ORIGINAL ARTICLE

Differences in motor abilities of boys and girls aged 7 in relation to the level of intellectual ability

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Abstract
Since previous studies suggest a relationship between motor and cognitive development in children, a research was conducted in order to examine the differences in motor skills of children with different levels of intellectual ability. In a sample of 88 respondents, boys and girls aged 7, an assessment of motor skills was performed by using the battery of seven motor tests and assessment of intellectual abilities by using the test of Raven's Coloured Progressive Matrices. Respondents were divided into three groups according to the results of the test. After analyzing the results of the research it was shown that there were no statistically significant differences in the area of motor abilities of children of different intellectual levels, but there were differences at the univariate level regarding the tests Hand Tapping and Seat-and-Reach.

Keywords Raven's Coloured Progressive Matrices • Motor skills • Intelligence • Younger school age

Introduction

Current theoretical approaches and empirical findings from the research conducted over the last decade indicate that physical activity may contribute to the improvement and preservation of cognitive abilities during the human life. Improvement of physical abilities is associated with improvement of brain tissue during aging, while also the functional aspects of a higher order, which are involved in the control of cognition are improved (Gomez-Pinilla & Hillman, 2013). Cognitive behavioral model emphasizes the role of cognitive functioning that contributes to the emergence of emotional and behavioral disorders. Incorrect assessment of social situations, the tendency self-underestimation, unreasonable sense of guilt for errors, are examples of dysfunctional cognitive processes. Cognitive abilities are responsible for forecasting, planning, decision-making processes, as well as comparisons and information processing along with the use of long-term memory in resolving problem situations.

Motor skills play a key role in the functioning of the child regarding the social and emotional area (domain). Weaker motor coordination in children can affect their feelings that they are less able than their peers, but also affects their academic achievements, and even the choice of recreational activities. The relationship between motor skills and social and emotional functioning is usually considered indirect. In other words, poor motor skills can lead to poor achievements in individual and team sports, which can reduce the feeling of competence in children and increase their anxiety and depression (Cummins et al., 2005). Children with poor motor coordination are less competent in their ability to recognize emotions. Study by Cummins and associates (2005) found that children with motor coordination problems are less accurate (correct) and slower in reacting to facial emotional signs. Children with coordination disorder may be at a disadvantage during the social process with their peers, as they may have more difficulties in detecting emotional states of others and in use of this

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information for their behavior in the social environment.

Sport and physical activity are positively correlated with children's physical and mental health (Strong et al., 2005). However, the increased participation of children in sport and other forms of physical activity also leads to improved cognitive functioning of children, better information processing, development of memory, concentration, behavior. There is sufficient evidence on the relationship between physical activity and improvement of cognitive skills and executive functioning and control. Executive functioning refers to the cognitive processes needed for target oriented cognition and behaviors that develop through childhood and adolescence (Best, 2010; Hillman, Erickson, & Kramer, 2008; Hillman, Pontifex, Raine, Castelli, Hall, & Kramer, 2009; Kamijo et al., 2011). Most motor tasks require precisely those processes, and many of them contain problematic component, for example, numerous situations in the sports game, creating their own solutions to overcome the track with obstacles, etc. The motor coordination tests also consist of a kind of problem situations that need to be addressed effectively (Dolenc, Pistotnik, & Pinter, 2002). In addition, individuals who are physically more active are able to process more information faster. These data suggest that physical activity may contribute to the improvement of cognitive skills, allows effective response to a given challenge with good results in carrying out the task. New evidence shows that physical exercise exerts its effects on cognition, by influencing the molecular events related to the control of energy metabolism and synaptic plasticity, and their processes (Ang, Tai Lo, Seet, & Soong, 2010). An important initiator of the molecular mechanism includes physical exercises because the brain (CNS) is a derived neurotrophic factor, which acts within the interface between the metabolism and plasticity. Recent studies show that exercise along with other aspects of lifestyle affects the molecular basis of cognition (Baker, et al., 2010; Berchtold, Chinn, Chou, Kesslak, & Cotman, 2010; Gomez-Pinilla & Hillman, 2013; Kamijo & Takeda, 2009). In addition, selected dietary factors have similar mechanisms as exercises and, in some cases, can complement the effect of exercise. So, exercise and diet are non-invasive and effective strategies of combating neurological and cognitive disorders.

In many studies the relations were found between mobility and intelligence (Dolenc, Pistotnik, & Pinter, 2002; Hariri et al., 2003; Planinšec, 2002; M. V. Stojanović i M. Stojanović, 2006; M. Stojanović, Rubin, M. V. Stojanović & Fratrić, 2006). The motor testing of children systematically uses appropriate measuring instruments, or tests, in order to quantify motor behavior. Differences in motor behavior are attributed to differences in coordination, explosive strength, speed of alternative movements, balance and flexibility, exogenous factors, as well as the functioning of the CNS during the manifestation of certain abilities in motor behavior. Even less mentally disabled persons are significantly inferior in motor skills compared to the standard population, where the level of motor behavior in less mentally disabled person falls behind 3-4 years compared to the standard population of the same age (Nićin, 2000). The connection between intellectual and motor functioning was first detected and confirmed in samples of persons who are mentally disabled (Bala, Sabo, & Popović, 2005). Bearing in mind the results of previous research, a research was conducted in order to examine the differences in motor skills of children aged 7 depending on the level of cognitive ability.

Method

Data were collected as part of the research project “Anthropological status and physical activity of the population of Vojvodina”, Faculty of Sport and Physical Education in Novi Sad.

The analysis was conducted on a sample of 88 students (43 boys and 45 girls) aged 7, from the cities across Vojvodina (Novi Sad, Bačka Palanka, Sombor, Sremska Mitrovica and Zrenjanin) which were included in the testing within the research project “Anthropological status and physical activity of the population of Vojvodina”. Testing of motor abilities was performed on the basis of the reduced model designed by Kurelić et al. (1975) with 7 motor tests.

Motor tests that were applied in this study were: 1) Obstacle course backwards test – coordination of body and reorganization of movement stereotypes; 2) Hand tapping test – movement frequency; 3) Sit-and-reach test – flexibility; 4) Standing broad jump test – explosive leg strength; 5) 20 meters run test – running speed; 6) Trunk lifting test – repetitive strength of the trunk and 7) Bent arm hang test – static strength of arms and shoulders.

To test the intelligence the Raven's Coloured Progressive Matrices were used (Fajgelj, Bala, & Tubić, 2007). Raven's Coloured Progressive Matrices are one of the most commonly-used tests for testing the intelligence of preschool and young school-age children in our country. Based on the results achieved by the respondents during the test, they were divided into three groups: the first group consisted of respondents whose result was located within the first quarter, the second group consisted of respondents who achieved results in the second and third quarters, and in the third group were classified respondents with the best results (the fourth quarter). The first group contained 11 respondents (from 55 to 81 of IQ), the second group was made of 56 respondents (86 to 107 of IQ) and the third group was made of 21 respondents (109 of IQ and more).To determine the quantitative differences, univariate and multivariate analysis of variance were applied.

Results

The results of testing by using the multivariate analysis of variance showed that at the level of the whole system of motor variables, there was no statistically significant differences between respondents with different levels of intellectual abilities (F = 1.446; P = .138). However, at the univariate level, statistically significant differences were obtained in two of the seven motor variables: Hand tapping and Sit-and-reach (Table 1). From the table we can conclude that the second group (AVERAGE) achieved the best average values regarding the variable Hand tapping, while the third group achieved the best results regarding the variable seat-and-reach (ABOVE AVERAGE).

Table 1. Results of MANOVA, ANOVA, and Post-hoc tests regarding the motor skills in all analyzed groups

	Below average (a) N=11	Average (b) N=56	Above average (c) N=21		
	mean ± SD	mean ± SD	mean ± SD	f	p
20m dash (0,1 s)	48.45 ± 5.126	48.18 ± 6.025	47.71 ± 4.417	.078	.925
Obstacle course backwards (0,1 s)	277.27 ± 140.895	241.04 ± 96.506	264.38 ± 114.381	.739	.481
Hand taping (n/15 s)	16.27 ± 3.690	19.25 ± 3.553 a/**b**	18.19 ± 2.804	3.730	.028
Seat-and-reach (cm)	37.00 ± 8.899	40.77 ± 8.093	45.19 ± 11.321 a/**c**	3.280	.042
Standing broad jump (cm)	121.82 ± 20.841	124.75 ± 21.277	122.90 ± 20.152	.124	.884
Bent arm hang (0,1 s)	155.18 ± 181.770	167.16 ± 120.181	185.48 ± 177.789	.191	.826
Trunk lifting (n/60 s)	28.64 ± 6.265	25.14 ± 10.147	26.52 ± 7.607	.723	.488
	F=1.446	P=.138			

Legend:
f – univariate f-test; p – significance of f-test; F – multivariate F-test; P – significance of F-test, a/b – significant Post-Hoc tests (a vs b, if b is bolded means that b is better than a)

In order to identify groups between which there are statistically significant differences in variables Hand tapping and Seat and reach, LSD – Post Hoc test was applied (Table 1). Statistically significant differences were noticed between the first and second group regarding the HAND TAPPING motor test. The differences are in favor of the second group (AVERAGE). When it comes to SEAT-AND-REACH motor test, statistically significant differences were observed between the first and the third group, and the difference is in favor of a third group (HIGHER VALUES).

Discussion

This study was aimed at the investigation of the differences in motor skills of children aged 7, with different levels of intellectual ability.

By reviewing the results obtained, we can conclude that there is no statistically significant difference in the general area ofmotor skills in children with different levels of intelligence. At the univariate level, however, there is a statistically significant difference regarding the two variables: Hand tapping and Sit-and-reach. Most authors agree with the fact that there are general mechanisms that are responsible for the speed of information flow, and that the tasks with measuring the information flow rate, even the easiest ones, are significantly positively correlated with general intelligence factor (Vernon & Mori, 1992). It is concluded that complex motor tasks have a stronger relationship with cognitive abilities, i.e. their performance involves cognitive processes to a greater extent, while the process of performing a simple motor tasks is at the lower, elementary level, where the share of intellectual processes is minimized.

Van der Fels et al. (2015) have obtained different results regarding the relations between the basic categories of motor and cognitive abilities, resulting in interesting conclusions: fine motor skills, bilateral coordination of the body and movement performance in a given time interval showed the strongest correlation with cognitive abilities. Fine motor skills involve those tasks that require fine motor precision and integration; bilateral coordination of the body, includes the tasks of coordination of the whole body and require the involvement of almost all body parts and bilateral coordination of upper and lower extremities; movement performance in a given time interval includes the tasks (coarse/fine motor skills or tasks that involve object control) where the time needed by the child to perform a number of movements is essential, and these tasks are often divided into repetitive movements and sequencing movements. Repetitive movements are simple movements that are repeated as quickly as possible. Sequential movements include alternating patterns of complex movements executed as quickly as possible. However, balance, strength and agility are less associated with cognitive abilities. This can be explained by the fact that the first group of motor skills (fine motor skills, bilateral coordination of the body and movement performance in a given time interval) requires a higher level of cognitive demand. Motor skills that show a higher correlation with cognitive abilities can be interpreted as complex motor skills and they require cognitive abilities of higher order. Motor tasks that show lower correlation with cognitive abilities require less cognitive engagement.

Children of higher intellectual capacity are better and more effective in solving motor problems and tasks set before them, especially if they are under significant influence of the mechanism for movement structuring and mechanisms for regulation of excitation intensity (Fratrić et al., 2012). Without the mutual effect of motor and cognitive abilities it is hard to imagine most human activities, and this relationship lasts a lifetime. Acquisition of intellectual and motor abilities takes place in a very similar way, i.e. similar mechanisms govern both types of abilities (Paz et al., 2004). In addition to its well-established role in balance, coordination and other motor skills, the cerebellum plays a prominent role in a number of cognitive and emotional functions, and is also associated with the ability to learn complex motor tasks (Tiemeierisar., 2010). Cardiorespiratory endurance, muscular strength and power, and physical activity are associated with learning capability, which was consistent with the hypothesis that physical activity improves academic achievement. They concluded that physical activity and physical fitness, at best, can contribute to improved academic achievements (Dwyer et al., 2001). Cognitive abilities include mental processing of information and include processes such as attention, perception, memory, reasoning and problem solving. These obtained results coincide with some previous research (M. V. Stojanović & M. Stojanović, 2006). The highest partial influence on intelligence was achieved by the variable for assessing the frequency of movements, which is consistent with previous research by local authors (M. V. Stojanović et al., 2006), who also concluded that in preschool children intelligence has the greatest impact on the movements frequency (hand tapping), because it is the ability that is under the direct influence of the mechanism for the synergistic regulation and regulation of tone. In rapid execution of individual movements the mechanism of regulation of tone, whose main function is the activation of motor units, has a special role. In addition, the centers located in subcortical areas include regulatory mechanisms of different degree of excitation depending on the load, during the performance of the movement (special importance is given to the function of the reticular formation in the facilitation effect to the cerebrum cortex areas). This assertion is confirmed by research by Jakšić, Kolar, & Cvetković (2007) who have obtained results confirming the influence of the intelligence to the motor ability of movement frequency (hand tapping) among children aged 5 to 6.5 years.

The results obtained in this study do not coincide with the results from the most of the previous studies. This fact can be attributed to the specifics of both the sample of respondents and measuring instruments themselves. The results of study (Colquitt et al., 2011) indicate that other indicators of physical fitness may predict academic achievement in students less than 10 years of age, as flexibility was a significant predictor of both language arts and mathematics achievement. The evidence of a relationship between flexibility and academic achievement in the results also provides support for the role of quality physical education in schools. The results of another study (Adesa et al., 2014) showed that there was an improvement of push up, trunk lift, nine meter running and sit and reach test for experimental group when it was compared from pre to post test measurements. The control group also improved in some aspects but it was not that much. The academic results showed that experimental group's academic achievement were greatly improved from first to second semester. But in the control group the mean value of academic achievement from first to second semester was decreased. The significance results showed that experimental group improved academic achievement due to participation of physical activities.

Regular participation in physical activity has a significant effect on the improvement and enhancement of physical fitness performance and improve academic achievements. The school participants, who take part in the regular physical activities can improve their physical fitness and academic achievement. Participation in regular exercises is very important for school children for overall development.

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