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STUDY ON THE RELATIONSHIP BETWEEN BMI AND VERTICAL JUMP IN CHILDREN

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Abstract

It is well known that the sedentary lifestyle is a major factor that leads to childhood overweight and implicitly to a low level of physical fitness. Childhood obesity is growing at an alarming pace, which allows us to talk about a real phenomenon of modern society. This phenomenon is recognized nowadays as a pathology that alters the well-being of mankind, as well as the social life of individuals. Against this background, the purpose of our study is to highlight a possible relationship between BMI (body mass index) and leg extensor power in children aged 8-9 years, which is indirectly assessed using the Jump-and-reach test, according to instructions specified in the *Tester's Manual for ALPHA-FIT Test Battery* (Suni, Husu, & Rinne, 2016). The research was conducted between 15 January and 25 March 2017 on a group made up of 177 children (both boys and girls), 51 being athletes and 120 attending the physical education classes provided by the school curriculum. Among the participants in physical education classes, 60 of the selected subjects had a BMI indicating overweight or obesity. BMI has an impact on the vertical jump scores achieved by the groups of subjects who do not practice performance sports, while in the case of athlete subjects, BMI has little influence.

Keywords: BMI, children, leg extensor power, vertical jump.

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1. Introduction

Across the world, there is a worrying phenomenon of rise in child obesity, which has reached alarming proportions in the European Union. 14 million children are overweight and their number increases annually by 400,000. This is why campaigns in all European countries require the Union to recognise obesity as a chronic disease.

The definition of infantile obesity is complex, because it occurs during child growth and development, the evolution rate of an individual not being the same as that of the same-age peers.

It is known that the percentage of active mass and fat tissue varies with age: from 17% at birth, fat tissue reaches 30% at 1 year old; around the age of 2, this is diminishing as the child begins to walk, run, play, the muscle mass reaching 21.7% of the total weight of the body around the age of 6. Low muscle mass and fitness are associated with metabolic risk, and muscular strength is positively related to higher insulin sensitivity in children and adolescents (McCarthy et al., 2013).

Obesity can be established in various ways, but the standard method is the Body Mass Index (BMI) (Centres for Disease Control and Prevention, 2016).

According to Chainé et al. (1989), BMI as an excellent indicator of the level of fitness and, implicitly, of health. It is an important indicator in infantile somatic screening that can identify early obese children or those at high risk of obesity; therefore, the weight and height of each child should be measured regularly.

BMI is calculated the same way for adults and children, but the results are interpreted differently. For adults, BMI classifications do not depend on age or gender. For children and adolescents between 2 and 20 years old, BMI is interpreted relative to a child's age and gender, because the amount of body fat changes with age and varies by gender.

In children, BMI is related to growth curves by age and gender, thus staging the growth curve of each child. Depending on the position of this curve relative to the mean values, a child weighing between 6 and 85% percentiles is considered to be normal. A child whose weight curve is below 5% percentile is considered to be underweight, one whose curve is over 85% percentile - overweight, and over 95% percentile - obese, according to the growth graphs developed by the National Centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion.

"The percentile refers to the position of a child on a given reference distribution which is often age-gender-specific. Percentiles are recommended to assess children's growth and nutritional status in view of considering anthropometric measures, as well as other health conditions." (Noha et al., 2016)

The study performed by Grund et al. (2000) indicated that overweight and obese children were less fit and watched TV more than their normal weight counterparts. Muscle strength was not associated with fat mass in young children, but was inversely associated with fat mass in older children (8-11 years old).

The relationship between BMI and the sports performance of children is a little studied topic in the literature.

In basketball, the jumping and running performance of overweight children is lower than that of normal-weight players, which has not been found in older age groups (Nikolaidis et al., 2015).

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A special study on volleyball players aged 18-30 years highlights that maximal vertical jump height correlates positively with muscle mass in the lower limbs and in all body as well, expressed in percentage value of body mass (Białoskórska et al., 2016).

Another study reveals that vertical jump height of martial arts athletes aged 18 to 24 years can be predicted by body fat % (Nahdiya & Mohd, 2013).

2. Problem Statement

Vertical jump is the most popular indirect method for assessing leg extensor power in populations of different ages, genders and physical condition levels, in this research being used the Jump-and-reach test. Explosive power is a very important motor quality in many sports, and the problem related to the possibility of improving vertical jump in the pre-puberty period remains controversial; however, the assessment of vertical jump height in children aged 8-9 years has not yet received much attention. Consequently, it is essential to identify the factors that contribute to vertical jump height in children. Besides the biomechanical and physiological factors, the anthropometric characteristics also play a significant role in performing vertical jump; BMI is a significant anthropometric parameter, but its impact on the results achieved by children in vertical jump is little addressed in specialized studies.

3. Research Questions

It is known that BMI is an indicator of the level of fitness and implicitly of health, but this research investigates whether BMI values influence vertical jump performance in children aged 8-9 years.

4. Purpose of the Study

The purpose of this study is to examine the relationship between BMI and vertical jump in children aged 8-9 years, divided into the 3 groups of the experiment group.

5. Research Methods

The following research methods were used in the study: scientific documentation, which provided the theoretical foundation of the paper, experimental method, graphical method, statistical and mathematical method – simple linear regression, testing and measurement methods.

The Jump-and-reach test used in this study was performed as indicated in the *Tester's Manual*. The aim is to jump as high as possible. The subject stands beside the jump-board facing forward. The dominant upper extremity is raised up straight against the jumping board. The "standing height" is marked with magnesium powdered middle finger. After that, vertical jumps are performed. Jump as high as possible, using your hands to enhance your performance. You may flex your knees to enhance the performance, but whole feet must stay on the floor. During the jump, touch the board with your middle finger while at the highest position. The vertical difference between "standing height" and "jumping height" is measured in centimetres with a tape measure. The maximal jump height is in centimetres.

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5.1. Subjects

In order to carry out the research experiment, children of both genders, aged 8-9 years, were selected, as they participated in physical education classes, some of them being in a sports school with 4 hours of weekly athletic training, beside the physical education classes provided in the school curriculum.

The study was conducted on a group of 177 children divided into 3 groups: the first group had 60 normal-weight children (31 girls and 29 boys), the second group consisted of 51 athletes (21 girls and 30 boys), and the third group had 60 subjects (30 girls and 30 boys) with a BMI indicating overweight/ obesity. Of the total, 89 participants were female and 88 male.

The research took place between 15 January and 25 March 2017, benefiting from the help of several colleagues from the schools of Bucharest.

6. Findings

The first group – Girls. Simple linear regression

Table 01. Descriptive statistics. The first group – Girls

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	20.61	4.19	0.405*	0.024	0.164	0.135
BMI	15.40	1.51				

* Correlation is significant at the 0.05 level (2-tailed).

There is a significant correlation between VJ and BMI, R = 0.405, p = 0.024 <0.05, 13.5% of VJ variable is due to the BMI variable. The mean value of VJ is 20.61 cm and the mean BMI is 15.40 kg/m^2. The regression model is valid, F = 5.699, P = 0.024 <0.05, according to ANOVA.

Table 02. Coefficients[a]. The first group – Girls

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	3.228	7.316	0.000	0.441	0.662	-11.736	18.191
	BMI	1.129	0.473	0.405	2.387	0.024	0.162	2.096

a. Dependent Variable: VJ

Regression equation: VJ = 3.228 + 1.129 BMI

The increase in BMI by one unit has the effect of increasing vertical jump performance by 1.129 cm. In Figure 01, the pairs of points (BMI, VJ) and the regression line are graphically represented. The coefficient of BMI variable may take values within the confidence range of 0.162; 2.096 (95.0% Confidence Interval for B).

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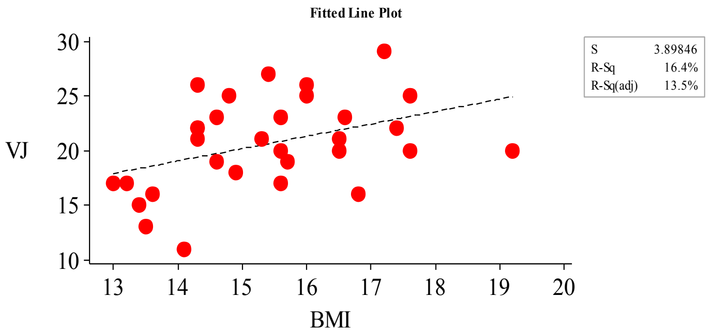

Figure 01. Fitted line plot. The first group – Girls

The first group – Boys. Simple linear regression

Table 03. Descriptive statistics. The first group – Boys

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	22.43	5.38	.609**	0.001	0.375	0.352
BMI	16.23	1.58				

**. Correlation is significant at the 0.01 level (2-tailed).

There is a significant correlation between VJ and BMI, R = 0.609, p = 0.001 <0.05, 35.2% of VJ variable is due to the BMI variable. The means of the two variables are 22.43 cm for VJ and 16.23 kg/m^2 for BMI. The regression model is valid, F = 15.347, P = 0.001 <0.05, according to ANOVA.

Table 04. Coefficients[a]. The first group – Boys

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-11.30	8.618	0.000	-1.297	0.206	-28.891	6.537
	BMI	2.079	0.528	0.609	3.917	0.001	0.983	3.155

a. Dependent Variable: VJ

Regression equation: VJ = -11.30 + 2.079 BMI

The increase in BMI by one unit has the effect of increasing vertical jump performance by 2.079 cm. In Figure 02, the pairs of points (BMI, VJ) and the regression line are graphically represented. The coefficient of BMI variable may take values within the confidence range of 0.983; 3.155 (95.0% Confidence Interval for B).

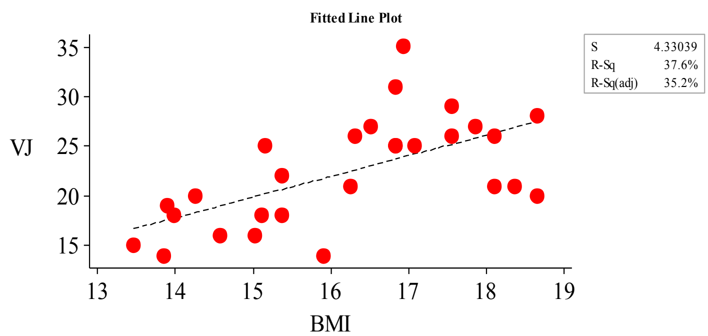

Figure 02. Fitted line plot. The first group – Boys

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The second group – Girls. Simple linear regression

Table 05. Descriptive statistics. The second group – Girls

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	25.24	4.21	0.042	0.856	0.002	0.051
BMI	16.81	1.65				

There is no significant correlation between VJ and BMI, R = 0.042, p = 0.856> 0.05. The mean value of VJ is 25.24 cm and the mean BMI is 16.81 kg/m^2. The regression model is not valid, F = 0.034, P = 0.856> 0.05, according to ANOVA.

Table 06. Coefficients[a]. The second group – Girls

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	23.43	9.878	0.000	2.372	0.028	2.751	44.103
	BMI	0.108	0.585	0.042	0.184	0.856	-1.117	1.332

a. Dependent Variable: VJ

Regression equation: VJ = 23.43 + 0.108 BMI

Because the model is not valid, the effect predicted by the regression equation does not accurately show the increase of performance by 0.108 cm, in the case of the increase in BMI by one unit. In Figure 03, the pairs of points (BMI, VJ) and the regression line are graphically represented. The fact that VJ does not correlate with BMI is reflected in the graph by the position of the regression line, which tends to a position parallel to the Ox axis (BMI).

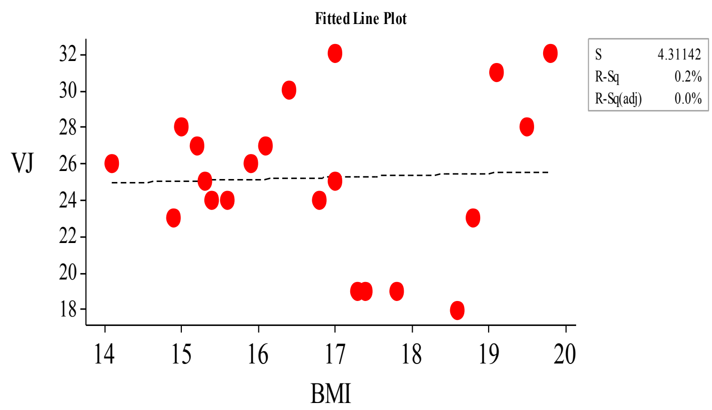

Figure 03. Fitted line plot. The second group – Girls

The second group – Boys. Simple linear regression

Table 07. Descriptive statistics. The second group – Boys

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	25.43	4.62	-0.227	0.227	0.052	0.018
BMI	16.57	1.38				

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There is a correlation between VJ and BMI, but it is not significant, R = -0.227, p = 0.227> 0.05. The mean VJ is 25.43 cm and the mean BMI is 16.57 kg/m^2. The regression model is not valid, F = 0.034, P = 0.856> 0.05, according to ANOVA.

Table 08. Coefficients[a] . The second group – Boys

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	38.082	10.268	0.000	3.709	0.001	17.049	59.115
	BMI	-0.763	0.618	-0.227	-1.236	0.227	-2.029	0.502

a. Dependent Variable: VJ

Regression equation: VJ = 38.082 - 0.763 BMI

Since the model is not valid, the effect predicted by the regression equation is not rendered correctly. In Figure 04, the pairs of points (BMI, VJ) and the regression line are graphically represented. The position of the regression line with the upper right-left down direction indicates a negative correlation.

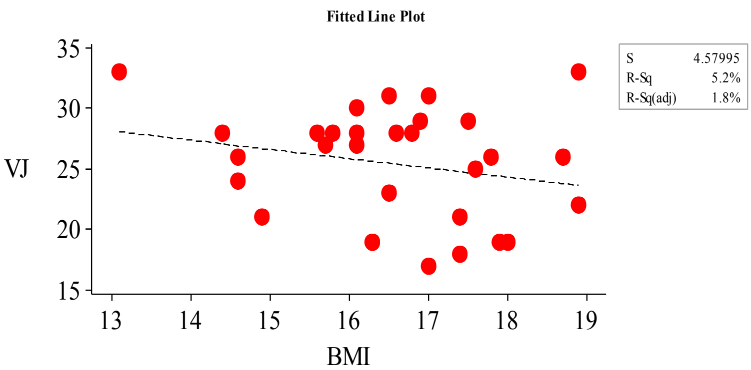

Figure 04. Fitted line plot. The second group – Boys

The third group – Overweight girls. Simple linear regression

Table 09. Descriptive statistics. The third group – Overweight girls

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	17.27	3.89	-.721**	< 0.001	0.520	0.503
BMI	19.68	1.40				

** Correlation is significant at the 0.01 level (2-tailed).

There is a very significant negative and significant correlation between VJ and BMI, R = -0.721, p <0.001 <0.05, and 50.3% of variation in the VJ variable is due to the BMI variable. The means corresponding to the two variables are equal to 17.27 cm for VJ and 19.68 kg/m^2 for BMI. The regression model is valid, F = 30.350, P <0.001 <0.05, according to ANOVA.

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Table 10. Coefficients[a]. The third group – Overweight girls

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	56.58	7.155	0.000	7.909	0.000	41.930	71.242
	BMI	-1.998	0.363	-0.721	-5.509	0.000	-2.741	-1.255

a. Dependent Variable: VJ

Regression equation: VJ = 56.58 - 1.998 BMI

The regression equation indicates a predicted decrease in VJ performance by 1.998 cm if BMI increases by one unit, the subjects being overweight. In Figure 05, the pairs of points (BMI, VJ) and the regression line are graphically represented. The downward position of the regression line reflects the negative correlation of the two variables.

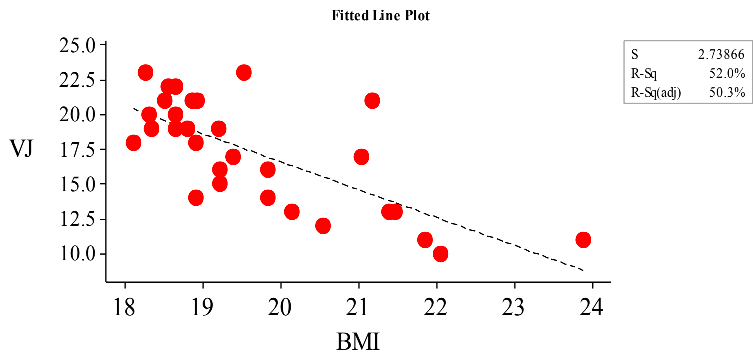

Figure 05. Fitted line plot. The third group – Overweight girls

The third group – Overweight boys. Simple linear regression

Table 11. Descriptive statistics. The third group – Overweight boys

Variable	Mean	Std. Deviation	R	P	R2	R2 adj
VJ	19.73	2.95	-.589**	0.001	0.346	0.323
BMI	20.63	1.23				

** Correlation is significant at the 0.01 level (2-tailed).

There is a very significant negative and significant correlation between VJ and BMI, R = -0.589, p = 0.001 <0.05, and 32.3% of the variance of VJ variable is due to the BMI variable. The mean VJ is equal to 19.73 cm and the mean BMI is 20.63 kg/m^2. The regression model is valid, F = 14.841, P = 0.001 <0.05, according to ANOVA.

Table 12. Coefficients[a]. The third group – Overweight boys

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	48.93	7.596	0.000	6.444	0.000	33.386	64.504
	BMI	-1.415	0.367	-0.589	-3.852	0.001	-2.168	-0.663

a. Dependent Variable: VJ

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Regression equation: VJ = 48.93 - 1.415 BMI

The regression equation indicates a predicted decrease in VJ performance by 1.415 cm if BMI increases by one unit, the subjects being overweight. In Figure 06, the pairs of points (BMI, VJ) and the regression line are graphically represented. The downward position of the regression line indicates the negative correlation between the two variables.

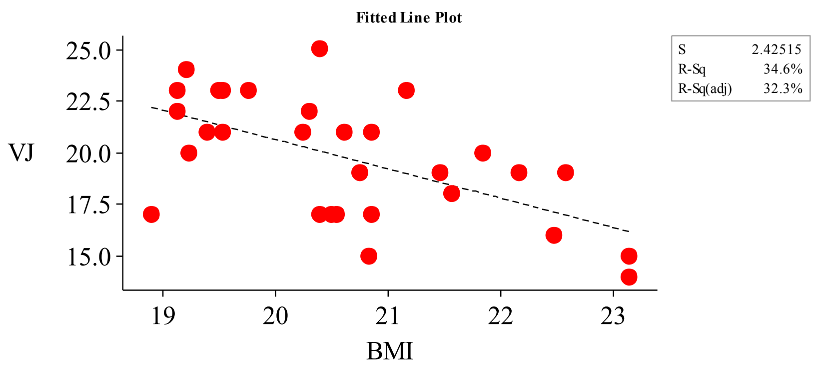

Figure 06. Fitted line plot. The third group – Overweight boys

7. Conclusion

The averages achieved by the 3 groups of children indicate better performance for VJ in boys than girls. For the group of athletes, there were recorded VJ averages of very close relevance for both genres.

Following the statistical processing, it has been revealed that, in the case of subjects of both genders participating in physical education classes, there is a significant correlation, which indicates the existence of an interdependence relationship between the two studied parameters.

In the overweight group, there is a strongly negative and significant correlation between VJ and BMI in both girls and boys (R = -0.589, p = 0.001 <0.05, 32.3% of variation in the VJ variable, which is due to the BMI variable), so a BMI that is above the 85% percentile leads to decreased performance in the case of VJ.

Regarding the group of subjects who practice sports on a regular basis (6 hours per week), it has been recorded a statistically insignificant correlation, the influence of BMI being low, which indicates an obvious influence of the factors involved in the specific training.

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