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THE EFFECTS OF ACUTE PHYSICAL EXERCISE TRAINING ON MATHEMATICAL COMPUTATION IN CHILDREN

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ABSTRACT

The aim of this study was to determine whether acute physical exercise may increase the ability of young children to quickly solve basic mathematical problems. The participants who took the basic mathematics test before and after physical exercise included 288 preschool children, 128 children from school institutions, and 13 from a special needs school (mildly mentally disabled children, ages 13-14). The participants who took the basic mathematics test without employing physical exercise included 18 children from pre-school and 67 from school institutions.

The results showed that the children's computation performance was enhanced significantly in the groups with 30, or 45, or 60 min of physical exercise, but not in the groups without physical exercise. This means that even acute intensive physical training can yield positive effects on children's mathematical abilities.

Keywords: *computation performance in children, cognitive abilities, physical exercise, neural networks*

UČINKI ENKRATNE TELESNE VADBE NA MATEMATIČNO RAČUNANJE PRI OTROCIH

POVZETEK

Cilj pričujoče raziskave je bil ugotoviti, ali lahko enkratna telesna vadba pri mlajših otrocih poveča sposobnost hitrega reševanja osnovnih matematičnih operacij. V raziskavo je bilo vključenih 288 otrok iz predšolskih ustanov, 128 šolarjev in 13 otrok iz šole s prilagojenim programom (rahlo duševno zaostali otroci v starosti 13 ali 14 let), vsi pa so se preizkusili v reševanju osnovnih matematičnih operacij pred in po telesni vadbi. 18 otrok iz predšolskih ustanov in 67 šolarjev pa se je v osnovnih matematičnih operacijah preizkušalo v obdobju brez vmesne telovadbe.

Raziskava je pokazala, da so bili pri računanju veliko uspešnejši v skupinah, ki so imele vmes 30, 45, ali 60 minut telesne vadbe, in slabši v skupinah, kjer vmes niso telovadili. To pomeni, da lahko tudi enkratna intenzivna fizična vadba prinese pozitivne učinke na računske sposobnosti otrok.

Ključne besede: *uspešnost otrok pri računanju, kognitivne sposobnosti, telovadba, nevronske mreže*

INTRODUCTION

The tendency in the current school system, and in society in general, is to put more emphasis on the development of children`s cognitive functioning than on the proper motor activity, thereby largely ignoring its importance in children's development and not only from a biological point of view. Increasingly we hear suggestions concerning the need to abolish physical education in primary and secondary schools because, allegedly, this time can be better spent teaching other subjects, mathematics, physics and the like. Furthermore, despite the position of kinesiological experts to introduce a minimum of three hours of physical education a week, it is clear that the state institutions do not look favorably upon this proposal, despite the fact that there is plenty of evidence indicating the positive impact of motor activity, not only on one's biological development and health status, but also on mental development and the whole range of cognitive and conative dimensions of personality.

Gabbard and Barton (1979) assessed the mathematical computation performance of 106 6th-grade boys and girls before and immediately following 20, 30, 40, and 50 min of vigorous physical activity. Contrary to the researcher's predictions, the children's computation performance was enhanced significantly following 50 min of exercise.

Kawashima (2008) found in his research that simple calculations activated the brain more effectively than any other activity. He also discovered that the best way to activate

the largest regions of the brain was to solve these calculations quickly. That is why he created the easy-to-solve problems.

The aim of this study was to determine whether acute physical exercise may increase the ability of young children to quickly solve basic mathematical problems. Since the previous research on young children from the same geographical area, which had a similar socio-economic status, found that there was no statistically significant differences in cognitive abilities between boys and girls aged 4 to 10 years (Fajgelj, Bala, & Tubić, 2007), the analysis was carried out in each subsample for boys and girls together.

METHODS

The participants who took the basic mathematics test before and after physical exercise included 288 preschool children (ages 5 to 6), 128 children from school institutions (ages 7 to 8), and 13 from a special needs school (mildly mentally disabled children, ages 13 to 14). The participants who took the basic mathematics test without employing physical exercise included 18 children from pre-school (ages 5 to 6) and 67 from school institutions (ages 7 to 9).

The type of institution (Group), the number of children in groups (N), and the school activities (Mode) are listed in the appropriate columns of Tables 1 and 2.

The test used to assess the success of solving basic mathematical operations consisted of 40 tasks with the operations of addition and subtraction (the same difficulty level for pre-school children and school attending children), and multiplication and divisions (the same difficulty level for school age). Each task only employed 2 members, the corresponding mathematical operation symbol and an equal sign (eg., 3 + 5 =, 10 – 7 =, 2 x 3 =, 6 : 2 =), and the respondents were asked to solve and write down the solution for each task as soon as possible, taking 2 minutes at the most. The test result was graded according to the number of correct answers.

Each group of children provided the consent of both children's parents and teachers to take the test. The same test with 40 tasks, with briefinstructions was applied in all subsamples of children tested prior to the class activities. Each child received a single sheet of printed tasks and an eraser pencil. In case of an incorrect response the child was able to erase the answer or cross it out and then enter another result. Children from each group started the test at the same time. After 2 minutes the examiner stopped the testing and collected all the tests. Afterwards, the teacher began the implementation of the relevant class activities. At the end of the lesson the children were given the same mathematical tasks. After 2 minutes the testing was finished. All testing and procedures were performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

For each subsample of children the basic statistics were calculated (mean − M, standard deviation − SD, standard error of the mean − SEM, minimum − MIN and

maximum − MAX score in the test) for the test scores before and after the individual class activity. The significance of differences between the test results before and after the class activity (p) was analyzed using a nonparametric technique of Wilcoxon Sign Test and Signed Test, but also a parametric technique Paired-samples t test (t). Since all techniques gave synonymous results, only the result of the last analysis technique was shown.

RESULTS

The results showed that children's computation performance was enhanced significantly in the groups with 30, or 45, or 60 min of physical exercise (Table 1). The calculated standard errors of means (SEM) can be applied in assessing the range of possible results of the means in the case before and after the application of the appropriate types of activities in class at pre-school children and school attending children for the population from which small samples of respondents were drawn.

Table 1: Differences in the successful solving of elementary mathematical problems before and after physical exercise.

Group	Mode	N	MIN	MAX	M	SD	SEM	t	p
Sp. school Preschool Novi Sad	Before physical exercise	47	0	40	12.1	14.1	2.1	-4.96	0.01
	After 60 min physical exercise	47	0	40	14.9	14.9	2.2		
Pre-school Novi Sad Novo Naselje	Before physical exercise	121	0	28	4.1	4.6	0.4	-6.94	0.01
	After 30 min physical exercise	121	0	34	5.8	6.1	0.5		
Pre-school Novi Sad	Before physical exercise	24	0	17	4.5	3.3	0.6	-4.29	0.01
	After 30 min physical exercise	24	1	23	6.5	5.0	1.0		
Pre-school Subotica	Before physical exercise	96	0	40	15.1	13.6	1.4	-5.84	0.01
	After 30 min physical exercise	96	0	40	17.6	14.4	1.4		
Sp. school School Novi Sad	Before physical exercise	26	2	40	19.6	10.2	2.0	-4.06	0.01
	After 60 min physical exercise	26	2	40	22.1	10.2	2.0		

School 1st grade Belgrade	Before physical exercise	28	2	40	29.1	10.8	2.0	-4.29	0.01
	After 45 min physical exercise	28	3	40	33.3	10.1	1.9		
School 2nd grade Belgrade	Before physical exercise	24	6	32	19.4	6.0	1.2	-5.82	0.01
	After 45 min physical exercise	24	14	39	24.8	5.5	1.1		
School 1st -3rd Sombor	Before physical exercise	150	8	40	31.1	8.6	0.7	-10.31	0.01
	After 45 min physical exercise	150	8	40	34.3	7.8	0.6		
Slightly mentaly-retarded children	Before physical exercise	13	6	40	20.6	10.8	2.9	-3.26	0.01
	After 45 min physical exercise	13	8	40	24.8	10.8	2.9		

Basic statistics and the significant differences between the means before and after class without exercise training in individual groups of children are presented in Table 2. It may be noted that although the results have improved, on average, there were no statistically significant increases in mathematics test results. In pre-school in Novi Sad the children even had impaired results. This indicates that the classes where there was no physical exercise did neither produce a significant improvement in mathematics test results, nor in the activation of the children's brain functions.

Table 2: Differences in the successful solving of elementary mathematical problems before and after school hours without physical exercise.

Group	M o d e	N	MIN	MAX	M	SD	SEM	t	p
Preschool Novi Sad	Before drawing class	18	2	18	6.2	4.5	1.0	3.74	0.22
	After 45 min drawing class	18	2	16	4.8	4.2	1.0		
School 1st grade Sombor	Before mathematics class	24	6	40	28.3	9.2	1.8	-1.02	0.32
	After 45 min mathematics class	24	3	40	29.2	10.1	2.0		
School 4th grade Belgrade	Before drawing	18	31	40	37.5	3.3	0.7	-1.36	0.19
	After 45 min drawing	18	31	40	38.5	2.2	0.5		
School 1st grade Belgrade	Before English class	25	13	40	29.3	9.4	1.8	-2.01	0.06
	After 45 min English class	25	9	40	32.9	8.7	1.7		

DISCUSSION

A quick resolution of short and simple mathematical tasks activated a large area of the brain (Kawashima, 2008). It is known that physical exercise with high intensity, even acute (which refers to one or a couple of hours of practice), and in particular chronic (several months and years) can increase brain activity. Thus, increased brain activity in physical training increases the capacity for mathematical function, which affects the integrated activity of the cerebral cortex and, possibly, the entire functioning of the nervous system, the level and quality of concentration, and thus also the cognitive functioning of children.

In this study, we observed a few children with dyspraxia, i.e. who had difficulty in understanding how to plan and organize what their body needs to do or how to sequence and perform movements. Motor planning, also known as praxia, represents the ability of conceiving, planning and execution of an unknown motor activity. Apraxia and dyspraxia are the states of impaired abilities. Quite often, children with difficulties in acquiring school skills also have difficulties in motor processing. For this reason, most children with dyslexia (disorder of acquiring reading skills) and dyscalculia (dis-

order of learning and comprehending mathematical terms and operations) are additionally diagnosed with developmental dyspraxia.

The results of this study confirm the findings of McNaughten and Gabbard (1993) who evaluated the mathematical computation speeds of 120 6th-grade boys and girls and found that performance was signficantly better following paced walks of 30 and 40 min duration than following 20 min of such excercise. There were no differences by gender of subject.

A similar research was conducted by Raviv and Low (1990) who compared children's rapid letter/cancellation performance prior and following physical education classes and science classes. Children's performance improved following both classes, suggesting to the researcher that the physical excitement, associated with traditional physical education classes, does not impair children's academic performance in other classes.

General results obtained in this study are consistent with findings of Tomporowski et al. (2008) who concluded that physical exercise has an effect on specific cognitive functions and the ones most likely to define the role of central executive processor. This processor is a part of the individual self, located in the prefrontal cortex and is responsible for the use of information, engagement, working memory, strategic planning and controlling behavior. Central executive processor governs everyday behavior, i.e., adjusts to the demands of the environment, including its own intellectual abilities.

CONCLUSION

The author believes that even acute intensive physical training can yield positive effects on children's mathematical ability, not only through aerobic exercises, but through a variety of exercises that are common in school gyms. Furthermore, this physical exercises will create better conditions for increasing the quality of neural networks in young children. Generally, regular and well-run physical exercise can positively affect brain health and cognition in children, which could enhance scholastic performance and greater overall cognitive functioning throughout their lives.

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REFERENCES

Fajgelj, S., Bala, G., & Tubić, T. (2007). Ravenove progresivne matrice u boji – osnovna merna svojstva i norme [Raven´s Coloured Progressive Matrices (CPM) – basic metric characteristics and norms]. Psihologija, 40(2), 293–308.

Gabbard, C. P., & Barton, J. R. (1979). Effects of physical activity on mathematical computation among young children. Journal of Psychology, 103, 287–288.

Kawashima, R. (2008). Train your brain more: 60 days to a better brain. London: Penguin Books.

McNaughten, D., & Gabbard, C. (1993). Physical exertion and immediate mental performance of sixth-grade children. Percept Motor Skills. 77(3 Pt 2), 1155–1159.

Raviv, S., & Low, M. (1990). Influence of physical activity on concentration among junior high-school students. Percept Motor Skills. 70(1), 67–74.

Tomporowski, P. D., Davis, C. L., Miller, P. H., & Naglieri, J. A. (2008). Exercise and children's intelligence, cognition, and academic achievement. Educational Psychology Review, 1, 20(2), 111–131.