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Original research article

EFFECTS OF AN "NTC" EXERCISE PROGRAM ON THE DEVELOPMENT OF MOTOR SKILLS IN PRESCHOOL CHILDREN

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Abstract. *The problem of the motor development of preschool children is a highly current topic at a time when modern society is faced with a very low level of physical activity, which in turn assumes an epidemiological extent. The aim of this study was to determine the effects of NTC (Nikola Tesla Centre) Program of physical exercise on the development of preschool children's motor skills. A longitudinal study was performed in state kindergartens with two parallel groups, one of which applied the NTC Program for a period of 6 months, while the second group applied the usual exercise program. The sample consisted of two groups of children aged 4 to 6. The children's motor abilities were estimated by a battery of tests, BOT 2, comprising 14 subtests. On the basis of the applied statistical analyses it was determined that children in the experimental group achieved significant improvement on the motor skills test. Bearing in mind the fact that for the development of motor abilities the preschool age is a sensitive period, the application of the NTC exercise system at this age could significantly improve the motor skills and health status of children as well as lead to a better sensorimotor integration and a stimulating effect on cognitive development. Such a program would improve the initial state of the physical abilities of children through the development of their motor skills to the optimum level and have a positive impact on the creation of habits of regular physical exercise.*

Key words: *NTC program, motor skills, preschool age*

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INTRODUCTION

The issue of motor development among preschool-age children is a much debated topic at a time when society is dealing with exceptionally low levels of physical activity which may soon evolve into an epidemic. Movement is an important factor in the healthy growth and development of the body (Graham, 1992), and play and physical activity allow preschool-age children to develop motor abilities which will serve as a foundation for the future learning and development of complex motor skills (Shenouda, Gabel, & Timmons, 2011). In the first six years of their life, children explore their bodies and their environment by means of motion and movement. Research carried out to date has confirmed that low physical activity results in decreased motor abilities in children (Malina, Bouchard, & Bar-Or, 2004), whereas higher levels of physical activity lead not just to the improvement of physical fitness but also to the improvement of intellectual abilities and one's emotional state (Malina et al., 2004), which is extremely important in the overall development of a child.

Child development

Growth and development are most turbulent at the preschool age, i.e. development is at its peak until the age of 3, but its pace remains accelerated until the age of 6 (Kamenov, 2008). Every stage in child development is marked by development in the social, emotional, cognitive, and physical domain (Berk, 2007). Together with inborn genetic factors, novel experiential inputs and behavioral responses act on a still immature brain substrate to stimulate the further development of neural circuits, and with time, experience has an increasingly more prominent function in the shaping of neural circuitry (Tau & Peterson, 2010). Although brain size does not undergo drastic changes in the so-called 'plateau' phase of development, i.e. between the ages of 2 and 5, myelination and synaptic remodeling are particularly active (Tau & Peterson, 2010). Medical studies have shown that overall brain metabolism rises to twice that of adult levels by 4–5 years of age and remains high until 9–10 years of age (Tau & Peterson, 2010). According to the theory of integral development (Gruber & Ismail, 1967), there is a correlation between motor, cognitive, and emotional development. This correlation decreases with age, which is why it is easier to exert influence on one domain of development through two other domains at an early age. Therefore, the domains of a child's development are not independent of each other, and progress in one domain often impacts progress in other domains, which is especially the case with the development of motor abilities in early childhood (Trajkovski, Tomac, & Marić, 2014). The need for different kinds of physical activity is a basic human need and it is particularly prominent in childhood (Kamenov, 2008), and at the preschool age, it has a vital role in physical, social, and psychological wellbeing (Strong et al., 2005).

The correlation between motor and cognitive function

The idea that motor and cognitive development is correlated is not new. Piaget held that sensorimotor experiences are critical to cognitive development (Piaget, 1953). Furthermore, Bushnell and Boudreau suggested that motor development functions like a control parameter for further development. If we draw a simple analogy and say that sessile organisms do not have neurons or nervous systems, whereas mobile organisms

have a nervous system, it is clear that upright gait and movement are important characteristics of human beings, and that movement is critical to brain development. This is particularly important for children as the brain develops most by the age of 5 (Rajović, 2010), which is why walking and running have to be one of the main activities for a child (Rajović, 2010, 2016). A lot of research has been conducted to date in view of examining and understanding the potential correlation between motor and cognitive skills in children, as well as adults. Numerous studies have shown that the development of motor abilities impacts cognitive development (Aron, Poldrack, & Wise, 2009; Chaddock-Heyman et al., 2016; Chaddock et al., 2010, 2012; Erickson, Hillman, & Kramer, 2015; Hillman et al., 2009; Hopkins, Davis, VanTieghem, Whalen, & Bucci, 2012; Koziol et al., 2014; Scudder et al., 2014; Sibley & Etnier, 2003).

Pillars of the NTC program

The NTC Program is a program of activities designed to promote the development of motor and cognitive abilities among preschool- and school-age children, and it rests on the research findings in the field of neuroscience and pedagogy. The aim of the program is to develop functional knowledge and creativity by increasing divergent production and practicing information, i.e. knowledge integration. According to the basic premise of the NTC methodology, motor development plays an important role in the cognitive development of a child, and certain problems (such as learning disorders, concentration problems, and attention deficit) can be a consequence of inadequate motor development and overall modern lifestyle trends which often entail little physical activity. The second premise at the core of the NTC program states that early childhood is the most important period for brain development, which is why implementation of the program rests on development of motor abilities and promotion of physical activity in preschool-age children. The NTC program is implemented in three phases. The key element of the first phase are evolutionary accordant activities, characterized by complex motor abilities that include elements of fine motor skills, dynamic eye accommodation, rotation, balance, and movement. These activities activate large regions of the cerebral cortex and stimulate their interconnectedness, which consequentially aids cognitive development. The second phase of the NTC program implementation is characterized by abstract classification, abstract seriation, and association. Associative learning promotes development of cognitive skills such as reasoning, comprehension, memory, synthesis, transfer of learning, etc. (Rajović, 2011). The third phase covers the development of divergent and convergent thinking, as well as functional knowledge. All three NTC program phases are implemented through play which, as the intrinsic motivation of every child, constitutes the key factor in NTC program implementation (Rajović, 2011). The three phases described above encompass sensorimotor and cognitive development in children (Rajović, 2010).

Research review

Research carried out to date (Caput-Joginica, Lončarić, & De Privitellio, 2009; Krneta et al., 2015; Reilly et al., 2006; Živčić, Trajkovski-Višić, & Sentderdi, 2008) has shown that extracurricular physical activities and sports programs have a positive effect on motor development in preschool-age and kindergarten-age children. The number of studies evaluating the NTC program methods is increasing every year. The effects of the

implementation of NTC methods have up to date been tested on both school-age children and preschoolers and younger children. The research covered various motor and cognitive aspects of development (Krajšek, 2015; Petkovska, Rajović, & Rajović, 2015; Plahutar & Rajović, 2015; Rajović, Stenovec, & Berić, 2015).

Research aims and objectives

The research objective was the study of the impact of the NTC program on motor development in preschool-age children. The aim of the research was to determine the effects of an NTC physical exercise program on the development of motor skills in preschool-age children.

METHODS

All parents, caregivers, and teachers received a written notice about the aims, course, participation, and potential adverse effects of the research. All parents and caregivers of the participants gave their written consent for the child's participation in the research prior to initiation, and all the participants were medically examined by pediatrics specialists.

Sample size

The research was carried out on a sample of 60 participants, 45 of whom participated in the testing. The participants were preschool-age children aged 4-6 from a Belgrade kindergarten (Cika Jova Zmaj Nursery School and Preschool, Vozdovac Municipality). The groups were homogenous in that the children came from the same district and had a similar social status and at-home and kindergarten conditions. In addition to that, the program in both groups up to the beginning of the experiment followed the same pattern and was supervised by the same pedagogue. The experimental group comprised 30 children, 21 of whom took part in the testing. The control group also comprised 30 children, 24 of whom participated in the testing.

Measuring instruments

Description of measuring instruments

Anthropometric characteristics: height, mass, and body mass index (BMI) were measured by standard procedures. Motor skills were assessed by means of the abbreviated version of the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks & Bruininks, 2005). The following motor skills were assessed:

- **Fine motor precision** (drawing lines through paths - crooked, folding paper);
- **Fine motor integration** (copying a square, copying a star);
- **Manual dexterity** (Transferring pennies);
- **Bilateral coordination** (jumping jacks - same sides synchronized, tapping foot and finger – same side synchronized;
- **Balance** (walking forward on a line with eyes open, standing on one leg on a balance beam with eyes open);
- **Running speed and agility** (one legged side hop);

- **Upper limb coordination** (dropping and catching a tennis ball with both hands, dribbling a tennis ball – alternating hands);
- **Strength** (push-ups and knee push-ups, sit-ups).

Evaluation organization

Motor proficiency and anthropometric characteristic were assessed at the initial assessment prior to the initiation of the experimental program based on the NTC program of physical exercises (September 2015) and at the final assessment upon the completion of the experimental program (April 2016). All assessments were carried out in the afternoon, at approximately the same time, using the measuring instruments described above, in accordance with standardized protocols and recommendations provided by appliance and equipment manufacturers. The assessments were carried out by highly qualified experts with previous experience in such procedures.

EXPERIMENTAL PROGRAM (NTC PROGRAM OF PHYSICAL EXERCISE)

Regular physical exercise involved complex field exercises which required the children to constantly maintain their balance, perform rotations, monitor the surroundings, and perform cognitive processes while performing exercises. The games which were used included:

Paper snowball fights – making snowballs out of chopped newspapers and shooting a target or paper basket placed one meter away. A slightly more demanding version of the game involved two 6-8 meter long lines at a 2-meter distance from each other out in the yard and the children grouped into two teams aiming at the opponent team while on the move and dodging paper snowballs thrown at them. The 10-minute game was performed twice a week;

Stork – stork on a wire, a one-foot rope stand. The 3-minute game was performed twice a week. After a while, i.e. when the children had mastered the game, a ball was passed to them as they performed the one-foot stand, which they were then supposed to throw into the box placed on the floor one meter away;

Clumsy waiter – transfer of small objects on a platter. The children were supposed to transfer objects on a platter, carefully placing them next to or on top of already transferred objects. Every child was to take a few turns during the 20-minute game. When the children had mastered the game, they were required to recite a nursery rhyme while carrying the platter, to skirt obstacles, or to follow a trail marked by a wide adhesive tape while performing complex movements (squats, rotations, and backwards walking);

Squirrels, basketball players – throwing chestnuts into glasses. The 5-minute game was performed three times a week;

Nesting sparrows – two-foot jumps forwards and backwards into white, yellow, and green hoops. Upon landing into a green hoop, the child was supposed to perform a squat. Upon landing into a white hoop, the child was supposed to perform a rotation. Upon landing into a yellow hoop, the child was supposed to perform a one-foot stationary jump three times. The 15-minute game was performed every day;

Spider's web – wriggling through intertwined Chinese jump rope. The game was performed 10 times a day because the "web" was set up in the part of the room used to store toys which was frequently visited by the children;

The magic line – moving along a 4-meter line. When leaving the room, the child was supposed to always walk along the line. Several parallel lines were drawn to prevent the children from walking into each other. Tiny stickers were placed along each line at a 50-centimeter distance. The child was supposed to perform a squat (upon arriving at the green sticker) or a rotation (upon arriving at the blue sticker). In case the child made a mistake, other children were supposed to correct them. The stickers were assigned a different meaning on a daily basis. The child was supposed to walk along the line at least 5 times a day;
Cinderella – picking up grains from the table and throwing them into a plastic cup. Another version of the game involved grains placed in a bowl of flour. The children were to pick up specific types of grain (rice, corn, wheat, etc.). Once they had mastered the game, the children were supposed to collect the grains using their thumb and pinkie finger as their index, middle, and ring finger were taped together. The 15-minute game was performed twice a week;
Froglings – leaps from a crouching posture, a game performed twice a week. In each leap, the children were required to say a word from the vocabulary they were expected to learn (names of wild animals, domestic animals, colors, objects, etc.);
Pin tumbling – a competitive game the children played twice a week. The children made the pins themselves out of toilet paper rolls and were divided into national teams (e.g. Serbia, Mexico, Japan, etc.). The teams were supposed to take pins painted in the colors found on the flag of their country and place them one atop the other to form the flag. In the game, the children learnt different national flags which was of use in other games;
Building the Leaning Tower of Pisa – stacking wooden sticks, blocks, or other small objects. The activity was performed once a week;
Books walking – a race along the 2-meter stretch of the magic line in which the child is balancing a book on their head. A more complex version of the game involved walking while reciting a nursery rhyme.
NOTE: Three or four games were combined every day based on the children's wishes.

Data processing

The collected data were analyzed with the help of descriptive statistics, by defining tendency parameters (mean value) and dispersion parameters (standard deviation, minimum and maximum variable value). The differences between the experimental and control group in the initial and final assessment, as well as the differences between the initial and final assessment within a group, were evaluated by means of dependent and independent samples t-test. The differences between the experimental and control groups on a multivariate level were calculated by means of the covariance analysis (ANCOVA). The effect size of the experimental program calculated by analysing the differences between the initial and final assessment. The effect size was classified as follows: <0,2 very small, 0,2–0,6 small, 0,6–1,2 moderate, 1,2–2,0 large, and >2,0 very large (Hopkins, Marshall, Batterham, & Hanin, 2009). Statistical significance was calculated at the level of $p < 0,05$.

RESULTS

Table 1 Descriptive statistics results for the initial and final assessment of the control group and the differences between the initial and final assessment (t-test)

	Control group – initial assessment						Control group – final assessment						T test		
Variables	N	Range	Min	Max	Mean	SD	N	Range	Min	Max	Mean	SD	MD	t	P Value
Drawing lines through paths	24	6	1	7	4.75	1.54	24	5	2	7	5	1.29	-0.25	-0.61	0.547
Folding paper	24	6	0	6	3.21	1.41	24	5	0	5	2.83	1.55	0.38	0.83	0.413
Copying a square	24	5	0	5	3.17	1.37	24	3	2	5	3.5	1.02	-0.33	-1.22	0.236
Copying a star	24	4	0	4	1.13	1.60	24	5	0	5	1.79	1.69	-0.67	-1.34	0.194
Transferring pennies	24	6	2	8	4.71	1.40	24	4	3	7	4.75	0.99	-0.04	-0.12	0.907
Jumping jacks	24	3	0	3	2.63	0.92	24	5	0	5	2.5	1.02	0.13	0.44	0.664
Tapping foot and finger	24	4	0	4	2.29	1.27	24	4	0	4	2.75	1.26	-0.46	-1.39	0.178
Walking forward on a line	24	0	4	4	4	0	24	3	1	4	3.54	0.78	0.46	2.88	0,008*
Standing on a balance beam	24	4	0	4	2.58	1.21	24	3	1	4	2.63	1.10	-0.04	-0.15	0.883
One legged side hop	24	7	2	9	7.33	1.99	24	7	2	9	7.5	1.67	-0.17	-0.33	0.741
Dropping and catching a ball	24	5	0	5	2.88	1.99	24	5	0	5	2.88	1.94	0	0	1
Dribbling a ball	24	5	0	5	1.17	1.49	24	4	0	4	1.38	1.38	-0.21	-0.52	0.611
Push-ups	24	3	1	4	2.79	0.78	24	5	0	5	2.92	1.18	-0.13	-0.44	0.664
Sit-ups	24	3	1	4	2.63	0.97	24	4	1	5	3.38	1.14	-0.75	-2.92	0.008*
Height	24	19	101	120	112.96	4.82	24	18	105	123	115.79	4.01	-3.04	-8.48	0*
Mass	24	13	13	26	19.95	2.88	24	15	13	29	20.83	3.25	-0.92	-4.65	0*
BMI	24	5.98	12.74	18.73	15.56	1.45	24	8.31	12.2	20.5	15.46	1.72	0.13	0.68	0.502

Based on the results presented in Table 1, it can be concluded that there is a statistically significant difference for the following variables: walking forward on a line and sit-ups. It should be mentioned that in the variable walking forward on a line, the results of the initial testing were better than the results of the final testing six months later. No statistically significant differences between the initial and final testing were recorded for other variables.

Table 2 illustrates the results of the t-test which evaluated the differences between the initial and final assessment within the experimental group.

Based on the results, it can be said that the experimental group achieved statistically significant progress in the mean value for the following variables: drawing lines through paths - crooked, folding paper, copying a square, copying a star, jumping jacks, tapping foot and finger, walking forward on a line, standing on one leg on a balance beam, one legged side hop, dropping and catching a tennis ball with both hands, dribbling a tennis ball – alternating hands. No statistically significant progress was recorded for the following tests: transferring pennies, push-ups and knee push-ups, and sit-ups.

Table 2 Descriptive statistics results for the initial and final assessment of the experimental group and the differences between the initial and final assessment (t-test)

	Experimental group – initial assessment						Experimental group – final assessment						T test		
Variables	N	Range	Min	Max	Mean	SD	N	Range	Min	Max	Mean	SD	MD	t	P Value
Drawing lines through paths	21	6	1	7	3.81	1.72	21	4	3	7	6.05	1.07	-2.24	-6.63	0*
Folding paper	21	11	0	11	5.76	3.33	21	9	3	12	7.57	3.16	-1.81	-2.76	0,012*
Copying a square	21	4	1	5	3.57	1.12	21	2	3	5	4.52	0.60	-0.95	-4.48	0*
Copying a star	21	4	0	4	0.76	1.45	21	5	0	5	2	1.87	-1.24	-3.92	0,001*
Transferring pennies	21	4	3	7	4.43	1.03	21	4	3	7	4.62	1.28	-0.19	-0.61	0.55
Jumping jacks	21	3	0	3	1.86	1.01	21	1	2	3	2.52	0.51	-0.67	-3.16	0,005*
Tapping foot and finger	21	4	0	4	2.43	1.17	21	2	2	4	3.76	0.54	-1.33	-4.64	0*
Walking forward on a line	21	3	1	4	3.48	0.98	21	0	4	4	4	0	-0.52	-2.45	0,024*
Standing on a balance beam	21	4	0	4	2.29	1.38	21	2	2	4	3.48	0.75	-1.19	-3.80	0,001*
One legged side hop	21	6	2	8	5.67	1.93	21	6	3	9	7.48	1.44	-1.81	-4.52	0*
Dropping and catching a ball	21	5	0	5	3.24	1.64	21	4	1	5	4.24	1.09	-1	-3.02	0,007*
Dribbling a ball	21	4	0	4	1.29	1.35	21	6	1	7	2.67	1.74	-1.38	-3.82	0,001*
Push-ups	21	5	0	5	3.19	1.29	21	2	2	4	3.62	0.59	-0.43	-1.37	0.186
Sit-ups	21	5	1	6	3.33	1.07	21	2	2	4	3.05	0.50	0.29	1.3	0.208
Height	21	26	101	127	113	6.51	21	22	107	129	116.86	6.41	-4.71	-10.52	0*
Mass	21	19	14	33	20.62	4.39	21	23	16	39	22.61	5.61	-2.2	-4.86	0*
BMI	21	10.2	13.08	23.3	16.06	2.52	21	11.7	13.1	24.8	16.42	3.06	-0.29	-1.02	0.322

Table 3 illustrates the results of the analysis of covariance, wherein the result of the initial assessment is taken as the covariance. A statistically significant difference between the experimental and control groups in the final assessment was found for the following tests: drawing lines through paths - crooked (p 0,002; based on the partial eta squared value of 0,200,a it can be concluded that the effect of the experimental program was large), folding paper (p 0,000; based on the partial eta squared value of 0,363, it can be said that the effect of the experimental program was large), copying a square (p 0,000; based on the partial eta squared value of 0,260, it can be said that the effect of the experimental program was large), tapping foot and finger (p 0,002; based on the partial eta squared value of 0,211, it can be said that the effect of the experimental program was large), in the test of walking forward on a line (p 0,018; based on the partial eta squared value of 0,127, it can be said that the effect of the experimental program was large), standing on one leg on a balance beam (p 0,002; based on the partial eta squared value of 0,200, it can be said that the effect of the experimental program was large), dropping and catching a tennis ball with both hands (p 0,009; based on the partial eta squared value of 0,150, it can be said that the effect of the experimental program was large), dribbling a tennis ball (p 0,009; based on the partial eta squared value of 0,153, it can be said that the effect of the experimental program was large), push-ups and knee push-ups (p 0,021; based on the partial eta squared value of 0,120, it can be said that the effect of the experimental program was moderate).

Table 3 Differences in the effects between the experimental and control groups (ANCOVA)

	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Drawing lines through paths	14.584	1	14.584	10.497	0,002*	0.2
Folding paper	116.874	1	116.874	23.904	0*	0.363
Copying a square	8.979	1	8.979	14.752	0*	0.26
Copying a star	1.073	1	1.073	0.353	0.556	0.008
Transferring pennies	0.126	1	0.126	0.097	0.758	0.002
Jumping jacks	0.065	1	0.065	0.095	0.76	0.002
Tapping foot and finger	11.148	1	11.148	11.21	0,002*	0.211
Walking forward on a line	2.029	1	2.029	6.104	0,018*	0.127
Standing on a balance beam	9.078	1	9.078	10.481	0,002*	0.2
One legged side hop	0.911	1	0.911	0.388	0.536	0.009
Dropping and catching a ball	18.785	1	18.785	7.422	0,009*	0.15
Dribbling a ball	17.742	1	17.742	7.604	0,009*	0.153
Push-ups	5.311	1	5.311	5.751	0,021*	0.12
Sit-ups	2.524	1	2.524	3.331	0.075	0.073

No statistically significant difference between the experimental and control groups in the final assessment was found for the following tests: copying a star (p 0,556; based on the partial eta squared value of 0,008, it can be concluded that the effect of the experimental program was small), transferring pennies (p 0,758; based on the partial eta squared value of 0,002, it can be said that the effect of the experimental program was small), jumping jacks (p 0,760; based on the partial eta squared value of 0,002, it can be said that the effect of the experimental program was small), one legged side hop (p 0,536; based on the partial eta squared value of 0,009, it can be said that the effect of the experimental program was small), sit-ups (p 0,075; based on the partial eta squared value of 0,073, it can be said that the effect of the experimental program was moderate).

Figure 1 summarizes the differences between the mean initial and final motor proficiency scores of the experimental and control group

DISCUSSION

Physical activity is one of key factors in health and wellbeing. Due to the nature of a child’s body, which is actively growing and developing, and due to the high brain plasticity in early childhood, susceptibility to environmental factors and lifestyle is remarkable. Therefore, not only is physical activity closely linked to children’s physical abilities, but it is also important for their physical, psychological and socio-emotional development. On the other hand, the problem of low physical activity levels is pronounced more than ever before, especially among the young. At the same time, total calorie intake is increasing, and an increase in body fat is common among children in industrially developed countries (Gopinath, Hardy, Baur, Burlutsky, & Mitchell, 2012), as is obesity, which increases the risk of numerous diseases such as diabetes, cardiovascular diseases and some types of cancer (WHO, 2000). Along with parent-oriented educational programs on the potential consequences of modern lifestyle and the importance of timely changes, the role of preschool and school institutions is becoming increasingly important.

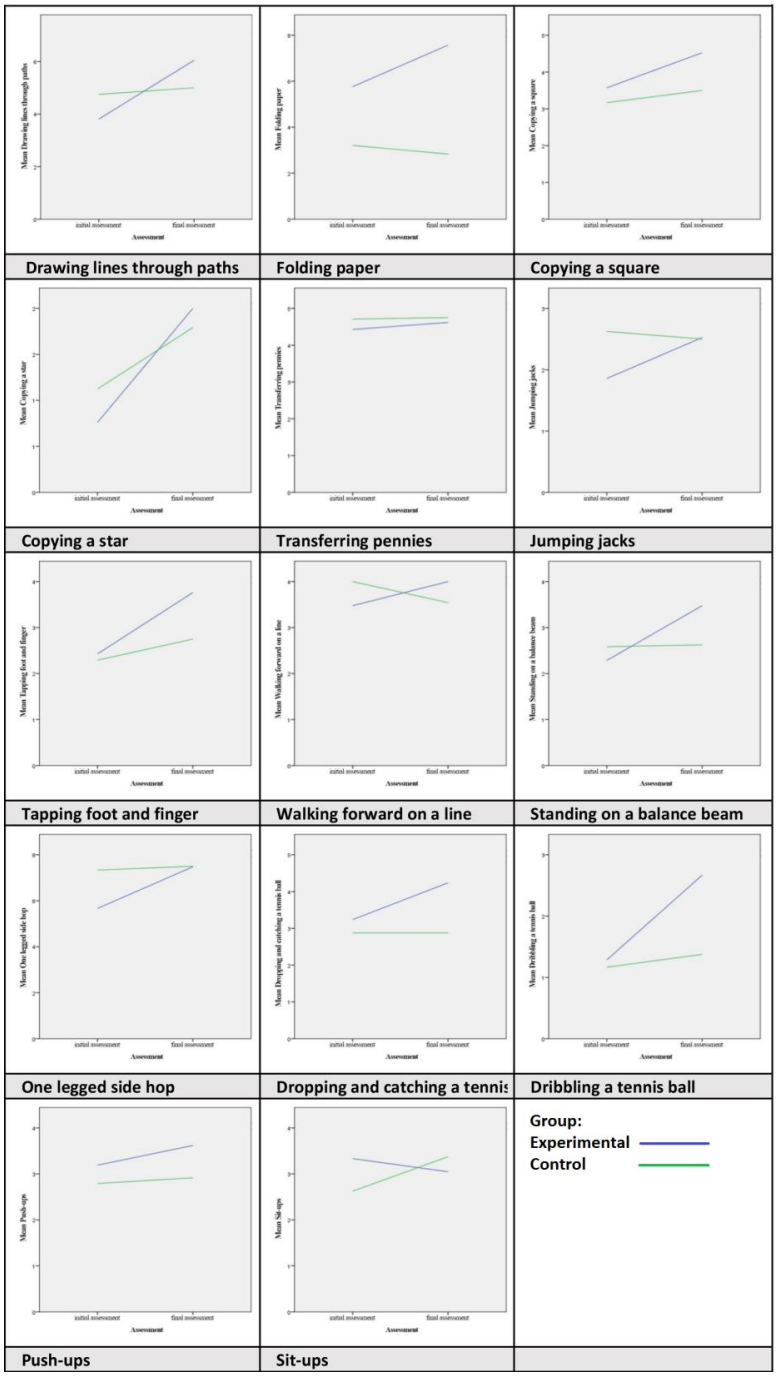

Fig. 1 Differences between the mean initial and final motor proficiency scores of the experimental and control group

A majority of games performed by the experimental group comprised elements of fine motor skills, balance, dynamic eye accommodation, and movement coordination. The more elements a game involved, the more interesting it was for the children. These games simultaneously activate several cortex regions: sensorimotor cortex, visual cortex, auditory cortex, and cortical association areas (motor, sensory, and visual). In addition to these cerebral cortex regions, other regions in the brain are activated as well, especially the cerebellum. The games were designed pursuant to the hypothesis drawn from the results of previously conducted research (Plahutar & Rajović, 2015; Rajović et al., 2015), which showed that very few activities children perform in and outside the kindergarten include rotation, balance, dynamic eye accommodation, fine motor skills, movement and complex movements involving jumping, skipping, moving backwards, etc. This is especially important since research has shown that aerobic fitness in children is linked to the volume of the dorsal striatum and globus pallidus (Chaddock et al., 2010), components of the basal ganglia. Research results also showed that increased childhood aerobic fitness is related to enhanced cognitive control (Chaddock et al., 2010). An alarming fact, however, is that an increasing number of research shows that children are not sufficiently physically active and that they tend to spend more and more time in front of TV and PC screens, or playing video games (Djedović, Rackov, & Stanojev, 2015).

The following evaluation instruments were used to assess motor parameters of the research subjects: **fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper limb coordination and strength.**

Compared to the control group, the experimental group has shown substantial progress in fine motor precision and integration, and manual dexterity. These results correspond to an extent to the findings of previous research (Plahutar & Rajović, 2015) evaluating the role of NTC program in complex motor skill development in preschool-age children. Though less specific and with a limited methodology, the research pointed to the improvement of fine motor skills in children whose preschool program included NTC program activities. Another research (Krajšek, 2015) which aimed to evaluate the impact of an NTC program on fine and gross motor skills showed that the most substantial difference in progress is exactly the motor parameter of fine motor skills. The long term effect of properly developed fine motor skills is becoming better understood. On the school readiness test, fine motor skills, together with attention and general knowledge, have shown to be much stronger overall predictors of later math, reading, and science scores than early math and reading scores alone (Grissmer, Grimm, Aiyer, Murrah, & JS, 2010). In addition to that, numerous research carried out to date has shown a clear correlation between fine motor skills and reading achievement (Brookman, McDonald, McDonald, & Bishop, 2013; Cameron et al., 2012; Grissmer et al., 2010). Fine motor skills and manual dexterity involve the activation of a great number of small muscles and muscle groups, as well as eye-hand coordination, which are exactly the aspects that NTC program of physical exercise strives to promote.

The results of the final assessment showed substantial progress in bilateral coordination and upper limb coordination in the experimental group. The importance of adequately developed coordination is obvious if we take into account the fact that coordination is an important predictor of physical activity in school-age children (Lopes, Rodrigues, Maia, & Malina, 2011) and that individuals with a lower IQ more often have underdeveloped motor coordination than those with a higher IQ (Smits-Engelsman & Hill, 2012). Moreover,

coordination, physical fitness and physical activity are positively correlated with academic performance and intellectual performance (Castelli, Hillman, Buck, & Erwin, 2007; Ismail, 1967; Taras, 2005).

Substantial progress of the motor parameter of balance was observed in the experimental group compared to the control group. A study carried out by Plahutar and Rajovic confirmed similar improvement, as its results pointed to improved balance in the children included in the NTC program of physical exercises (Plahutar & Rajović, 2015). Likewise, a research (Rajović et al., 2015) involving participants aged 2-4 showed an NTC program to be efficient in improving balance, primarily walking forward and backward on a line.

As regards the motor parameter of strength, the experimental program did not bring about a statistically significant improvement in strength evaluated by the number of push-ups and knee push-ups and sit-ups. This is in line with the initial expectations as the NTC program does not include exercises that promote development of strength. It should also be noted that the ages 4-6 are not a sensitive period for strength development, which peaks in adolescence (Arunović et al., 1992).

The results show that an NTC program holds substantial potential for maximizing development of the following abilities in preschool-age children: fine motor precision, fine motor integration, bilateral coordination, balance, speed and agility and upper limb coordination. Numerous studies (Aron et al., 2009; Chaddock-Heyman et al., 2014; Chaddock et al., 2010, 2012; Erickson et al., 2015; Hillman et al., 2009; M. Hopkins et al., 2012; Koziol et al., 2014; Scudder et al., 2014; Sibley & Etnier, 2003) confirmed that motor abilities affect the development of cognitive abilities, since analyzed parameters contribute to the development of large and complex regions of the cerebral cortex, they can bear relevance for development of cognitive abilities in children, especially at preschool age. This period is characterized by exceptionally intense and dynamic remodeling of the synaptic network.

CONCLUSION

Based on the results of the dependent and independent samples t-test, as well as the univariate covariance analysis (ANCOVA) and calculated effect size, it can be concluded that the NTC program exerted a statistically significant impact on the motor abilities of the children in the experimental group as large effect was observed for eight motor proficiency variables, whereas small effects were determined for four variables. The experimental group performed NTC physical exercises 2-3 times a week for 10-15 minutes. It is clear that the exercises did not take much time nor did they require any special equipment. This research has shown that kindergarten teachers can easily organize certain games alongside usual activities, without disrupting the regular curriculum. The children did not find the activities difficult as they are designed as games, not as exercises. This is why children gladly participate in NTC activities, especially when they see themselves making progress, which drives them to ask for more complex games and to extend playtime centered on those games.

It is a well-known fact that organized physical activity at the preschool age can considerably affect motor development in children, as well as the development of their overall anthropological status. Preschool age is the right time to start implementing

different physical exercise programs. This is the period when basic motor abilities develop which will serve as the foundation for development of specific motor skills later. Preschool age is considered to be fundamentally important as motor abilities continue to develop at a slower pace in the subsequent stage, i.e. at school age, and any developmental progress will depend on motor proficiency. If early stimulation is important for the development of the overall abilities of a child, then motor development is an integral component of those abilities, as it is well-known that complex movements involved in running and walking, such as rotation, balance, and dynamic eye accommodation, impact development of the cerebral cortex. Lack of movement and physical activity entail a higher likelihood of poor development of certain cerebral cortex regions, which can hamper cognitive development. Numerous research has confirmed that some cognitive problems are caused by a sedentary lifestyle, particularly in the student population, as well as among middle-aged adults. Since the preschool age is a sensitive period for motor development, the implementation of an NTC program of physical exercise at this stage could bring about a substantial improvement in motor and health status of children, while at the same time promoting sensorimotor integration and cognitive development. A program consisting of NTC exercises would result in the improvement of physical abilities in children by optimizing motor development, and it would also have a positive impact on the formation of habits that involve regular exercises. Lastly, the system would also be a valuable source of information for parents, who would be able to independently support and supervise the motor development of their children.

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UTICAJI “NTC” PROGRAMA VEŽBANJA NA RAZVOJ MOTORIČKIH SPOSOBNOSTI DECE PREDŠKOLSKOG UZRASTA

Problem motornog razvoja predškolske dece je aktuelna tema u vreme kada se moderno društvo suočava sa veoma niskim nivoom fizičke aktivnosti, što poprima epidemiološki mere. Cilj istraživanja bio je da se utvrde efekti NTC (Nikola Tesla centar) programa fizičkog vežbanja na razvoj motoričkih sposobnosti predškolske dece. Longitudinalno istraživanjeje sprovedena u državnim obdaništima sa dve paralelne grupe, od kojih je jedna sprovodila NTC program u trajanju od 6 meseci, dok je druga grupa sprovodila redovni program vežbanja. Uzorak se sastojao od dve grupe dece uzrasta od 4 do 6 godina. Motoričke sposobnosti dece su procenjene uz pomoć baterije testova, BOT 2, koja se sastoji od 14 podtestova. Na osnovu primenjene statističke analize utvrđeno je da su deca u eksperimentalnoj grupi postigla značajan napredak na testu motoričkih sposobnosti. Imajući u vidu činjenicu da je za razvoj motoričkih sposobnosti predškolski uzrast osetljiv period, primena NTC sistema vežbanja u ovom uzrastu može značajno da unapredi motoriku i zdravstveni status dece, kao i da dovede do bolje senzorimotorne integracije i da stimulativno deluje na kognitivni razvoj. Takav program mogao bi da poboljša početno stanje fizičkih sposobnosti dece kroz razvoj njihovih motoričkih sposobnosti do optimalnog nivoa i ima pozitivan uticaj na stvaranje navika redovnog fizičkog vežbanja.

Ključne reči: *NTC program, motoričke veštine, predškolski uzrast*