500	14.720	1.298
SU	66	52.985	30.000	82.000	10.313
SAR	66	51.258	30.000	70.000	7.117
PUH	66	33.818	1.000	80.000	22.002
age	66	13.477	-14.100	15.800	6.077
BMI	66	22.242	14.200	33.400	4.842

Table 4. *Results of the regression analysis for the relationship of body mass index and motor abilities of male students*

	BMI					
N=66	b*	Std.Err. of b*	b	Std.Err. of b	t	p
HT	0.033	0.125	0.033	0.124	0.267	0.790
SLJ	-0.455	0.111	-2.944	0.719	-4.092	0.000
SRCO	0.292	0.120	0.078	0.032	2.446	0.017
SU	-0.014	0.125	-0.029	0.266	-0.110	0.913
SAR	0.301	0.119	0.442	0.175	2.522	0.014
PUH	-0.524	0.106	-2.380	0.484	-4.917	0.000

b*: unstandardized beta coefficient; Std.Err of b*: standard error of unstandardized beta coefficient; b: standardized beta coefficient; Std.Err of b: standard error of standardized beta coefficient; t: t-test value p: level of significance; *significant at the p<.05 level; HT: hand tapping; SLJ: standing long jump; SRCO: shuttle run with carrying objects; SU: sit-ups; SAR: sit and reach; PUH: pull-up hold; BMI: body mass index

Table 5. *Results of the regression analysis for the relationship of body mass index and motor abilities of female students*

	BMI					
N=64	b*	Std.Err. of b*	b	Std.Err. of b	t	p
HT	-0.151	0.126	-0.149	0.123	-1.207	0.232
SLJ	-0.274	0.122	-1.432	0.638	-2.245	0.028
SRCO	0.137	0.126	0.032	0.029	1.092	0.279
SU	-0.040	0.127	-0.099	0.315	-0.313	0.755
SAR	0.023	0.127	0.056	0.314	0.179	0.859
PUH	-0.417	0.115	-1.667	0.461	-3.615	0.001

b*: unstandardized beta coefficient; Std.Err of b*: standard error of unstandardized beta coefficient; b: standardized beta coefficient; Std.Err of b: standard error of standardized beta coefficient; t: t-test value p: level of significance; *significant at the p<.05 level; HT: hand tapping; SLJ: standing long jump; SRCO: shuttle run with carrying objects; SU: sit-ups; SAR: sit and reach; PUH: pull-up hold; BMI: body mass index

From table 3. it can be seen that most of male students belong to the normal weight category (66,7%), but a lot of them are unfortunately overweight and obese (10,6% and 7,6%). Also, among male students not so few of them are in the thin (10,6%) and very thin category (4,5%). On the other side, the majority of female students (81,2%) are normal weight, but also among them there are 10,9% overweight and 4,7% are obese. Unlike in male students, only one female student belongs to the thin category and one to the very thin.

The results of the regression analysis for male students shown in table 4., point to statistically significant influence of BMI variable on four motor abilities: standing long jump (SLJ), shuttle run with carrying objects (SRCO), sit and reach (SAR) and push-up hold (PUH), while in variables sit-ups (SU) and hand tapping (HT) no statistically significant difference was observed. On the other side, the regression analysis for female students showed the existence of statistically significant difference only in two variables (standing long jump – SLJ and push-up hold – PUH), where in other variables the difference wasn't found.

DISCUSSION

Statistically significant connection in male students was evident in tests for evaluating explosive leg power, agility, flexibility and static arm and shoulder strength. The negative influence of BMI on tests for measuring explosive leg power, endurance and the ability to solve complex motor tasks, was obtained in the research on students 10 – 11 years of age (Šuk, 2019), which supports our findings. The association of anthropometric characteristics and motor abilities was confirmed by another research conducted on first grade students (Markutović, 2018). According to the author, the upper arm skin fold, as one of the possible indicator of nutritional status, influenced the performance of standing long jump and pull-up hold, while body weight as an anthropometric measure influenced the sit and reach performance (Markutović, 2018). The obtained part of the results also confirms our findings. Statistically significant connection of BMI and agility is confirmed by research conducted on children and adolescents aged 10 to 14, where overweight and obese students achieved notably worse results than their normal weight peers (Nunes, Izar, & de Maio, 2017).

Regarding the statistically significant difference gained in the variable pull-up hold for static arm and shoulder assessment, it could be said that this might be so because heavier students are less likely to be able to hold their entire body in the air, in comparison to lighter weight students.

Furthermore, a very week connection of BMI and hamstrings flexibility was obtained in the research by Arora, D'souza, and Yardi (2016), while research conducted on younger adult subjects hasn't established any connection (Gite, Mukkamala, & Parmar, 2021).

Although most of the subjects among male students belonged to the normal weight category, still there were 12 students who were overweight and obese, which is quite a few. Also, not few of them were in the below average weight category, which is a signal of their malnutrition. Possible reasons for such state could potentially be the reflection of substandard socioeconomic status of students, irregularities in diet or different psychological factors. The stated factors don't enter the domain of our research, but surely should be taken into consideration for the overall students' well-being. Unfortunately, in our sample of subjects, overweight is more pronounced in both male and female students, and the reasons for that may lie among the same factors. Anyway, both occurrences are equally worrying because they represent a potential health risk to students and therefore require reaction of both school and the society as a whole. There are evidence pointing to a significant increase of thinness, overweight and lack of micronutrient intake among adolescents (Rah, Chalasani, Oddo, & Sethi, 2017).

Due to extreme growth and development in that age and accordingly increase in physiological needs, an optimal food and nutrients intake is necessary in orderto satisfy daily energetic needs (Rah, et al., 2017). School age as the most sensitive time when adopting healthy living habits helps to create the foundations for health responsible life in adult age, which should be the goal of any civilized society.

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As for the female students, the regression analysis results shown in table 5., demonstrate statistically significant difference in only two variables – standing long jump (SLJ) and pull-up hold (PUH), which is consistent with the results of male students. In other variables, no significant difference was found. Among the female students the vast majority also belong to those with normal weight, but there is 10 of them in the overweight and obese category, which is certainly worrying.

Unlike in male students, where there was a larger number of thin and very thin, only two female students belonged to those categories, one to each group. The research of Fiori et al (2020) showed that underweight students were worse than their normal weight peers in the tests for upper limb strength assessment, while in tests for explosive arm power, overweight and obese students were better than the rest. Based on the obtained results, authors conclude that overweight and obesity negatively affect aerobic endurance, agility, lower limb power and balance, but positively influence only explosive upper limb power. Underweight on the other hand, negatively affects upper limb power (Fiori, et al. 2020). As the mentioned research used the test for evaluating explosive power of the arms and shoulders, and not static power, the connection to our research cannot be drawn. But still, as indicated in the previously stated research by Markutović (2018), static arm and shoulder strength in the pull-up hold test is negatively associated with higher BMI, which is consistent with our results in this test.

The fact that women tend to be naturally more flexible than men is confirmed by the research conducted on the population of subjects aged 6 to 30 (Valdivia, et al., 2009), as well as by another research on subjects between 20 and 79 years of age (Youdas, et al., 2005). In both of them, the flexibility of hamstrings and lower back was examined, which is precisely what the sit and reach test in our research is used for. It is possible that because of the stated our results of female students in the same test didn't show statistical significance, regardless of the level of nutrition.

Isokinetic indicators of the trunk power in the research of Al-Shenqiti, Emara, Algarni and Khaled (2021), point out that overweight and obesity of adolescents are related to reduced trunk power. BMI of older adolescents negatively correlates with power and endurance of the trunk regardless of sex (Pasupatham, Muthulakshmi, Subbiah, & Revathi, 2021).

On the other hand, research conducted on subjects aged 18 to 25 also shows negative correlation between BMI and trunk power, but only in female subjects (Motka and Shah, 2012). The power of more abdominal muscles was tested by various tests, but negative correlation wasn't obtained in any of the variables in male subjects. Our research hasn't shown significant connection in the sit-ups test for repetitive trunk power assessment in students of both sexes, which partially coincides with the aforementioned research, but we can't say with certainty why is that so.

Possible reasons may lie in not well enough described sample of subjects, which would certainly be an insufficiency of our research and a guideline for the future ones.

Limitations of this research lie in the fact that in the sample of subjects, students that participate in sports in their free time, or any other regular physical activities, weren't singled out, what could have influenced the results. Those students surely have higher level of motor abilities in comparison to their peers that lead a more sedentary lifestyle, which could have impacted the results.

Research of Puciato and et al (2011) and of Ignasiak, Slawińska and Domaradzki (2002) say that certain motor abilities can be influenced by the objective quality of life of children and their families, as well as the socioeconomic status, all of which wasn't covered by our research. Eating habits of the subjects are another important variable also omitted by our research. The information about all the mentioned variables could be gathered by a questionnaire before conducting the testing in future research on similar topics, which would describe the sample of subjects in a more detailed way, and thereby enable making more accurate conclusions. Because motor abilities are an important health indicator, and there are many factors associated with them, it is necessary to conduct future research that would explain more clearly what else can influence or interfere with their progression required for proper growth and development of children and adolescents.

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CONCLUSION

A growing trend of obesity and overweight of children and adolescents is present all over the world (Cali, & Caprio, 2008), which is certainly worrying. Obesity increases the risk of occurrence of many physical and psychological illness (De Leonibus, Marcovecchio, & Chiarelli, 2012; Kansra, et al. 2021; Gurnani, Birken, & Hamilton, 2015; Sahoo, et al., 2015; Rankin, et al., 2016; Topcu, et al., 2016; Witchel, Burghard, Tao, & Oberfield, 2019), and those children are in danger of premature death (Cali, & Caprio, 2008). On the other side, malnutrition and nutritional deficit in the period of intensive growth and development is also very important for overall health status of adolescents. Both conditions surely affect certain disorders which could momentarily have unwanted consequences in terms of health, as well as later in adult life. Motor abilities are, as previously mentioned, an important indicator of participation in physical activities (Mračević, 2020). It is particularly important to develop them in childhood and adolescents in order to acquire habits and set the foundations for leading a healthy, active and quality life in adult age. Calculating the BMI of children in schools along with measuring their motor abilities are one of the ways that can help identify potential health problems of students. It is precisely because of the stated that Physical education classes in elementary and high schools play an irreplaceable role in systematic monitoring the student's health status, and increasing its weekly teaching hours is of outmost importance for healthy development of children and adolescents.

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SAŽETAK

Cilj ovog istraživanja bio je utvrditi povezanost indeksa tjelesne mase učenika osmih razreda sa rezultatima u testovima motoričkih sposobnosti. Svrha istraživanja je dobivanje uvida u kojim je testovima ta povezanost više, odnosno manje izražena, ili povezanosti nema. Uzorak ispitanika činilo je 66 učenika i 64 učenice iz četiri osnovne škole sa područja grada Varaždina koji su polazili 8. razred školske godine 2018./2019. Za potrebe istraživanja korišteni su rezultati finalnih provjeravanja motoričkih sposobnosti u 8. razredima šk.god. 2018./2019. Uzorak varijabli činilo je njih deset: 6 motoričkih, 2 antropometrijske, dob učenika i indeks tjelesne mase. Za svih 10 varijabli izračunati su osnovni parametri deskriptivne statistike (aritmetička sredina, standardna devijacija, minimalna i maksimalna vrijednost), posebno za učenike te učenice. Daljnja obrada podataka učinjena je pomoću regresijske analize - 6x linearna regresija za svaku varijablu (motoričku sposobnost) posebno. Rezultati regresijske analize kod učenika pokazali su statistički značajnu povezanost indeksa tjelesne mase i četiri varijable (skok u dalj s mjesta, prenošenje pretrčavanjem, pretklon raznožno i izdržaj u visu zgibom), dok se kod učenica statistička značajnost očitovala u samo dvije (skok u dalj s mjesta i izdržaj u visu zgibom). Pretilost i prekomjerna tjelesna težina djece i adolescenata rastuća su pojava u cijelom svijetu. Motoričke sposobnosti jedan su od važnih pokazatelja bavljenja tjelesnim aktivnostima te jedan od mogućih pokazatelja razine tjelesne kondicije. Prekomjerna tjelesna težina negativno utječe na stanje i razvoj motoričkih sposobnosti te je utjecaj tjelesne i zdravstvene kulture od iznimnog značaja u prevenciji i promociji zdravih životnih navika učenika.

Ključne riječi: *vježbanje, tjelesna težina, aktivnost*

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