



A racket-sport intervention improves behavioral and cognitive performance in children with attention-deficit/hyperactivity disorder



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ABSTRACT

The present study assessed the effects of a 12-week table tennis exercise on motor skills, social behaviors, and executive functions in children with attention deficit hyperactivity disorder (ADHD). In the first 12-week phase, 16 children (group I) received the intervention, whereas 16 children (group II) did not. A second 12-week phase immediately followed with the treatments reversed. Improvements were observed in executive functions in both groups after the intervention. After the first 12-week phase, some motor and behavioral functions improved in group I. After the second 12-week phase, similar improvements were noted for group II, and the intervention effects achieved in the first phase were persisted in group I. The racket-sport intervention is valuable in promoting motor skills, social behaviors, and executive functions and should be included within the standard-of-care treatment for children with ADHD.

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1. Introduction

Attention deficit hyperactivity disorder (ADHD), one of the most common childhood psychological disorders, persists until adolescence and adulthood in the majority of diagnosed patients (American Psychiatric Association [APA], 2013). ADHD is characterized by inattention, impulsiveness, and hyperactivity; these symptoms have various cognitive, social, and behavioral consequences (Barkley, 1997; Bohlin, Eninger, Brocki, & Thorell, 2012; Tseng & Gau, 2013; Wählstedt, Thorell, & Bohlin, 2008). Impaired executive function is considered one of the central deficits in ADHD (Barkley, 1997). Deficits in inhibition have been associated with ADHD and attention problems as well as internalizing (Karasinski, 2015) and externalizing behavior problems (Karasinski, 2015; Riccio, Lockwood, & Blake, 2011). Furthermore, approximately 30%–50% of people with ADHD were reported to experience a comorbid motor coordination problem (Sergeant, Piek, & Oosterlaan, 2006). Studies have reported potential interrelationships between motor skill performance and executive functions in children with ADHD (Hung et al., 2013; Piek et al., 2004) and other disabilities (Hartman, Houwen, Scherder, & Visscher, 2010; Schott & Holfelder, 2015); hence, poorer motor skill performance is associated with in poorer executive functions and vice versa. These executive dysfunctions, motor skill difficulties, and social behavior deficits may interfere with the daily functioning of a child with

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ADHD and negatively affect academic performance (Loe & Feldman, 2007). Therefore, early physical exercise interventions targeting motor skill training may be particularly helpful in addressing the essential behaviors and executive functions in children with ADHD.

The potential therapeutic effects of physical exercise on cognitive functions, specifically executive functions, are increasingly investigated in typically developing children and young adults (Verburgh, Königs, Scherder, & Oosterlaan, 2014). Although few studies have examined the effects of exercise on people with ADHD, the available data suggest that physical exercise of moderate to vigorous intensity and lasting 30–45 min per session for 8–10 weeks likely has beneficial effects on motor skills, behavioral symptoms, and executive functions (Smith et al., 2013; Verret, Guay, Berthiaume, Gardiner, & Beliveau, 2012). Smith et al. (2013) used a within-subjects experimental design to examine an 8-week school-based physical activity program (30 min, 5 times a week) held prior to classes and included 14 young children (Grades K–3) with a risk of ADHD who exhibited at least four symptoms of hyperactivity or impulsivity. The findings revealed significant improvements in pre-post program measurements of gross and fine motor skill proficiency and inhibitory control, in addition to teacher-reported improvements in weekly measurements of response inhibition and problem behaviors (i.e., inattention or overactivity and oppositional defiant behavior). Verret et al. (2012) used a between-subjects experimental design to compare elementary school-aged children diagnosed with ADHD who either did ($n = 10$) or did not ($n = 11$) participate in a thrice weekly 45-min moderate- to high-intensity physical activity program at lunchtime, reporting positive effects of physical exercise. These results indicated that the exercising children experienced significant improvements in their muscular capacity (i.e., push-ups), motor skill performance (i.e., locomotion and total gross motor skills), parent-reported behavior (i.e., social, thought, and attention problems), and neuropsychological tests (i.e., information processing and auditory sustained attention).

In the present study, a racket-sport intervention, namely table tennis training, was applied as physical exercise program for children with ADHD because table tennis is easy to learn and culturally well accepted. Despite limited evidence, table tennis training is considered effective in improving focus and attention. Pilot studies using this exercise as treatment for children with ADHD (Pan et al., 2015) and intellectual disabilities (Chen, Tsai, Wang, & Wuang, 2015) have reported positive outcomes. Pan et al. (2015) examined the effect of a table tennis program involving physical and cognitive training and observed positive effects of long-term physical exercise (70 min, twice a week for 12 weeks) on motor skills and executive functions measured using the Stroop test and Wisconsin Card Sorting Test (WCST) in children diagnosed with ADHD. Compared with the children in the ADHD nontraining group, those in the ADHD training group exhibited specific significant improvements in locomotor and object-control skills, selective attention, and overall performance in cognitive flexibility. Improvements were also noted in tendency toward perseveration and correct set shifting in the ADHD training group over time. Chen et al. (2015) examined the effect of a 16-week (60 min, three times a week) table tennis training program and standard occupational therapy on visual perception and executive functions in school-age children with mild intellectual disabilities and borderline intellectual functioning. Children in the two intervention groups exhibited specific significant improvements in performance compared with those in the control group on all measures of visual perception and executive functions measured using the Stroop and WCST-64; and children in the table tennis training group showed significantly greater improvements in all measures of visual perception and executive function tests compared with those in the standard occupational therapy and control groups. The authors concluded that table tennis training can be considered a therapy option for treating cognitive or perceptual problems in children with mild intellectual disabilities and borderline intellectual functioning.

Collectively, these preliminary studies provide evidence that physical exercise may be a viable strategy for improving symptoms, behaviors, inhibitory control, and neurocognitive function in children with ADHD. However, the studies have shortcomings, limiting their impact. Smith et al. (2013) did not use a control group, Verret et al. (2012) did not randomly assign participants to either an exercise or a control group, and none of the physical exercise interventions used in these studies aimed at achieving sustained and constant improvements in children with ADHD. Therefore, the primary aim of the present study was to examine the effects of a racket-sport intervention on motor skills, social behaviors, and executive functions by using a randomized controlled trial (RCT) design, and the secondary aim was to determine whether any training effects persisted several weeks after the training was completed. We focused on cognitive inhibition because of its centrality in current theories on executive dysfunction in ADHD (Barkley, 1997). Impaired motor skills and social behaviors, although not considered a core deficit in ADHD, are often associated with the disorder (Karasinski, 2015; Sergeant et al., 2006). We hypothesized, first, that a racket-sport intervention would improve motor skills, social behaviors, and executive functions in two groups (groups I and II) of children with ADHD and, second, that the intervention effects would be sustained in group I for 12 weeks of follow-up.

2. Methods

2.1. Study design

This study was an RCT investigating the effects of a 12-week racket-sport intervention on the motor skills, social behaviors, and executive functions of two groups of boys with ADHD. All participants were screened for eligibility and matched for age, severity, and medication usage prior to random assignment to one of the two groups, groups I ($n = 16$) and II ($n = 16$). Group I received the intervention in the first 12 weeks, whereas group II did not receive any table tennis exercise during the 12

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