Original article

The Impact of Physical Activity and Sports on Academic Achievement of Students in Primary and Secondary Schools in Osijek-Baranja County, Croatia

Anja Vučić [*1], Vesna Bilić-Kirin [2,3]

1 Healthcare Centre, Family Medicine, Vukovar-Srijem County, Vinkovci, Croatia
2 Institute of Public Health for the Osijek-Baranja County, Department of Medicine for School-Age Children, Osijek, Croatia
3 Faculty of Medicine Osijek, Josip Juraj Strossmayer University of Osijek, Croatia

*Corresponding author: Anja Vučić, anja_osk@hotmail.com

Abstract

Introduction: The study aimed to examine the prevalence of sports outside of regular school classes among primary and secondary school students. The secondary aim was to study the correlation of physical activity, students' socioeconomic status and parents' level of education with students' educational outcomes.

Material and Methods: Data were collected from medical records of the Croatian Institute for Health Insurance in the Osijek-Baranja County and through regular physical examination of students in the fifth and eighth grade of primary school and the first grade of secondary school.

Results: Over a 5-year period, 120 boys and 141 girls were examined; 66.28% of the students were involved in sports activities in the fifth grade, 49.04% were involved in sports in the eighth grade, and in the first grade, 43.68% of students were involved in sports. No statistically significant differences were observed in the seventh and eighth grade of primary school ($p = 0.076$) and in the first grade of secondary school ($p = 0.057$). Students in the seventh and eighth grade who played sports had slightly higher grades (4.45 ± 0.68) compared to those who did not participate in sports activities (4.3 ± 0.69). Similar results were obtained for students who were involved in sports in the first grade of secondary school, who had achieved slightly better results in the seventh grade (4.41 ± 0.69) compared to those who did not participate in sports activities (4.41 ± 0,69).

Conclusion: The results of this study suggest that physical activity in children could be associated with better school performance, which may have implications for sports having positive health benefits in both childhood and adulthood.

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Introduction

The link between exercise and children's mental functioning has not, until recently, been systematically researched (1). Exercise in childhood is associated with greater cognitive control, memory and academic achievement (2-6,1,7-9). Growing evidence suggests that cognitive and academic differences due to exercise may have an underlying cerebral biological foundation. Specifically, children that are more active have greater brain structural volume in the hippocampus and dorsal striatum, two subcortical regions important for memory and learning, as well as more efficient brain activation patterns measured by magnetic resonance imaging (MRI) and event-related potential (ERP) during surveillance and interference tasks over lower-ability peers (3-6,1,7,10-12). It is believed that exercise increases both cerebral blood flow and alertness, accelerates the development of brain-derived neurotrophic factor related to neuronal growth and plasticity, as well as stimulates angiogenesis and neurogenesis in the hippocampus. Besides, research has shown that there might be indications of vascularization and irregular growth in the prefrontal cortex in brain regions related to executive functions (13-17).

Exercise could improve other biological outcomes such as bone density, arterial wall elasticity and general mental health (18,19). Despite the many benefits of physical activity and exercise, obesity in children is a growing problem in developed countries. In 2011, 31.8% of school children were found to be overweight and 7.9% of children in Europe were obese (20).

Childhood obesity has been shown to increase the risk of chronic diseases in adulthood, such as cardiovascular disease, type 2 diabetes, certain types of cancer, and osteoarthritis (21,22). Important adverse effects on growth, blood pressure, lipids, and glucose metabolism, as well as respiratory problems such as asthma and obstructive sleep apnoea have also been reported. Childhood obesity is also considered to be an important risk factor for early adulthood myocardial infarction (23-27). Based on the abundance of positive effects, physical activity and exercise, as well as playing sports in school, may be beneficial to children; in contrast to obesity, physical activity has a potential positive correlation with academic achievement (28,29).

Material and Methods

For this study, data were obtained from medical records of the Croatian Institute for Health Insurance in the Osijek-Baranja County in the period between 2013 and 2018. Data were collected through regular longitudinal physical examinations conducted in the fifth and eighth grade of primary school and in the first grade of secondary school. The study sample included 120 boys and 141 girls from Osijek and Baranja. Additional data collected included participation in sports activities throughout the fifth and eighth grade of primary school and the first grade of secondary school, academic achievement at the end of the fourth, seventh and eighth grade of primary school, form of education continued after primary school (in regard to vocational and grammar school education programmes). Physical characteristics, which include body mass index (BMI) and the locomotor system, were also reported. Demographic data containing socioeconomic factors, such as the place of residence, parents' professional qualifications and their age, were likewise collected. Written parental consent was obtained before conducting this study. The study was approved by the Ethics Committee of the Institute of Public Health for the Osijek-Baranja County.

Statistical analysis

The data were statistically analysed using the Statistica software (StatSoft, Oklahoma, USA, version 11). Categorical variables are presented descriptively, using absolute and relative frequencies, and numerical variables are presented using arithmetic mean and standard deviation. Distribution was tested for normality using the Kolmogorov-Smirnov test. Differences between categorical variables were examined

using the $\chi 2$ test, and among numerical variables, one-way and two-way repeated measurements ANOVA was used. P-levels lower than 0.05 were considered statistically significant.

Results

The study included 120 boys and 141 girls (p = 0.194), 59% of them living in a city and 41% living in the countryside. Considering the parents' level of education, 59% of mothers and 62.45% of fathers completed secondary education, 28.35% of mothers and 27.2% of fathers are university graduates, while 12.64% of mothers and 10.34% of fathers finished primary school. 54.02% of students enrolled in a vocational school and 45.98% went to a grammar school (Table 1).

Table 1. General information about the respondents

		N (%)	p	
Gender	Male	120 (45.98)		0.194*
	Female	141 (54.02)		
Respondents' secondary school	Vocational school	141 (54.02)		0.194*
	Grammar school	120 (45.98)		
Involved in sports	5th grade of primary school	173 (66.28)	< 0.001*	
	8th grade of primary school	128 (49.04)	0.757*	
	1st grade of secondary school	114 (43.68)	0.041*	
Academic achievement, 4th grade of primary school	4th grade of primary school	4.7 ± 0.5	< 0.001†	
	7th grade of primary school	4.38 ± 0.69		
	8th grade of primary school	4.48 ± 0.6		

* χ 2 test, †repeated measures ANOVA, data are expressed and arithmetic mean and s.d. – standard deviation

When observing academic achievement, the grade point average in the fourth grade of primary school was 4.7 ± 0.5, in the seventh grade it was 4.38 ± 0.69, and in the eighth grade it was 4.48 ± 0.6. In the fifth grade of primary school, 66.28% of students were involved in sports, 49.04% were involved in sports activities in the eighth grade, and 43.68% were involved in sports in the first grade of secondary school.

Statistically significant differences were found in BMI percentiles (p < 0.001). In the fifth grade of primary school, the average BMI percentile was 65.6 ± 28.74, in the eighth grade, it was 59.48 ± 27.55, and in the first grade of secondary school, it was 59.43 ± 28.23.

An increase in the incidence of scoliosis is observed in older students. The lowest percentage of scoliosis (4.6%) was observed in the fifth grade of primary school, while twice as many eighth grade students (9.2%) had scoliosis; however, the highest number was observed in the first grade of secondary school (12.25%). In contrast, the students' posture improved inversely. Fifth and eighth grade students had an overall poor posture (20.31%), while an improvement was observed in the first grade of secondary school, where the numbers decreased (17.24%).

Observing the students' feet, an increase of about 12% was observed in the proportion of

normal findings with increasing age of the students (p = 0.008). In the fifth grade of primary school, the proportion of regular findings was 60.77%, in the eighth grade it was 60.92%, and in the first grade of secondary school it was 72.03% (Table 2).

Table 2. The physical status of the spine and feet

		5th grade of primary school	8th grade of primary school	1st grade of secondary school		
		N (%)			p*	
Physical findings of the spine	**Proper**	196 (75.1)	181 (69.35)	176 (67.43)	< 0.001	
	Kyphosis	0 (0)	3 (1.15)	8 (3.07)		
	Scoliosis	12 (4.6)	24 (9.2)	32 (12.26)		
	Poor posture	53 (20.31)	53 (20.31)	45 (17.24)		
Normal findings, feet status		158 (60.77)	159 (60.92)	188 (72.03)		0.008

* χ 2 test

No statistically significant interactions were observed between academic achievement and sports. The highest achievement in all cases was in the fourth grade of primary school, followed by a decline in achievement and then an increase in the eighth grade of primary school (Figure 1). Statistically significant values were not recorded in the seventh grade, but were present in the eighth grade (p = 0.076) and in the first grade of secondary school (p = 0.057). Students who were involved in sports in the eighth grade of primary school had a slightly higher achievement rate in the seventh grade (4.45 ± 0.68) compared to those who did not play sports (4.3 ± 0.69). Similar results were found for students who played sports in the first grade of secondary school, who had a better performance in the seventh grade (4.41 ± 0.69) compared to those who did not play sports (4.41 ± 0.69) (Table 3)..

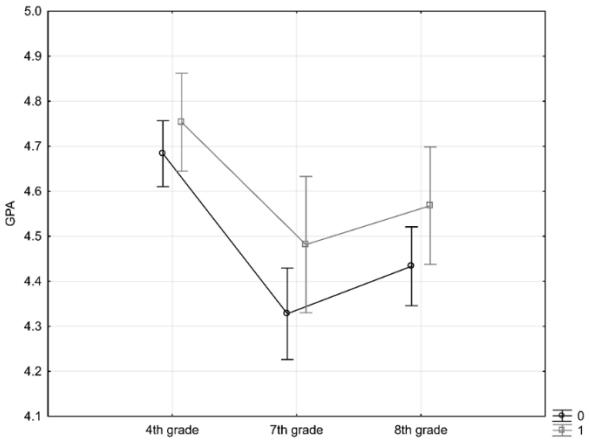
Table 3. The correlation between academic achievement and sports

		Achievement in the 4th grade	p**	Achievement in the 7th grade	p**	Achievement in the 8th grade	p**	p*
Playing sports in the 5th grade	No	4.64 ± 0.53	0.112	4.32 ± 0.64	0.493	4.47 ± 0.57	0.509	0.401
	Yes	4.74 ± 0.48		4.4 ± 0.72		4.48 ± 0.62		
Playing sports in the 8th grade	No	4.68 ± 0.53	0.447	4.3 ± 0.69	0.076	4.41 ± 0.62	0.452	0.16
	Yes	4.73 ± 0.46		4.45 ± 0.68		4.54 ± 0.57		
Playing sports in the 1st grade of secondary school	No	4.69 ± 0.51	0.859	4.35 ± 0.69	0.057	4.45 ± 0.6	0.424	0.923
	Yes	4.73 ± 0.48		4.41 ± 0.69		4.51 ± 0.6		

* two-way ANOVA, * Student's t-test

Figure 1. presents the relationship between GPA and sports activities at three different points in time. No statistically significant differences in interactions were found (p = 0.437). There are indications that students who were involved in sports throughout their education had slightly higher academic achievement, although the results are not statistically significant.

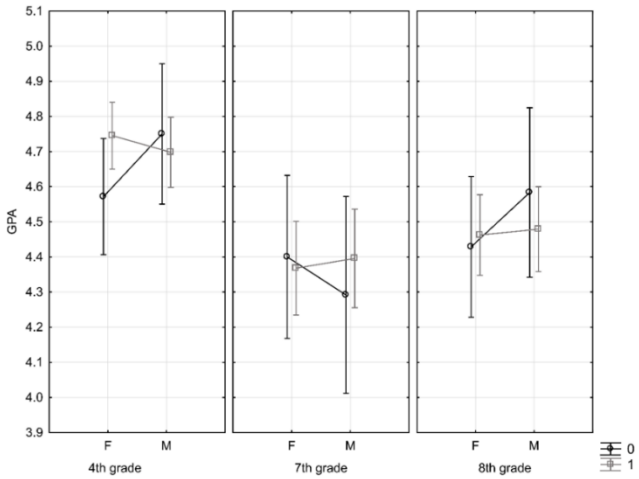
Figure 1. The relationship between GPA and sports activities at three different points in time



GPA – grade point average, 0 – no sports activities, 1 – sports activities during all school years, p = 0.437

Figure 2. presents GPA scores in children who were involved in sports for at least one school year. Statistically significant differences were found in the interactions (p = 0.048). In the fourth grade of primary school, girls who played sports had higher academic achievement than those who did not play sports, while this difference was not statistically significant in boys. In the seventh grade of primary school, the differences were not statistically significant, and there was considerable variety in the results of children who did not play sports compared to those who did. It is similar in the eighth grade of primary school. Girls who played sports had slightly better achievement than those who did not, but the results were not statistically significant.

Figure 2. GPA scores in children who were involved in sports for at least one school year



GPA – grade point average, 0 – no sports activities, 1 – sports activities during at least one school year, p = 0.048

Figure 3. Impact of parents' level of education on academic achievement of students

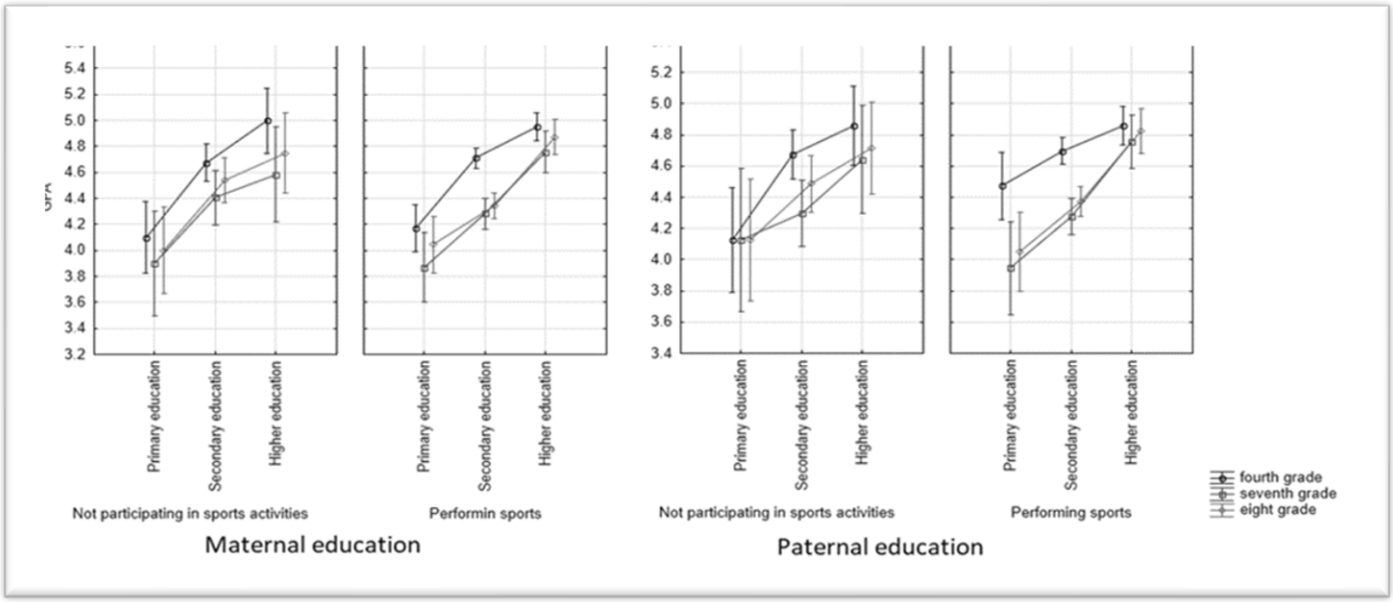


Figure 3 contains school outcomes in different grades, based on students' sports activities and their parents' professional qualifications. Based on the parents' levels of education, no differences were observed in the interactions between their professional qualifications and sports activities ($p = 0.173$ for maternal, and $p = 0.109$ for paternal education).

Discussion

The recommended daily amount of moderate to vigorous physical activity is 60 minutes (18,30). Only one third of young people worldwide are found to be sufficiently active (31). A population-based study found that more than 50% of children in Australia did not meet these recommendations (32-35). According to the National Health and Nutrition Examination Survey (NHANES), only 42% of children in America participate in the recommended daily amount of physical activity (36,35), while approximately 67% of children and young people in Canada do not participate in the recommended amounts of daily physical activity (37). A study from Japan, however, states that, according to a 2017 National Nationwide Survey conducted by the National Institute for Educational Policy Research, 67.3% of third-year secondary school students participated in extracurricular sports activities, and 83.7% of such students were involved in sports for 1 hour a day or more (38).

From the data collected in physical examinations in the Osijek and Baranja area, we could not determine how much daily activity was moderate to severe physical activity, but what we noted was that in the fifth grade of primary school, 66.28% of students were involved in sports, in the eighth grade it was 49.04% students, and in the first grade of secondary school, it was only 43.68% students. Although increasing physical activity and playing sports has been suggested as a way of improving children's health and academic achievement, there have often been contradictions between various studies regarding exercise, aerobic exercise and academic achievement. This may be due to a lack of measurement parameters if only physical activity or exercise is measured, without the inclusion of other socioeconomic variables.

In this study, no statistically significant differences were observed between the interaction of academic achievements and sport. No statistically significant differences were recorded in the seventh grade, in the eighth grade and in the first grade of secondary school between children who played sports and those who did not. Children who played sports in the eighth grade of primary school had slightly higher achievement in the seventh grade in comparison with those who did not play sports. Similar results were found for students who were involved in sports in the first grade of secondary school, who had slightly better success in the seventh grade than those who did not play sports.

Results similar to ours were also obtained in the research by David M. Hansen et al. (39), who studied the linear and nonlinear relationship between physical activity and aerobic exercise with children's academic achievement. This research did not show a significant correlation between academic achievement and physical activity. Another study published in 2016 also found no significant correlation between moderate to vigorous physical activity and working memory or academic achievement when comparing children involved in activity measurement and those excluded by age, gender, ADHD, height, weight, BMI, puberty stage, exercise, overweight or obesity (40). However, there are many more studies that show a positive correlation between academic achievement and sports.

In a study conducted in Finland on children from the age of 12 ($n = 1,723$, 49% boys) and 15 ($n = 2,445$, 48% boys) until they were 40 years old, Jaana T. Kari et al. (41) confirmed the longitudinal correlation between physical activity and educational outcome, but also that physical activity in adolescence may not only predict academic achievement during compulsory primary education, but may likewise improve educational outcomes later in life.

In South Korea, students who were more physically active were generally found to have higher academic achievement. In addition, their final exam scores in English, mathematics and science were significantly correlated with the PAPS (Physical Activity Promotion System) scores (42). Extensive research has also been conducted in Australia to measure cardiovascular endurance, muscle strength, strength and academic achievement at school. They also found a positive correlation between physical activity and academic achievement, which is inconsistent with our results (43). The same goes for a study of the California Department of Education, which observed aerobic capacity, body composition, strength, and flexibility in addition to California Standard Tests for assessing language, the arts, and mathematics success as academic identifiers (44).

Other similar research on this topic was conducted by Castelli et al. (8). They measured aerobic performance, flexibility, muscle strength and found that exercise had a positive effect on mathematics achievement and overall academic achievement, while Stevens et al. (45) found a positive correlation of physical activity with mathematics and reading success achieved among boys and girls.

Sometimes different results are observed between boys and girls. In Japanese adolescents, a hybrid approach reported a positive effect of exercise on boys' academic achievement, but was observed as not statistically significant among girls (46). If we compare these same differences in our research, we can see that in the fourth grade of primary school, girls who played sports had higher academic achievement than those who did not play sports, while this difference was not statistically significant in boys. In the seventh grade of primary school, the differences were not statistically significant, and there was greater variability in the results of children who did not play sports compared to those who did. This is similarly observed in the eighth grade of primary school. Girls who played sports had slightly better academic achievement than those who did not; however, the results were not statistically significant.

In relation to sports and other physical activity, obesity is becoming a growing problem in school children. Corresponding to this thesis, it has been investigated how weight can affect academic achievement, but the evidence itself is not conclusive. Luis B. Sardinha et al. (47) noted that cardiorespiratory exercise and weight were independently and collectively linked to academic performance of seventh grade students. One study found that in Turkey, among children aged 10-19 in urban areas, one in five were obese; the incidence of obesity among children in urban areas was thus twice as high as in children from rural areas (48). Such data indicate a significant need for research to improve our understanding of the factors contributing to the high prevalence of childhood obesity, as well as for the development of potential urban intervention strategies (49).

Our study involved 120 boys and 141 girls ($p = 0.194$), where 59% of children live in the city and 41% live in the countryside. It has been confirmed that academic success may be correlated with the parents' level of education, as well as with socioeconomic status (41). Looking at the professional qualifications of parents, we observed that 59% of mothers and 62.45% of fathers completed secondary education, 28.35% of mothers and 27.2% of fathers are university graduates, while 12.64% of mothers and 10.34% of fathers finished primary school. In our study, based on the data about education after primary school, we found that 54.02% of students enrolled in a vocational school and 45.98% in a grammar school. Parents' level of education lower than secondary school qualifications negatively affected academic achievement in boys and girls in a study conducted in Japan, which observed the students' academic success (46).

Conclusion

Today, more and more studies are being conducted on this topic and similar topics, and each of these studies highlights the positive effects of physical activity in children.

Nonetheless, the results are mostly devastating in the sense that fewer and fewer children are engaged in physical activity and sports. What is even more worrying is that there has been an increase in health problems in children. Although our data did not show a significant statistical correlation between sports activities and academic achievement, research alone could contribute to a better understanding of the subject, as well as to the creation of positive habits that influence the reduction of overweight and obesity, and thus also the diseases associated with it. The disadvantages of this research are that it was not possible to determine the exact amount of physical activity in children involved in sports or the intensity of exercise. Since it has been proven that physical activity improves the quality of life, it is necessary to involve local communities in organising sports activities that would be easily accessible to children and parents, which would increase the number of interested children and adults. It is important to make society aware of the fact that sports and sports activities are not reserved exclusively for top athletes, but that they are an important aspect of child development and adult recreation for persons who care about their physical and mental health.

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[i] **Author contribution.** Acquisition of data: Vučić A, Bilić-Kirin V
Administrative, technical or logistic support: Vučić A, Bilić-Kirin V
Conception and design: Vučić A, Bilić-Kirin V
Critical revision of the article for important intellectual content: Vučić A, Bilić-Kirin V
Drafting of the article: Vučić A, Bilić-Kirin V
Final approval of the article: Vučić A, Bilić-Kirin V
Guarantor of the study: Vučić A, Bilić-Kirin V
Provision of study materials or patients: Vučić A, Bilić-Kirin V