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Managing childhood and adolescent attention-deficit/hyperactivity disorder (ADHD) with exercise: A systematic review

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ABSTRACT

Background: Attention deficit hyperactivity disorder (ADHD) is one of the most common neuropsychiatric disorders affecting some 8–10% of children worldwide. Increasing research has shed light on the life course of the disorder, suggesting that majority of children with ADHD will continue to have persistent symptoms into adulthood. The mainstay of ADHD management has been pharmacologic and behavioural/psychological interventions, with little attention paid to exercise as a potential management strategy. A systematic review, examining both the short-term and long-term effects of exercise on children with ADHD, is timely and necessary to guide further research in this area.

Methods: Using the keywords [exercise OR physical OR activity OR sport] AND [attention deficit hyperactivity disorder OR ADHD OR ADDH], a preliminary search on the PubMed and Ovid database yielded 613 papers published in English between 1-Jan-1980 and 1-July-2016. Full articles were also reviewed for references of interest.

Results: A total of 30 studies were included in this systematic review. Both short-term and long-term studies support the clinical benefits of physical activity for individuals with ADHD. Cognitive, behavioural and physical symptoms of ADHD were alleviated in most instances, and the largest intervention effects were reported for mixed exercise programs. No adverse effects arising from physical exercise were reported in any of the studies, suggesting that exercise is a well-tolerated intervention.

Conclusion: Physical activity, in particular moderate-to-intense aerobic exercise, is a beneficial and well-tolerated intervention for children and adolescents with ADHD. Future research should include more adequately-powered trials and investigate the ideal exercise prescription.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neuropsychiatric disorders, estimated to affect 8–10% of children [1] and 5–6% of adults worldwide.[2] Increasing research has highlighted the life course of the disorder, suggesting that majority of children with ADHD will continue to have persistent symptoms into adulthood.[3]

Management of ADHD has been mainly focused on pharmacologic [4] and behavioural/psychological interventions,[5] with little attention paid to exercise as a potential management strategy. There are several issues with current pharmacologic and behavioural strategies for ADHD. Medications, in particular stimulants, often have intolerable side effects [6] and many parents are concerned about “overmedicating” their child and the short- (headache, nausea and anorexia) and long-term (reduced growth velocity) side effects of stimulants.[7] On the other hand, behavioural/psychological interventions are considered cumbersome and difficult to keep to on an ongoing basis for many patients and families.[8] Symptoms of ADHD generally recur with cessation of pharmacologic and/or behavioural/psychological therapies.[9] There is thus a pressing need for new management strategies, especially one that seeks to promote successful functioning during adolescence and alter the trajectory of the condition. Current management strategies have largely overlooked the fact that ADHD is a developmental disorder that spans one’s preschool to adult years.

Exercise is a novel and underexplored option for ADHD management. In addition to the general health benefits of exercise, both animal [10] and human studies [11–13] have reported beneficial and lasting effects of physical exercise on cognitive function, with increased blood flow to the brain and neurotransmitter levels, enhanced plasticity and better focus, attention and information processing. This raises the possibility of positively altering the course of ADHD through exercise. As the last

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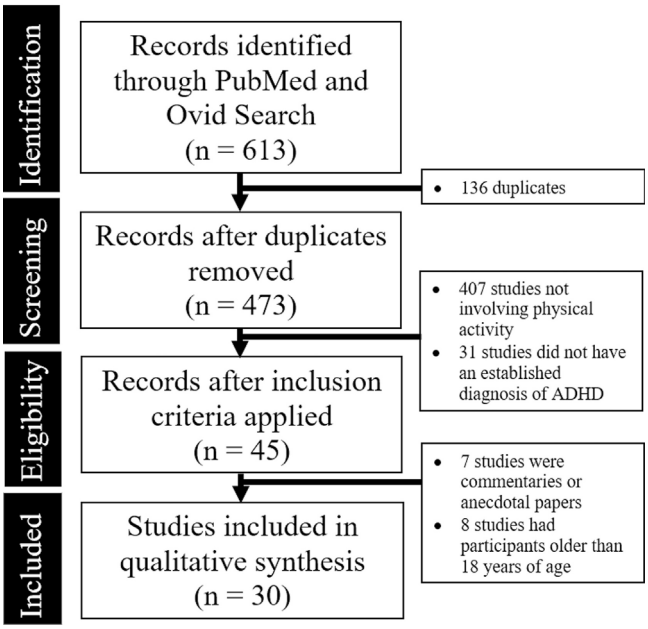

Fig. 1. PRISMA diagram showing the studies identified during the literature search and abstraction process.

systematic review on the topic was done in 2014 and focused only on the acute effects of exercise interventions,[14] an updated and complete systematic review examining both the short-term and long-term effects of exercise on children with ADHD is thus timely and necessary to guide further research.

2. Methods

A comprehensive literature search was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (as illustrated in Fig. 1). Using the keywords [exercise OR physical OR activity OR sport] AND [attention deficit hyperactivity disorder OR ADHD OR ADDH]; a preliminary search on the PubMed and Ovid database yielded 613 papers published in English between 1-Jan-1980 and 1-July-2016. Grey literature was not searched. Title/abstract screening were performed independently by three researchers to identify articles of interest. For relevant abstracts; full articles were obtained; reviewed and also checked for references of interest. The authors of the articles were not contacted to provide additional data.

Full articles were obtained for all selected abstracts and again independently reviewed by three researchers for inclusion. Any disagreement was resolved by discussion and consensus amongst three researchers. The inclusion criteria for this review were: (1) original research study of a type of exercise or physical activity, (2) study participants were children or adolescents (less than 18 years old), (3) study participants had an established clinical diagnosis of ADHD, and (4) outcome measures relating to ADHD symptoms were available. Data such as study design, study population, exercise intervention and outcome measures were extracted and summarized in Table 1.

Despite best efforts, a meta-analysis was not possible due to the heterogeneity of study designs (with methylphenidate supplementation in some studies) and dissimilar exercise interventions, limiting comparability. The small sample size of these trials also limited the quality and possibility of a meta-analysis.

3. Results

A total of 30 studies were included in this systematic review. Studies of the effects of physical exercise on the neurocognitive and behavioural symptoms of ADHD could be broadly classified into short-term/immediate (following a single bout of activity) and long-term (cumulative effects of activity over a longer duration) studies. The key study characteristics and findings were summarized in Table 1.

4. Discussion

Both short-term and long-term studies support the clinical benefits of physical activity for individuals with ADHD. Cognitive, behavioural and physical symptoms of ADHD were alleviated in most instances, and the largest intervention effects were reported for mixed exercise programs.

With regard to the short-term benefits of exercise, a 2010 study examined the effects of a single 30-min of high-intensity treadmill exercise in 25 children with ADHD.[19] There were significant improvements in response time and normalization of impulsivity and vigilance (go/no-go task) measures post-exercise, based on Conner's Continuous Performance Test-II (CPT) performance. A more recent study examined the effects of a single 20-min session of moderate-intensity aerobic exercise on children (aged 8–10 years) with ADHD.[21] The study found that both children with ADHD and healthy matched control children had better response accuracy and improved stimulus-related processing when performing an attentional-control task following exercise, with the children with ADHD also exhibiting enhancements in regulatory processes, compared with after a similar duration of seated reading. Improved performance in the areas of math and reading were also observed following exercise in both groups.

As for the long-term effects of exercise, a large-scale pilot study recruited 17 Grades K-3 children and investigated the effects of 26 min of continuous moderate-to-vigorous physical activity daily, before school, over eight school weeks.[41] The 17 children recruited for the study exhibited four or more hyperactivity/impulsivity symptoms on the Disruptive Behavior Disorders Rating Scale.[45] The researchers administered cognitive, motor, social, and behavioural functioning measures pre- and post-study, assessed response inhibition weekly, and recorded negative behaviours daily. Several of these measures showed a reduction of severity of ADHD symptoms, with response inhibition effects being the most consistent. Most of the children enrolled in the study (64–71%) also had overall improvements, as quantified by post-study teacher, program staff and parent ratings.

Interestingly, a study, which employed two separate 12-week training programs (one that focused on the abilities ball handling, balance and manual dexterity, and the other where the children were trained in sports without a specific focus), found significant and comparable improvements in both groups compared to the control group.[43] This implies that long-term physical activity has a positive effect on the executive functions of children with ADHD, regardless of the specificity of the sports program.

Notably, no harm arising from physical exercise (intervention) were reported in any of the aforementioned studies, suggesting that exercise is a well-tolerated intervention. Furthermore, it is known that children with ADHD are at an increased risk of becoming sedentary and obese adolescents,[46] hence an exercise intervention may be beneficial for both behavioural problems and obesity.

Dopamine deficiency in the pre-frontal cortex is widely implicated in the pathophysiology of ADHD.[47] The potential benefits of physical exercise in ADHD could be explained by the increased norepinephrine, dopamine, and serotonin levels in the pre-frontal cortex, hippocampus, and striatum following exercise.[48–50] Dopamine is essential for normal motor and cognitive functioning of the brain,[51] while norepinephrine is involved in executive functions and impulse control.[52] Similar to stimulant medications used to treat ADHD, exercise appears to exert physiological effects that increase dopamine and norepinephrine neurotransmitters, thus alleviating the symptoms of ADHD. The increased levels of serotonin and endogenous opioids (i.e., endorphins) following exercise may further enhance mood and attention.[12]