

Ingrid RUZBARSKA
0000-0003-0459-8161
University of Presov

Physical Activity and Cognitive Functions in Young School-age Children with Attention Deficit and Hyperactivity Disorder*

Abstract

The paper is based on an analysis of research approaches for identifying the effects of physical activity on the cognitive dimensions of primary school-age children with ADHD. The emphasis is on analyzing research findings on the effect of physical activity on the various symptoms exhibited by children with ADHD from the perspective of short-term or long-term effects. We focus also on describing the effect of some specific forms of physical activity and their potential therapeutic effects on children with ADHD. In this context we should note there is a certain degree of ambiguity in the research conclusions, which is probably linked to variations in the research designs used.

Keywords: attention deficit and hyperactivity disorder, primary education, physical activity

Introduction

In the last decade the scientific and expert communities have displayed greater interest in verifying the benefits of physical activity in relation to levels of cognitive functioning in specific groups of the child population. As Hillman, Erickson and Kramer (2008) have stated, the variety of variables investigated and methodological discrepancies make it difficult to draw clear conclusions as to the effect physical exercise has on an individual's cognitive domains.

Gapin, Labban and Etnier (2011) indicated that, despite knowledge on the potential positive therapeutic effects of physical activity, the scientific knowl-

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edge on identifying the specific effects of various forms of physical activity on the behavioral symptoms or cognitive performance of children with ADHD is limited. They emphasized that the population of children with ADHD could profit from physical activity more than the non-ADHD child population.

As Heijer a. oth. (2017) have stated there are various ways in which we can distinguish between the physical interventions used in research monitoring the effects of physical activity on cognitive domains in individuals with ADHD. As far as intervention length is concerned, both short-term and long-term exercise programs have been investigated. While the different physiological effects are reflected in cardio and non-cardio exercise programs. Cardio exercise includes all types of physiological exercise that raises the body's heart rate and oxygen consumption. Examples include many locomotion or cyclical physical activities (running, cycling, swimming, jumping, etc.) that are relatively aerobically demanding. As Heijer a. oth. (2017) have stated other distinct aspects are the dependent variables identified. In this respect, research measuring cognitive, behavioral/socio-emotional and neurophysiological variables or combinations thereof is important.

In relation to intervention length, Verburgh a. oth. (2013) stated that physical interventions generally consist of short-term physical activity or single sessions lasting 10 to 40 minutes. Examples of longer programs are those consisting of regular exercise repeated several times a week, typically in intervals of 6 to 30 weeks.

Heijer a. oth. (2017) defined the short-term (direct) effects of exercise on the research variable as effects measured immediately following the physical exercise or at least 24 hours after the intervention, but ideally on the same day as the intervention took place. The long-term effects of physical activity are defined as effects lasting longer than 24 hours following completion of the physical intervention and are recorded once the entire physical intervention has ended.

Based on the above, one can state that the research verifying the effect of physical activity on cognitive functions in children with ADHD tends to identify the direct effect of a single session of physical activity or of long-term physical exercise programs. Therefore, in the next section we focus on analyzing research findings on the effect of physical activity on the various symptoms exhibited by children with ADHD from the perspective of short-term or long-term effects.

Short-term effects of physical activity on cognitive functioning in children with ADHD

Hernandez-Reif, Field and Thimas (2001) stated that we still lack knowledge on the immediate effect of physical activity on cognition in individuals with ADHD.

Etscheidt and Ayllon (1987) according to Verret a. oth. (2010) verified the effect of five minutes' intensive exercise aimed at reducing "hyperactive" behavior manifested mainly during school tasks in 13-year-old pupils with ADHD. As the authors stated this short-term exercise "therapy" contributed to a significant reduction in the level of negative behaviors during math and reading lessons.

Smith a. oth. (2013) found cognitive control and flexibility, inhibition, attention selection, and information-processing speed improved immediately after a single session of physical exercise. Research by Pontifex a. oth. (2013) demonstrated that even one aerobics session of middling intensity could be a form of nonpharmacological therapy for 8–10-year-olds with ADHD. As they further stated, the results of experimental testing indicated a statistically significant increase in level of inhibition control, attention selection and distribution, and in information-processing speed. These improvements related both to children with ADHD and the control group of children without ADHD. Moreover, based on research findings, the authors stated that immediately after the exercise both samples showed a significant improvement in level of reading comprehension and arithmetic task-solving. These findings indicate that immediate improvements in neurocognitive functions following physical exercise probably contribute to an enhancement in academic skills and competencies, which are significantly affected by inhibition level.

Tantillo a. oth. (2002) stated that the immediate, short-term neuropsychological effect of aerobic-stamina exercise was to reduce levels of motor agitation, disharmony, and excessive movements in a sample of boys; although not in the sample of girls.

Further research conclusions are still needed to boost knowledge on the direct effect of physical activity. The question is whether other factors (e.g., age, diet, temperament, or other personality traits) could be associated with changes in level of cognitive functions, stimulated through a single session of physical exercise (Pontifex a. oth., 2013). As the authors of the paper further noted, another area in which we lack relevant information is the various lasting effects on cognitive functioning level elicited by a single session of brief physical activity. Based on the relatively inconsistent findings of some research it seems that the positive effect of brief physical activity on working memory and inhibition may last for 60 minutes after the exercise has ended (Hillman a. oth., 2009).

Based on these research findings we can suppose that a brief single session of physical activity positively stimulates cognitive functioning, both in children with ADHD and in the non-ADHD population. Moreover, the benefits of physical activity have been confirmed in relation to some adverse behavioral symptoms in individuals with ADHD. Nonetheless, not all aspects of cognitive and academic functioning in individuals with ADHD can be considered sensitive to this type of physical activity. Hence, the need for further research aimed at defining in greater detail the determinants of brief physical exercise on the various cognitive dimensions.

Long-term effects of physical activity on cognitive functioning in children with ADHD

Verret a. oth. (2010) found that a 10-week exercise intervention (45 minutes of exercise, three times a week) positively determined cognitive and behavioral parameters in 7–12-year-old children with ADHD. In the area of cognitive functions, the positive changes mainly concerned acoustic and visual information-processing.

Many other studies consistently refer to the positive effects of long-term regular physical activity on behavioral, or socioemotional, symptoms in children with ADHD, such as self-esteem, self-respect, self-confidence, and classroom behavior (Choi a. oth., 2014). Similarly, Smith a. oth. (2013), and Verret a. oth. (2012) showed that long-term stamina-based physical activity had positive effects on social skills, ability to work with others, social perception, disruptive behaviors, unintentional aggression, and so on.

In relation to the effects of regular physical activity in the ADHD and non-ADHD child populations, Best (2010) stated that other aspects that should be taken into account when designing research in this area is current cognitive developmental level and the specific components of executive functions being investigated. In Best's opinion the link between executive functions and physical exercise could be significantly affected by the age of the population or the specific executive functions being investigated. This is supported by Hillman a. oth. (2009) who considered inhibition control in late childhood to be more sensitive to physical activity than cognitive flexibility is, but that this does not apply to adolescence.

Despite the many benefits of regular physical activity, Kim a. oth. (2004) stated that children with ADHD participated more in very high intensity physical activity and less in organized sports when compared with the non-ADHD population. This, and the research finding on the positive effects of long-term physical sports programs on neurocognitive functions and behaviors of individ-

uals with ADHD, are relevant arguments for running dedicated physical-exercise programs in school settings. Therefore, it is important to have specially designed physical exercise and sports models that can be incorporated into the everyday school routine and that can serve as an important pedagogical means of stimulating learning in pupils with ADHD and pupils without ADHD.

Specific forms of physical activity and cognitive functions in children with ADHD

Besides these findings and comparisons of the direct and long-term effects of physical exercise, recent research efforts have been aimed at ascertaining which forms of physical exercise most effectively contribute to mitigating undesirable symptoms in individuals with ADHD. Equally, we still do not know enough about how to maximize the benefits of physical activity, especially in relation to raising cognition levels, and not just in children with ADHD but also in the non-ADHD child population. Therefore, in the last section we briefly describe research findings relating to some specific forms of physical exercise and their potential therapeutic effects on behavioral and cognitive domains in individuals with ADHD.

As regards aerobic exercise, Best (2010) defined three basic, generally valid effects of physical exercise that have an effect on an individual's executive functions:

- 1) team-based physical and sports games are inherently cognitively demanding;
- 2) cognitive difficulty is based on the complex coordination required in complicated physical activities;
- 3) complex physiological and biochemical changes in the human organism triggered by aerobic exercise.

In this respect Best (2010) emphasized that more cognitively demanding physical exercise is highly likely to have a "stronger" effect on the development of an individual's executive functions than less cognitively demanding exercise.

Recent scientific interest has focused on various specific, non-traditional, or innovative forms of physical exercise. Hernandez-Reif, Field and Thimas (2001) reported a reduction in anxiety, hyperactivity, negative emotions, and daydreaming in children with ADHD immediately after tai-chi exercises. However, they did not find any changes in asocial behaviors in the sample.

Educational exercise programs consisting of balance and coordination exercises, and exercises aimed at developing manipulation skills, catching, throwing, and so, on have been found to have a significant positive effect on a pop-

ulation of children with learning disorders (Reynolds, Nicolson, Hambly, 2003).

We can agree with Cortese a. oth. (2013) that in recent decades experts and scientists have debated the use of medication-based therapies. Tucha a. oth. (2006) stressed that physical activity could be of important benefit in treating children with ADHD in cases where:

- 1) pharmacological treatment does not mitigate the impairments;
- 2) medicine-based treatments are not the first choice;
- 2) medicine-based treatments have inconsistent effects on the child's behavior;
- 4) the child exhibits only a slight impairment and pharmacological treatment is unnecessary.

Conclusions

In conclusion we can state that there is still insufficient clarity on how physical activity and cognitive performance interact in young school children with ADHD. It is important to investigate the effects of physical activity at the level of cognition in the non-ADHD population and in individuals with various types of specific disorders for at least two reasons:

- a) it is an important argument for promoting physical activity as an important and effective educational and therapeutic medium;
- b) physical sports education programs can help mitigate a whole range of behavioral disorders or cognitive dysfunctions.

Our view is that various forms of exercise and sports programs should occupy a firm position in the primary-school curriculum. Ensuring that physical activity is part of the school curriculum is not a "waste of time" better spent on "more important" subjects. On the contrary it provides a range of opportunities for achieving the psychomotor, cognitive, and affective goals set out in relation to all subjects on the curriculum. Moreover, physical activity makes it possible to maximize the positive education effects for children with special educational needs as well.

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