



Review article

Acute and chronic effect of physical activity on cognition and behaviour in young people with ADHD: A systematic review of intervention studies



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ABSTRACT

Background: Young people with attention deficit hyperactivity disorder (ADHD) often have learning and behavioral control difficulties.

Aim: The aim of this review is analyse the acute and chronic effect of physical activity (PA) on the cognition and behaviour of children and adolescents with ADHD.

Methods: Studies were identified in five databases (PubMed, SPORTDiscus, ProQuest, Web of Science, and SCOPUS), from January 2000 through to January 2017. A total of 16 interventional studies met the inclusion criteria.

Results/conclusions: PA practice of 20–30 min (intensity 40–75%) produces a positive acute effect on processing speed, working memory, planning and problem solving in young people with ADHD. However, these effects on behaviour are contradictory and vary depending on age. Chronic PA practice (≥ 30 min per day, $\geq 40\%$ intensity, \geq three days per week, \geq five weeks) further improves attention, inhibition, emotional control, behaviour and motor control. The results must be treated with caution, because only 25% of the studies used confounders.

Implication: More research is needed to justify the causes of these effects. It is necessary to establish programs with regard to the duration, intensity, kind of exercise, and time of PA to improve cognition and behaviour in young people with ADHD taking into account potential confounders.

What this paper adds?

This systematic review shows that physical activity practice has a positive effect on cognition of children with ADHD, and in 35% of analysed studies also appear an improvement on the behaviour in these young people. However, these results show differences between short and long-term effects, and they could differ according to duration, intensity, kind of exercise and time of the working day. These important findings should be highlighted in the neurophysiological understanding of ADHD. In school context, it is necessary to find more periods of physical activity during school hours and new ways for interdisciplinary combination between

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subjects.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is characterized by a persistent pattern of inattention and/or hyperactivity/impulsivity (ICD10, 1992). This pathology is considered one of the most common neurodevelopmental disorders in children, and it is frequently associated with other psychiatric conditions such as defiant opposition/negative disorder, conduct disorder, learning disabilities and anxiety (Van der Oord, Prins, Oosterlaan, & Emmelkamp, 2008). The global prevalence rate of ADHD in young people ≤ 18 years is between 5.3% (Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015), being nearly three times more common in boys than in girls (9.2% versus 3.0%), independent of age (Wittchen et al., 2011).

The main conditions of ADHD in schoolchildren are related to two key elements for learning: deficits in cognition and behaviour problems (Gapin & Etnier, 2010). Cognition refers to cognitive performance (CP) —including mainly executive functions such as memory, attention or mental planning/organization (Diamond, 2013)—. Behaviour problems, are characterized by persistent impulsive or emotional behaviour that disrupts the educational process and harms the CP of these children (Polanczyk, de Lima, Horta, Biederman, & Rohde 2007; Wittchen et al., 2011).

Currently, to treat ADHD the first strategy is to use medication, because ADHD is mainly associated with low dopamine levels in the frontal lobe and the striatum (Vaidya et al., 1998). However, some children reflect a partial response to treatment or suffer secondary effects (Westover & Halm, 2012). The second strategy is based on behaviour modification to teach young people with ADHD to control their impulsive or emotional behaviour and take advantage of the cognitive abilities required for successful AP, such as sustained attention or concentration on the task (Watson, Richels, Michalek, & Raymer, 2015). It has been found that medication is less effective for social skills and executive functions (Hoza et al., 2005). Other studies indicate that psychosocial interventions are not as effective as medication in reducing the basic symptoms of ADHD, although they do positively improve the associated deficiencies, like oppositional and defiant behaviour (Van der Oord et al., 2008). However, the benefits of psychosocial interventions decrease rapidly after the intervention (Westover & Halm, 2012).

As an complement to the above strategies, treatments based on PA have recently emerged. Recent studies have shown that the PA practice is associated with an improvement in processing speed, working memory, planning and problem solving (Chuang, Tsai, Chang, Huang, & Hung, 2015; Piepmeier et al., 2015; Pontifex, Saliba, Raine, Picchietti, & Hillman, 2013). Katz et al. (2010), observed that children with ADHD who performed high-intensity exercise in Physical Education (PE) class were able to reduce their stimulant medication intake. This was due to an increase in norepinephrine and dopamine levels in the brain, and a biological adaptive response of brain function to the stimulus generated by exercise (Wigal, Emmerson, Gehricke, & Galassetti, 2012).

This study raised the following question: ‘Can PA produce short- and long-term improvements on cognition and behaviour in young people with ADHD?’. Understanding the effects of PA on cognition and behaviour in young people with ADHD could clarify the discussion of the importance of PA in this population, and help in making decisions about the level of PA integration in education systems. This study aims to carry out a systematic review of the results of studies that have examined the acute and chronic effect of PA on cognition and behaviour in children and adolescents with ADHD. Additionally, this paper also reviews potential mediators and moderators that could influence this relationship.

2. Methods

The study was designed following the structure and recommendation of other systematic reviews (Cerrillo-Urbina et al., 2015), the treatment used by PRISMA guidance for reports and studies (Beller et al., 2013) and AERA guidelines for reviews (<http://www.era.net/>). Databases, search strategies and limits, and filtered papers are detailed in Table 1. The above allows replication of the search (Higgins & Green, 2013).

2.1. Search limits

A comprehensive search of five databases (PubMed, SPORTDiscus, Web of Science, ProQuest and SCOPUS) from January 2000 to January 2017 was undertaken. Additionally, reference lists of the selected papers were reviewed. The principal categories of search

Table 1
Search strategy in databases.

Database	Search Strategy	Limits	Filter
PubMed	((("physical fitness"[Title] OR "physical activity"[Title] OR "physical education"[Title] OR "fitness"[Title] OR "exercise", "physical exercise"[Title] OR "acute exercise"[Title] OR "chronic exercise"[Title] OR "healthy exercise"[Title] OR "aerobic exercise"[Title] OR "resistance exercise"[Title] OR "anaerobic exercise"[Title])) AND ("attention deficit hyperactivity disorder"[Title] OR "ADHD"[Title] OR "attention deficit disorder"[Title])) AND ("children"[Title] OR "childhood"[Title] OR "school-age youth"[Title] OR "adolescent"[Title] OR "teenagers"[Title] OR "student"[Title] OR "school"[Title] OR "high school"[Title])	Publication date from 2000/01/01 to 2017/01/31	9 items
SportDiscus (EBSCO)	OR "chronic exercise"[Title] OR "healthy exercise"[Title] OR "aerobic exercise"[Title]	-Humans	11 items
Web of Science	OR "resistance exercise"[Title] OR "anaerobic exercise"[Title])	Children: 6–12 years	46 items
ProQuest ERIC	hyperactivity disorder"[Title] OR "ADHD"[Title] OR "attention deficit disorder"[Title])	Adolescent: 13–18 years	1 items
SCOPUS	disorder"[Title]) AND ("children"[Title] OR "childhood"[Title] OR "school-age youth"[Title] OR "adolescent"[Title] OR "teenagers"[Title] OR "student"[Title] OR "school"[Title] OR "high school"[Title])	-English language	5 items

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