

Protection From Genetic Diathesis in Attention-Deficit/Hyperactivity Disorder: Possible Complementary Roles of Exercise

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Objective: The degree of functional impairment and adverse developmental outcomes in individuals with attention-deficit/hyperactivity disorder (ADHD) likely reflect interplay between genes and environment. To establish whether physical exercise might reduce the level of ADHD symptoms or ADHD-related impairments, we conducted a comprehensive review of the effect of exercise in children with ADHD. Findings on the impact of exercise in animals and typically developing human beings, and an overview of putative mechanisms involved, are also presented to provide the context in which to understand this review. **Method:** The electronic databases PubMed, OVID, and Web of Knowledge were searched for all studies investigating the effect of exercise in children and adolescents with ADHD, as well as animal models of ADHD behaviors (available in January 2013). Of 2,150 initially identified records, 16 were included. **Results:** Animal studies indicate that exercise, especially early in development, may be beneficial for ADHD symptom reduction. The limited research investigating the effect of exercise in children and adolescents with ADHD suggests that exercise may improve executive functioning and behavioral symptoms associated with ADHD. Although animal research suggests that brain-derived neurotrophic factor (BDNF) and catecholamines (CAs) play a role in mediating these effects, the association between BDNF and ADHD remains unclear in human beings. **Conclusions:** The potential protective qualities of exercise with regard to reducing symptoms and impairments commonly associated with ADHD may hold promise for the future. Further research is needed to firmly establish whether there are clinically significant effects of exercise on the severity of ADHD symptoms, impairments, and associated developmental outcomes. *J. Am. Acad. Child Adolesc. Psychiatry*, 2013;52(9):900–910. **Key Words:** attention-deficit/hyperactivity disorder (ADHD), epigenetics, exercise, physical activity, protective factors

Attention-deficit/hyperactivity disorder (ADHD) is a complex neurodevelopmental disorder characterized by developmentally inappropriate and impairing levels of hyperactivity, impulsivity, and/or inattention.¹ ADHD is associated with multiple cognitive impairments, including lower average IQ,² impairment in attentional processing, response inhibition, and other aspects of executive functioning,³ which share genetic/familial risks with ADHD.^{3,4} Genetic factors play a pivotal role in the susceptibility to ADHD, with 60%

to 75% or more of the variance in ADHD symptoms attributable to genetic variation.^{5,6} Environmental factors are also likely to contribute to the development of the disorder and to the associated emotional, behavioral, and academic difficulties.⁷ Moreover, the effects of genetic risks on development may depend on exposure to either adverse or enriched environments, leading to either negative or positive long-term outcomes.^{8,9} Such gene–environment interactions mean that specific environments may be more or less beneficial to the long-term outcomes in children with ADHD.

Several environmental risk factors have been linked to ADHD.⁷ Yet, less attention has been paid to protective factors that might reduce levels of ADHD symptoms and impairments associated



This article is discussed in an editorial by Dr. Samuele Cortese on page 894.