

Is Physical Activity Causally Associated With Symptoms of Attention-Deficit/Hyperactivity Disorder?

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Objective: Emerging evidence suggests that physical activity (PA) enhances cognition and may be a protective factor for attention-deficit/hyperactivity disorder (ADHD). Yet the impact of PA on ADHD symptoms has been investigated only in a few undersized, non-randomized, and retrospective studies. We examined the effect of PA during late adolescence on ADHD symptoms in early adulthood while controlling for unmeasured genetic and shared environmental confounding.

Method: The effect of PA at age 16 to 17 years (baseline) on ADHD symptoms at age 19 to 20 years (follow-up) was examined using a within-monozygotic (MZ) twins fixed-effects model in 232 MZ twin pairs born in Sweden between May 1985 and December 1986. Parents rated their children's DSM ADHD symptoms at baseline and follow-up. Participants' weekly energy expenditure (in metabolic equivalent task minutes per week) was based on self-reports at baseline of PA frequency, intensity, and duration.

Results: Greater weekly energy expenditure in adolescence was significantly associated with reduced ADHD

symptom levels in early adulthood, even when controlling for unmeasured confounding (all genetic and environmental factors shared within MZ twin pairs) as well as ADHD symptoms and body mass index (BMI) at baseline, $\beta = -0.21$, $p = .013$ (95% CI = -0.38 to -0.05). Similar results were observed for the 2 ADHD subcomponents: hyperactivity/impulsivity, $\beta = -0.21$, $p = .022$ (95% CI = -0.39 to -0.03), and inattention, $\beta = -0.19$, $p = .049$ (95% CI = -0.36 to -0.0005).

Conclusion: In line with a causal hypothesis, PA was inversely associated with ADHD symptoms, even after adjusting for unmeasured confounding. These findings suggest that PA in adolescence might decrease ADHD symptoms in early adulthood. However, given the size of the effect, the clinical value of this intervention needs to be explored further.

Key Words: physical activity, ADHD, exercise, twin modeling, TCHAD

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Attention-deficit/hyperactivity disorder (ADHD) is a complex neurodevelopmental disorder characterized by developmentally inappropriate and impairing levels of hyperactivity, impulsivity, and/or inattention.¹ Both the symptoms and functional impairments associated with ADHD persist from childhood into adolescence and adulthood in around 65% of individuals with the disorder.² Across the lifespan, ADHD is associated with a significant risk of lower academic and occupational achievement,³ interpersonal problems, mental illness, and delinquency.⁴ Multimodal treatment plans including psychostimulant medication, nonpsychostimulant medication, and psychological interventions, tailored to the specific needs of the patient, are recommended for the treatment of ADHD.⁵ Because of their persistence, there is a continued need for treatment and management of ADHD symptoms and impairments from childhood through adolescence and into adulthood.

A robust evidence base stemming from randomized controlled trials attests to the efficacy of psychostimulant and nonpsychostimulant medication in reducing the

symptoms of ADHD.⁶ Yet treatment with medication has its limitations. Some individuals may not respond to medication, and complete normalization of symptoms is rare.⁷ Medication may be less effective for treating associated impairments of ADHD, such as poor social skills⁸ and executive function (EF) deficits,⁹ and its long-term effectiveness for control of ADHD symptoms and impairments is yet to be established.¹⁰ Adverse side effects on sleep, appetite, and growth are also possible.¹¹ Furthermore, some patients, parents, and clinicians have reservations about medication use,¹² and the majority of individuals who are prescribed medication stop taking it within the first year.¹³ These potential problems are acknowledged by the National Institute for Health and Care Excellence (NICE) clinical guidelines, which recommend that nonmedical interventions should be considered as possible first-line treatment where ADHD is associated with moderate levels of impairment.⁵

A variety of nonpharmacological interventions, such as psychological (cognitive training, neurofeedback, and behavioral training) and dietary (restricted elimination diets, artificial food color exclusions, and free fatty acid supplementation) interventions, are also available. A recent meta-analysis found blinded evidence that behavioral interventions used to treat children and adolescents with ADHD had beneficial effects on important aspects of child



This article is discussed in an editorial by Dr. Jeffrey M. Halperin on page 537.