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## *Engagement in sports and children's cognitive abilities: an analysis of executive functions<sup>2</sup>*

### Extended summary

Executive functions (EF) are higher-order cognitive processes that facilitate goal-directed behavior, and are activated during social interactions and in new, complex situations. Scholars agree that the basic aspects of EF are inhibitory control, working memory, and cognitive flexibility (Friedman & Miyake, 2017), which are building blocks of complex functions such as reasoning, problem solving, and planning (Diamond, 2020). Basic and complex EFs are highly relevant to academic achievement (e.g., De Santana et al., 2022) and mental health (e.g., Diaz-Marsa et al., 2023). Considering that some external factors can modulate performance in the domain of EF, it is of great importance to investigate the factors that contribute to their optimal development.

Recent research indicates a significant correlation between physical activity and cognitive abilities, especially EF (Hernández-Mendo et al., 2019). A current research trend examines how the type of movement in specific sports and the predictability of the sports environment influence the improvement of EF. Sports can be classified into activities that require open or closed-type skills, with each type activating specific cognitive abilities depending on the characteristics of the environment (Knapp, 2024). Open-skill (OS) sports, such as basketball, require perception, attention, planning, and decision-making in a dynamic and unpredictable environment, while closed-skill (CS) sports, such as running, typically require less cognitive engagement and are performed in predictable contexts.

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The results of the previous research indicate that people who engage in OS sports, especially team sports from this group, have better EF compared to those who are engaged in CS sports (Krenn et al., 2018). However, research findings are not uniform; some authors find no significant differences between the sport groups, while others report the opposite results. The discrepancy in the findings, both in adults and children, may be due to an insufficient control of the variables associated with performance in the EF domain. One of these variables is the level of intellectual functioning, as individuals with higher IQ tend to have better EF, making the control of this factor important for understanding the relationship between physical activity and EF. Therefore, the aim of this research is to examine the level of development of the basic and complex EF in children aged 9–11, depending on whether they play sports in their free time or not, while controlling for the influence of intelligence. Additionally, this research will compare the EF of the children who practice OS and CS sports.

The research included 83 children (53% girls), students of an elementary school in Belgrade. Out of the total number of children, 48.2% play sports in their free time. These respondents were further divided into two groups: (a) children engaged in OS sports (56.8%) and (b) children engaged in CS sports (43.2%), who train at least twice a week.

Intelligence was assessed with Raven's progressive matrices; working memory with backward span tasks (numbers and figures backwards); inhibitory control with the Stroop test and the Go/Stop task, and cognitive flexibility with the Wisconsin card sorting test. Planning was analyzed with the 20-question Test and the Tower of London (details about the tasks can be found in: Buha & Gligorović (2012; 2015; 2016) and Gligorović & Buha (2013)).

The obtained results indicate that playing sports is associated with better achievement in the domain of non-verbal working memory. Intelligence as a covariate did not significantly change the results, nor did it influence the change in effect size. Both independent variables together (intelligence and involvement in sports) explain about 15% of the variability of the results,  $R^2=.148$ ,  $F(2, 80)=6.96$ ,  $p=.002$ . Additional analysis revealed that respondents who play OS sports have a higher capacity of non-verbal working memory,  $F(1, 76)=3.82$ ,  $p=.026$ , partial  $\eta^2=.09$ . Both independent variables together explain about 17% of the variance,  $R^2=.167$ ,  $F(3, 76)=5.09$ ,  $p=.003$ . Differences in other EF domains and modalities are not present.

Although sports activities affect certain cognitive abilities in children, these effects cannot be generalized to all domains of EF. The correlation between sports activities and working memory suggests that such activities could also benefit children with neurodevelopmental disorders, which emphasizes the need for additional research aimed at understanding specific mechanisms and adapting interventions to support their cognitive development.

The results of this research can help policy makers in health and education to recognize the importance of sports activities, especially those involving open-ended skills, in improving cognitive functions (working memory), and thus the academic success of children. In education policy, these findings emphasize the need to include in the curriculum the physical activities that require cognitive engagement - educators can advocate structured physical education programs, the introduction of active school holidays, and specifically designed after-school activities. Also, policy makers should support extracurricular sports programs to ensure equal access for all students.

**Keywords:** executive functions, nonverbal working memory, sport, open skills sports, closed skills sports

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