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The effect of physical activity on spatial perception and attention in early childhood

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ABSTRACT

This study examined whether physical activity improves spatial perception and attention in early childhood. A pre–post intervention trials design with intervention and control groups was implemented. Participants were 123 kindergarten children, divided into three groups: experimental—orienteering, experimental—dance, and control—no intervention. Instrumentations: attention measured by the MOXO-CPT, a computerized test, and The Cognitive Modifiability Battery Reproduction of Patterns measured spatial abilities. Measurements were conducted pre- and post-interventions. Results showed fast improvement from pre- to post-intervention, achieved simultaneously in both EFs for the experimental groups only. No differences were found between boys and girls. It was concluded that in order to successfully achieve the required tasks, an integration of physical and cognitive skills is needed.

1. Introduction

Executive functions develop from childhood, peak in adulthood, and deteriorate in old age (Kamijo & Takeda, 2010; Tomporowski, Lambourne, & Okumura, 2011). In looking for ways to slow down or decrease this deterioration, researchers have examined the influence of physical activity on Executive functions (e.g., Themanson & Hillman, 2006; Themanson, Pontifex, & Hillman, 2008; Tomporowski, Davis, Miller, & Naglieri, 2008). Physical activity may support executive function because the former increases cerebral vasculature (Ding, Zhou, Rafols, Clark, & Ding, 2006), and leads to the production of neurotrophins that regulate the survival of neurons (Poehlman & Danforth, 1991; Vaynman & Gomez-Pinilla, 2006). Physical activity also affects synaptogenesis, which occurs concomitantly with myelination, and angiogenesis, which influences glucose and oxygen distribution (Ding et al., 2006; Kerr, Steuer, Pochtarev, & Swain, 2010). All of the above can account for improved cognitive ability following exercise over time (Guiney & Machado, 2013).

Given that executive functions have been reported to be essential for everyday life (Jackson, Loxton, Harnett, Ciarrochi, & Gullo, 2014; Murray, Pattie, Starr, & Deary, 2012) and associated with well-being (e.g., Brissos, Dias, & Kapczinski, 2008; Cruise et al., 2011), evidence concerning the benefits of physical activity on well-being may imply that physical activity also contributes to the performance of executive functions. Various studies have sought to explain what kind and what dose – meaning the duration, frequency, and intensity – of activity are required in order to decrease or slow down the deterioration

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of executive functions in old age. Hence, the benefits of physical activity on executive functions were extensively examined, and proved to be positive among the elderly (e.g., Lin, Chan, Zheng, Yang, & Wang, 2007; Wellenius et al., 2012). Following this line of research, further studies examined the influence of physical activity on executive functions in other age groups, such as infants (e.g., Friedman, Watamura, & Robertson, 2005; Robertson, Bacher, & Huntington, 2001; Sommerville, & Woodward, 2005) and early adulthood (e.g., Sibley and Beilock, 2007; Sibley, Etnier, & Le Masurier, 2007). Other groups of interest were children with learning disabilities (e.g., Gapin & Etnier, 2010) and individuals in the process of rehabilitation (e.g., Brummel et al., 2012). Research is scarce in the early childhood age group regarding this matter.

Modern society has become increasingly sedentary, beginning in childhood (World Health Organization, 2010). The link between physical activity and cognitive performance among schoolchildren has previously been researched using two main approaches (see Barnett, 2011; Best, 2010). The first approach examined the link between chronic exercise and intelligence and academic achievements (Tomporowski et al., 2008), and the second examined the link between acute bouts of exercise and cognitive performance (Tomporowski, 2003). We suggest that in addition to these two approaches, it would be of great value to explore the benefits of physical activity on executive functions in early childhood. The kinds of activities that are appropriate for early childhood should be specifically identified, in order to achieve two main targets: increasing physical activity among children, and strengthening executive functions along the process of development.

Orienteering and dance were chosen as the physical activities to be included in this study, for several reasons: first, both are activities that can be easily learned in early childhood, incorporated as a new activity in kindergarten, and used to diversify a physical activity program. Second, by learning these activities, executive functions may be trained, namely spatial perception and attention. Cognitive psychologists (see Coventry, Griffiths, & Hamilton, 2014; Hommel, Gehrke, & Knuf, 2000; Sanocki, 2003) have emphasized the contribution of spatial perception to a wide range of everyday human activities, such as reaching and grasping an object, learning letters while acquiring a language, typing on a keyboard, finding one's way home, or getting along in an unfamiliar environment. Lahav (2006) claimed that mental mapping of spaces, and mapping of the possible paths for navigating these spaces, are essential for the development of efficient orientation and mobility skills. Furthermore, a recent review demonstrated that attention and spatial perception are interrelated; in fact, attention plays a particularly important part in spatial perception. Both functions have been shown to be a major factor in the way that individuals process objects, faces, and scenes, and how they interact with their environment (van der Hama, Postmaa, & Laengc, 2014). In addition, both activities – dance and orienteering – were identified as endeavors that require generating, observing, executing, and coordinating movement patterns that require the integration of physical and cognitive skills (Bläsing et al., 2012; Eccles, Walsh, & Ingledew, 2002). Moreover, in order to improve performance, orienteers and dancers need to practice their spatial perception ability and their attention ability (Bläsing et al., 2012; Jola, Davis, & Haggard, 2011; Oña, 2005), both of which were the examined executive functions of the current study. These executive functions enable young children not only to perform well in cognitive tasks (see Eccles et al., 2002; Enghauser, 2007; Ratey, 2008), but they are also essential to their everyday life functioning (see Jola et al., 2011; Oña, 2005). Nevertheless, in these studies each activity was investigated separately, as was each executive function.

We followed Memmert's (2006) study that aimed to examine the contribution of a diversified sport enrichment program on the development of cognitive abilities.

However, while Memmert's study examined gifted children, we examined typically developing children.

Along these lines, we tried to determine in what way can the study of dance and orienteering contribute to the advancement of children's cognition and behavior. Hence we hypothesized that physical activity, specifically orienteering and dance, will improve executive functions such as spatial perception and attention in early childhood.

2. Method

2.1. Participants

Kindergarten children, 60 boys and 63 girls, 4–5 ($M = 5.07$; S.D = 0.68) years old (n = 123), participated in the study. The participants were assigned to three groups, as follows: experimental group 1 (orienteering), $n = 44$; experimental group 2 (dance), $n = 40$, and control group (no intervention), $n = 39$. The three kindergartens that the children attended were selected to be part of this study because of their similar demographic background: middle-class socio-economic status, rural environment, and activity curriculum. Additionally, it should be noted that we had pre-existing groups, since every classroom as a whole was assigned to a group.

2.2. Instruments

2.2.1. Attention

The MOXO Continuous Performance Test (Neurotech Solutions Ltd.)—this is a standardized computerized test designed to measure attentional performance (see also Berger & Goldzweig, 2010). A set of target and non-target stimuli was shown in the center of a computer screen. Both the target and non-target stimuli were cartoon pictures. Thus, these stimuli do not include either letters or numbers. In each trial a stimulus (target/non-target) was presented for 500, 1000, or 3000 ms, and then followed by a "void" period of the same duration. The stimulus remained on the screen for the full duration, regardless of whether or not response was produced. This procedure allowed for the measuring of response timing (whether the