

Asia Pacific Journal of Developmental Differences
Vol. 6, No.2, July 2019, pp. 296—303
DOI: 10.3850/S2345734119000286



ADHD: Current Research On the Contribution of Physical Exercise to Improvements in Cognitive Performance and Executive Functions (EF)

Mary Mountstephen¹,

¹ University of Reading, United Kingdom

Abstract

In this article, a commentary on the potential of physical exercise to ameliorate the deficits associated with ADHD is presented. The evidence suggests that this can be a useful tool for teachers in working with this group, and a range of alternative suggestions are presented. Implications for teaching generally are also considered.

Keywords: ADHD, Exercise, Cognitive Performance, Executive Function

* Correspondence to:

Mary Mountstephen, Doctoral Candidate at the University of Reading (UK)E: kcsmary1@gmail.com

INTRODUCTION

The importance of Executive Functions has recently been recognised and defined as a group of inter-related mental processes including working memory and inhibitory control that is responsible for supporting skills including reasoning, problem-solving and planning, that underlie cognitive performance. This is itself defined as the ability to sustain or shift attention in response to different demands.

Interestingly, executive function typically includes aspects of motor control. However, historically motor development and cognitive performance have been studied as two separate areas, with an understanding that motor development precedes cognitive development, Diamond (2010). There is, however, a growing interest among academic researchers and the world of education into how different forms of physical exercise may influence the ways in which children learn, behave and achieve in school. This links to research into the interrelation of motor development and cognitive development, with a focus on the ways in which physical activity may potentially influence children's functioning across several domains (McLelland, Pitt & Stein, 2015; Crispiani, Mountstephen & Palmieri, 2019; Tomporowski & McCullick, 2018).

This research suggests that there is a general consensus among researchers that executive functioning is not a unitary process; it is a complex process that recognizes that teachers are 'uniquely positioned' to create the circumstances that foster effective development. This is related to a research-based understanding of the interaction between the cognitive, motor and affect domains of learning in terms of supporting all students, as well as those at risk of identification of ADHD.

Working from a perspective that seeks to combine research with its practical implications, the author has been studying in this field for several years, both working on a doctorate at the University of Reading (England) and as a specialist in learning differences. The work has focused on the role of interventions that are supported by research and that can guide training for those working with young students at risk of under-achievement, where their barriers to learning are not recognized early enough to prevent this, as well as the associated low self-esteem and longer term disaffection.

Schools are frequently targeted in terms of investing in commercial intervention programmes that are intended to address the links between exercise and classroom performance. However, as Bailey (2018) points out, the relationship between practical contexts and empirical science has been 'an uncomfortable one'. This is echoed by Goswami (2006), in terms of exercising caution in adopting 'brain-based' interventions that may be based on oversimplified, misunderstood or misapplied notions. In order for schools to invest time, and resources in 'innovative approaches', they need to be confident that their choices are based on thorough evaluations, where possible.

A number of underlying issues emerge. Firstly, what is known about ADHD that might indicate that motor interventions have a role to play? Secondly, which activities show indications of potential benefit, and what is known about the most appropriate speed, duration and intensity?

ADHD AND MOTOR INTERVENTIONS

The terms 'movement' and 'motor' are often used interchangeably, although the term 'movement' is used more in relation to observable behaviours in posture and locomotion. By contrast, the term 'motor' refers more to the non-observable neurological processes associated with the observable movement (Barnett and Peters, 2004). Diamond (2000) proposed that motor coordination problems are common in children identified with ADHD, although this is not generally the focus for interventions. Moreover, she proposes that 'at least half' fit the diagnosis for developmental coordination disorder, citing many sources. In addition, Diamond (2000), notes these are also associated with students with Dyslexia, although the focus is not typically on this aspect of the learning differences.

Currently, it is estimated that there is a global prevalence of ADHD of around 6% and that boys are diagnosed with this more often than girls. Ludgya and colleagues (2018) stress that early interventions should be seen as a necessity to avoid longer-term negative impact of the condition. They go on to explain how ADHD related deficits might be attributed to aspects of brain function, structure and chemistry. Their research led them to consider whether physical exercise had potential as a complementary intervention for ADHD, drawing on the work of other researchers that had identified exercise-induced improvements on executive functioning and cognitive flexibility. Their conclusions indicated that physical exercise possessed 'great potential' as a complementary intervention for ADHD, although they exercise caution in drawing conclusions based on non-ADHD studies.

Ludgya et al., (2018), overview of the current state of research does, however, suggest that exercise can exert an influence on skills as well as leading to fewer anxiety and depression symptoms. They recognise that intensive research has taken place into the neurobiological aspects of ADHD, but the mechanisms by which exercise reduces the cognitive and behavioural impairments are less well developed. There is an understanding, nevertheless, that regular, daily, challenging exercise can contribute a complementary element in reducing impairments in executive functioning and control and behavioural deficits. The research does not, however, suggest that these should be a substitute for pharmacological or behavioural therapies.

Diamond and Lee (2011) has also written about the role that a range of interventions can play in improving children's executive functions. Those cited include aerobics, martial arts, yoga and mindfulness, in addition to computerised games and the school curricula. A key point Diamond and Lee (2011), also identifies is the need for these interventions to

involve repeated practice that constantly challenges executive functions. In addition to the definition of executive functioning above, Diamond and Lee (2011) stresses the significance of creativity, flexibility, self-control and discipline as key qualities characteristic of executive functions, in addition to problem-solving, reasoning and planning. She also raises the issues of considering ways in which early years' support should best target interventions to improve school readiness. Diamond and Lee (2011) provides an overview of scientific evidence to support six approaches for improving executive functions in the early years.

In the context of this article, reference is made to those that are characterised as motor interventions as opposed to, for example, computerised training.

YOGA /TAI CHI/ MARTIAL ARTS/ FLOOR-BASED MOTOR PROGRAMMES

Many motor intervention programmes tend to focus on aerobic activity, where there is less focus on being mentally present and consciously aware of the ways in which the mind and body work together as they tend to place a greater emphasis on the healthy aspects of physical activity. There is now a growing research base to support the use of a wider range of movement interventions that combine different types of activities to address specific needs. Many yoga teachers would propose that their programmes develop flexibility of the mind as well as the body and that there are correlations between improved focus, executive function and yoga practice (Gothe et al., 2013). The practice of yoga has also found to be beneficial when combined with pharmacological interventions.

What distinguishes yoga and the martial arts is the mental focus, with links between improved focus and executive function. Some research has indicated that two 60-minute sessions of yoga over a 20-week period found improvements in ADHD related symptoms after six weeks (Harrison, Manochaa & Rubia, 2004). Tai Chi and martial arts programmes have been proposed as potential interventions for ADHD, based on their structured approach to combining cognitive and motor approaches to increasing attention, focus and control.

Diamond and Lee (2011) identified that gains across the dimensions of executive functioning were greatest for children in Grades 4 & 5, with the least impact for the youngest, with boys benefiting to a greater extent. However, there is a need to further explore the research into the comparative impact of various interventions in relation to the age of the students involved. This raises the question of whether particular types of interventions are more effective and appropriate specifically in the early years, primary and secondary sectors.

Floor-based motor programmes that focus on developmental immaturities such as retained primitive reflexes have also shown some potential to improve ADHD traits of

inattentiveness and hyperactivity, although the evidence base is somewhat limited at this point in time. These programmes have some evidence of improving these skills, but may benefit from being applied in conjunction with more physically challenging interventions.

MODERATE AEROBIC ACTIVITY

Examples of this include tasks such as jumping on a trampoline for 5 minutes, 15 minutes jumping and running on the spot, and table tennis training.

There is evidence to suggest that this type of exercise can produce improvements in cognitive flexibility and working memory. However, researchers point out that there is insufficient data relating specifically to their impact on children with ADHD. At the same time, there are suggestions that aerobic exercise sessions have the potential to improve inhibitory control temporarily when the activity takes place close to the cognitive task. The implication is that schools could benefit all their learners by integrating more physical activity in short bursts throughout the day, (Hill et al., 2011).

Diamond and Lee (2011), cites research into aerobic exercise with students aged 7 and above, but there are no references to this type of intervention with younger students, although there are references to the evidence of physical activity and music training in relation to improving executive functions, as well as exerting a positive impact on the social and emotional domains of learning (Dumont et al., 2017).

IMPLICATIONS

Ludgya and colleagues claim that 'Exercise reduces the cognitive impairments and developmentally inappropriate behaviour in children and adolescents with ADHD... Children with ADHD should be encouraged to perform aerobic exercise for a temporary enhancement of capabilities in executive functioning'. (Ludgya et al., 2018).

Regular exercise is also considered to contribute to long-term benefits for cognitive performance and behaviour in children and adolescents with ADHD. There is a consensus that the relationship between physical activity and educational performance offers the potential to inform new practices. However, there is a concern that pseudoscience and neuromyths risk schools and parents being liable to the claims of various commercial interventions (Bailey et al., 2018). This implies that caution needs to be exercised when considering making financial investments in programmes that may lack credible evidence-based or peer-reviewed research.

The positive emotion of enjoyment is a strong motivation to practise physical activity. This can lead to enhancing cognitive processing when teachers understand the relevant teaching methodologies that integrate enjoyable activities based on research-led interventions. Students of all ages with ADHD and comorbid difficulties may benefit from

daily physical activities to prime classroom performance.

The approach could prove a useful tool for schools generally. Research has shown that even a daily 10-minute programme had a positive impact on attention and on-task behaviour, particularly for children with difficulties in remaining on task with an improvement of 20% (Mahar et al., 2006).

Furthermore, research has indicated that even a short 4-minute daily exercise programme has beneficial effects for typically achieving children aged 9-11 (Ma et al., 2015). This suggests that even short exercise periods are beneficial for all children, particularly at a time when there is evidence for shortening of children's playtime and opportunities for physical play.

Table 1. Take Away Strategies for Parents/ Schools:

EXERCISE STRATEGIES FOR PARENTS AND SCHOOLS	
◆	Encourage daily exercise at 3+ intervals in the school day, that takes into account a variety of speed/duration/ intensity
◆	Sessions can be 10-15 minutes and include a wide range but balanced selection of activities.
◆	Devise a daily schedule that over the week balances out a combination of aerobic/yoga/floor-based activities.
◆	Children need to enjoy the activity they are doing, but it needs to be incrementally challenging to induce cognitive improvement
◆	It can be useful to include breathing exercises (often included in yoga programmes) as a part of daily routine and selecting a time when you think you, or your child/ student feel the greatest need to relax. This should ideally be at the same time every day.
◆	Use a more intensive activity (appropriate to the individual) prior to important tests requiring high cognitive control or competitions requiring tactical planning.
◆	Consider martial arts as a possible activity

There is some research (e.g. Diamond and Lee, 2011) to suggest that the traditional forms of martial arts that combine mental and motor aspects with qualities such as respect, perseverance and self-control can exert an influence on aspects of ADHD weaknesses, whereas the modern equivalents, with an emphasis on the competitive elements, did not produce positive changes.

CONCLUSIONS

This is an interesting and potentially significant area of research, particularly in relation to interventions for students in the early years and primary sectors of education. If learning is framed in the widest sense, within motor, affective and cognitive domains, teachers would benefit from access to training that recognises this body, mind, spirit interplay.

When considering support in these phases, there may be more opportunities to integrate daily motor/ physical programmes into the school schedule and to assist those students who enter school lacking in appropriate 'school readiness' skills. Whereas this is not the place for discussion about where the responsibility for school readiness lies (home/ pre-school/ school), the reality is that some children present with weaknesses that may present as symptomatic of ADHD/ SpLD, that can be addressed through approaches that recognise the motor and affective domains of learning, as well as the cognitive. Thus, there needs to be an understanding that students might, for example, benefit from exercise plus character development such as traditional martial arts or, regular exercise and mindfulness (Houseman & Solanto, 2016).

A key element appears to be the need for the students to be active, engaged and continuously challenged, based on schools having access to training in integrating the 3 domains of learning into their whole school ethos (Carpenter, 2018). The activities need to be cumulative and novel, rather than repetitive. operating in a spiral principle that enables activities to be revisited and reinforced, but with an element of challenge.

Although the main focus of this article has been on exploring the potential of interventions to address aspects of ADHD, there is an 'emerging consensus (Fawcett, 2017), in terms of the comorbidity in terms of ADHD, dyslexia, dyspraxia and SLI., linked to the importance of early intervention. This is an area of great interest when considering and evaluating programmes that include some of the elements outlined here.

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