Emerging Perspectives
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Working it Out: Physical Activity and Cognitive Performance Among School-Aged Children

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A growing body of evidence suggests that modern society is facing a physical activity deficit of unprecedented magnitude. Furthermore, research suggests that physical inactivity is associated with decreased cognitive performance and diminished academic competence. The growing implications of physical inactivity among school-aged children have necessitated an urgent response from health professionals and educators to develop innovative and timely solutions. Psychologists who work with school-aged children are in the position to raise awareness of the link between physical inactivity and cognitive development and integrate this body of knowledge into their practice frameworks. This article covers the role of physical activity in the development of cognitive skills, critical research findings in this area, and implications for psychologists who work with school-aged children.

Keywords: Physical activity; cognitive development; school-aged children; psychologists; professional practice

Beks, T. (2019). Working it out: Physical activity and cognitive performance among school-aged children. *Emerging Perspectives, 3*(2), 5-13.

In this age of technological revolution and knowledge-based economies, the increasingly prevalent use of computer technology has raised concerns about the coinciding decrease in physical activity among school-aged children (Hillman, Erickson, & Kramer, 2008). Physical inactivity is associated with poor physical health outcomes among school-aged children, including obesity, decreased musculoskeletal fitness, and increased risk for cardiovascular disease (Tremblay, Leblanc, et al., 2011). Conversely, *physical activity* (PA) is associated with positive effects on mental health, physiological functioning, cardiovascular fitness, and quality of life among school-aged children (Ortega, Ruiz, Castillo, & Sjöström, 2008). Furthermore, PA plays an important role in the development of cognitive abilities needed for youth to participate fully in academic, social, and vocational spheres throughout life (Booth & Lees, 2006; Ellemberg & St-Louis-Deschênes, 2010; Vaynman & Gomez-Pinilla, 2006).

A complete review of the bodies of literature on cognitive development and PA is beyond the scope of this article. Therefore, the role of PA in the development of cognitive abilities among school-aged children (i.e., youth aged 5 to 17; Statistics Canada, 2015) is briefly discussed. This article will begin by introducing the importance of cognitive development, followed by a discussion of the societal changes that have occurred concurrently with decreased physical activity. The next section provides a review of the critical research findings elucidating the effects of PA

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on cognitive performance. This article will conclude with a discussion of the implications for psychologists who work with school-aged children.

School-Aged Children and Cognitive Development

In the field of developmental psychology, *cognitive ability* refers to the capacity to correctly or appropriately process information in a way that leads to successful knowledge acquisition and manipulation (Bjorkland & Myers, 2015; Floyd, 2010). Accordingly, cognition includes such processes and faculties as perception, attention, memory, motor skills, language, visual and spatial processing, and executive functioning (Bjorkland & Myers, 2015). By extension, *cognitive development* concerns changes in the way information is represented, acquired, and manipulated across the lifespan (Bjorkland & Myers, 2015). For the purpose of this article, it is important to note that *cognitive ability* is distinguished from *academic achievement* in that variance in academic achievement takes into account more variables than cognitive faculties and processes alone, and includes such factors as learning environment, parental involvement, school demographics, motivation, affect, and quality of instruction (Kaufman, Reynolds, Liu, Kaufman, & McGrew, 2012). Thus, the literature discussed herein will focus on the constructs of cognitive abilities and cognitive development.

Psychologists who work with school-aged children have long focused on cognitive development because it is considered critical to problem-solving (Keen, 2011), language acquisition (Dodd & McIntosh, 2010), social functioning (Krogh-Jespersen, Liberman, & Woodward, 2015), academic success (Lu, Weber, Spinath, & Shi, 2011), and the development of employability skills (Broecke, Quintini, & Vandeweyer, 2015). That is, cognitive abilities are an important element of what enables human beings to adapt to changing environments and societal conditions (Heyes, 2012). In a society characterized by rapid advancements in information and communication technologies, cognitive abilities continue to be a vital competency across the lifespan (Voogt, Erstad, Dede, & Mishra, 2013). For these reasons, cognitive abilities are a frequent target of psychological assessments and interventions in schools (Floyd, 2010).

Physical Inactivity in School-Aged Children

A growing body of evidence suggests that modern society is facing a PA deficit of unprecedented magnitude (Agatston, 2012; Kohl et al., 2012; Tremblay, 2012; World Health Organization [WHO], 2010). Children, who depend on PA to reach developmental milestones (Ellemberg & St-Louis-Deschênes, 2010), are among the most vulnerable to the ill effects of sedentary behaviour (WHO, 2010). In accordance with the Canadian Physical Activity Guidelines (CPAG), PA involves any form of aerobic exercise (Canadian Society for Exercise Physiology [CSEP], 2011). The CPAG (CSEP, 2011), which serves to promote and assist Canadians in being more physically active, recommends that children between the ages of 5 and 17 incur approximately 60 minutes of moderate-to-vigorous PA per day. This recommendation has evolved from years of research confirming the benefits of PA for youth (CSEP, 2011; Tremblay, Warburton, et al., 2011).

Despite the plethora of evidence highlighting the importance of PA for healthy youth development, school-aged children are not engaging in the recommended PA advised by the CPAG (Statistics Canada [SC], 2015). Specifically, only 13% of male and 6% of female school-aged children are averaging the daily recommended 60 minutes of moderate-to-vigorous PA (SC, 2015). Equally alarming is that youth between the ages of 5 and 17 spend an average of 8 hours and 27 minutes per day engaged in sedentary activities (SC, 2015). Research suggests that major

social, economic, and political changes are largely responsible for decreased PA among school-aged children (Engström, 2004; Sattelmair & Ratey, 2009). For instance, the significant shift from high levels of physical exertion to a life much less physically demanding (Bonde & ViikariJuntura, 2013), increased reliance on the automobile (Kohl et al., 2012), and the reduced emphasis on physical education programs within schools in favour of academics (Sattelmair & Ratey, 2009) have been implicated in decreased PA among children. However, the ill effects of physical inactivity among school-aged children have only recently begun to surface and are associated with a number of serious health conditions such as heart disease, obesity, and communicable diseases (Kohl et al., 2012; Tremblay, Leblanc, et al., 2011). Furthermore, and of particular importance to psychologists, research suggests that physical inactivity is associated with decreased cognitive performance and diminished academic competence (Ardoy et al., 2014; Budde et al., 2010; Esteban-Cornejo et al., 2015; Van der Niet et al., 2015). While this body of research is in its infancy, it is likely that future studies will continue to illuminate the impact of physical inactivity on cognitive development among children.

Physical Activity and the Development of Cognitive Abilities

While the majority of empirical research has focused on the relationship between PA and physical health outcomes among school-aged children, less attention has been paid to the role of PA in cognitive functioning in this population (Ellemberg & St-Louis-Deschênes, 2010). However, research suggests that improvements in cognitive abilities result from the effects of PA on the brain. PA increases the development of new neurons and levels of brain-derived neurotrophic factor, enhances cerebral blood flow and oxygen concentrations, and heightens synaptic plasticity (Chaddock, Pontifex, Hillman, & Kramer, 2011; Hamer & Chida, 2009; Hillman et al., 2008). These changes are associated with attention, information processing, storage and retrieval, and concentration (Eddy, Stansfield, & Green, 2014; McMorris, 2015; Wipfli, Landers, Nagoshi, & Ringenbach, 2011). Furthermore, because childhood and adolescence are periods of marked plasticity, PA may be an important stimulus to enhance cognitive abilities (Romeo & McEwen, 2006). For example, Van der Niet et al. (2015) found that sedentary behaviour was negatively associated with inhibition performance whereas moderate to vigorous PA was positively associated with planning speed and performance. Budde et al. (2010) found that 15 to 16 year-old adolescents with poorer working memory profited the most from the PA intervention, and that moderate PA intensity was most strongly associated with working memory performance. Esteban-Cornejo et al. (2015) examined levels of PA among adolescents (i.e., aged 11-18), which were subsequently divided into three ranges of activity level: low PA (an average of 109 minutes per week [min/week] and 36 minutes per week among boys and girls, respectively), moderate PA (an average of 335 min/week and 151 min/week among boys and girls, respectively), and vigorous PA (an average of 767 min/week and 413 min/week among boys and girls, respectively). At the age of 18, cognitive performance was assessed using the Wechsler Adult Intelligence Scale-III (WAIS-III) short form, which measures verbal comprehension, perceptual organization, working memory, and processing speed (Wechsler, 1997). Adolescents categorized as moderate performed significantly better on the WAIS-III, whereas those who were categorized as vigorous or low demonstrated poorer cognitive performance (Esteban-Cornejo et al., 2015). The authors theorized that moderate levels of PA benefit cognitive performance, whereas low levels of PA may lack adequate stimulation to improve learning and high levels of PA may replace the time that would be devoted to learning activities thereby undermining cognitive performance (Esteban-Cornejo et al., 2015). However, it is evident from this study that additional research is needed to better

understand the relationship between poor cognitive performance and high levels of PA. Nevertheless, the abovementioned studies provide early evidence of the important role of PA in cognitive performance and cognitive development among school-aged children. Furthermore, these studies suggest that PA may be an important intervention for school-aged children with cognitive difficulties. While a comprehensive review of the body of literature examining the relationship between PA and cognitive development in school-aged children is beyond the scope of this paper, Chaddock-Heyman, Hillman, Cohen, and Kramer (2014) provide a detailed review for further reading.

School-Based Intervention

The growing implications of physical inactivity among school-aged children have necessitated an urgent response from health professionals to develop innovative and timely solutions. Schools provide an accessible conduit through which to promote PA and intervene against PA deficits and their subsequent effects on cognitive abilities (Ardoy et al., 2014). However, interventions have focused largely on reducing obesity (Dobbins, Husson, DeCorby, & LaRocca, 2013). To date, few school-based interventions target the relationship between PA and cognitive abilities, in part because of the limited research in this area.

The Education for Fitness (EDUFIT) program represents one program that operates within a naturalistic school setting in Murcia, Spain, and has focused on measuring the effects of PA on cognitive abilities (Ardoy et al., 2014). This program focuses specifically on increasing PA as a means to enhance cognitive performance among 12 to 14 year olds. The program is intended to increase and intensify students' PA over and above the current physical education curriculum of the Murcia school, which previously adhered to the national curriculum standards in Spain. During the pilot stage of this program, researchers from the University of Granada conducted a group-randomized controlled trial. Sixty-seven adolescents (43 males and 24 females) between the ages of 12 to 14, from three different classes participated in the study. Groups were assigned to one of three conditions. In the control group, adolescents received 2 x 55 minutes of physical education per week as mandated by law. These sessions followed the typical pedagogical practice in Spain, meaning the 55 minutes included time for physical education teachers to organize the session, for students to change their clothes, and for shower time at the end of the session. In the first experimental condition, adolescents received 4 x 55 minutes of physical education per week, all of which followed the same pedagogical parameters as the control group. In the second experimental condition, adolescents received 4 x 55 minutes of physical education per week at increased intensity (i.e., activities requiring a heart rate of 120 beats per minute); otherwise, all pedagogical parameters remained the same. Prior to beginning the intervention, all adolescent participants completed the Spanish Overall and Factorial Intelligence Test as a measure of overall cognitive abilities, as well as specific domains including non-verbal and verbal abilities, abstract reasoning, spatial ability, verbal reasoning, and numerical ability (Yuste-Hernández, 2001).

Following the 4-month intervention period, performance in all cognitive domains, except for verbal reasoning, increased significantly among adolescents in the increased intensity physical education group (i.e., experimental group 2). There were no significant differences in cognitive improvements between experimental group one and the control group. Based on the categorization of activity level, these findings appear to contradict the results of Esteban-Cornejo et al.'s (2015) study. Cain, Sallis, Conway, Van Dyck, and Calhoon (2013) point out that the field of PA research employs inconsistent methods for measuring and defining activity levels among youth, thereby limiting the comparison of findings across studies. Thus, in order to design effective PA

interventions, it is critical that this growing field of research move toward standardization of measuring and operationally defining PA levels (Cain et al., 2013). Nevertheless, programs like EDUFIT provide compelling evidence for the benefit of naturalistic, school-based interventions to enhance cognitive performance through PA. With few programs like EDUFIT in operation, it is crucial that psychologists take an active stance toward promoting the benefits of PA for cognitive abilities.

Implications for Practice: Psychologists as Change Agents

In an era where physical education and physically-active play are increasingly viewed as expendable aspects of schooling (Simon & Childers, 2006), psychologists who work with school-aged children are in the position to advocate for the continued need for school-based PA. The growing evidence suggesting a linkage between moderate levels of PA and cognitive development among school-aged children provides a compelling impetus for psychologists to consider PA in psychological service delivery (Fedewa & Clark, 2010). Psychologists are not only privy to the emergent research on the cognitive benefits of PA, but they are also subject to the *Canadian Code of Ethics for Psychologists*, which delineates the ethical principles, values, and standards that guide all Canadian psychologists (Canadian Psychological Association [CPA], 2000). Under Principle II: *Responsible Caring*, psychologists are urged to keep up-to-date on research findings and how they affect individuals and broader society "in order that their service or research activities and conclusions will benefit and not harm others" (CPA, 2000, p. 16). In addition, under Principle IV: *Responsibility to Society*, psychologists are encouraged to "provide the public with any psychological knowledge relevant to the public's informed participation in the shaping of social policies and structures" (CPA, 2000, p. 30). Thus, psychologists have an ethical obligation to remain abreast of research on the interactions between PA and cognitive abilities, and when necessary, to integrate this information into their practice to advance the effectiveness of the psychological services they provide. Psychologists also have an ethical duty to promote the link between PA and cognitive abilities where it applies to policies or decisions that affect children within broader society.

PA has more recently emerged as a palpable treatment for severe mental health conditions, including major depressive disorder, postpartum depression, schizophrenia, generalized anxiety disorder, and bipolar disorder (Rosenbaum, Tiedemann, Ward, Curtis, & Sherrington, 2015). Additionally, PA has been implicated as a viable intervention for children and youth with executive functioning difficulties, including children with ADHD (Chaddock et al., 2011; Hillman et al., 2008). While these emerging cases of PA-based interventions are encouraging, the application of PA in routine psychological assessments and treatment planning for cognitive skills is in its infancy (Fedewa & Clark, 2010; Weir, 2011). This suggests that more work is needed to increase awareness of the link between PA and cognitive development. Future research should focus on the development of evidence-based interventions that are directly applicable to psychological practice involving school-aged children.

Conclusion

The purpose of this article was to elucidate the important link between PA and cognitive abilities among school-aged children, and to stimulate dialogue as to the role of psychologists in raising awareness of the PA-cognitive development relationship. PA is a vital component of cognitive development. Likewise, the development of cognitive abilities remains a vital competency needed for individuals to participate fully in all facets of life. Some of the most

significant changes in cognitive abilities and functioning occur during childhood and adolescence. Although PA is an important contributor to cognitive developmental processes, children and adolescents are not engaging in adequate levels of PA. Cognitive development may be compromised by this deficit. PA may be a viable intervention for school-aged children with certain cognitive weaknesses; however, additional research is needed to support and strengthen early findings on this topic. In summary, psychologists who work with school-aged children may not only play a critical role in promoting the benefits of PA, but also play a role in critically analyzing research on the relationship between PA and cognitive performance.

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