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Short Communication

Towards a Physical Literacy Framework to Guide the Design, Implementation and Evaluation of Early Childhood Movement-Based Interventions Targeting Cognitive Development

John Cairney^{1,2*}, Chloe Bedard³, Dean Dudley^{2,4}, and Dean Kriellaars^{2,5}

¹Departments of Family Medicine, Kinesiology and Psychiatry and Behavioural Neurosciences, Canada

²Physical Literacy Research Group: Sport for Life Society, Canada

³Department of Clinical Epidemiology and Biostatistics, Infant and Child Health (INCH) Research Lab, McMaster University, Canada

⁴Department of Educational Studies, Human Sciences, Macquarie University, Australia

⁵Faculty of Health Sciences, College of Rehabilitation, University of Manitoba, Canada

***Corresponding author**

John Cairney, INfant and Child Health (INCH) Research Lab, McMaster University, 100 Main Street West, Hamilton, ON, Canada, Tel: 905-525-9140 x28506; Fax: 905-527-4440; Email: cairnej@mcmaster.ca

Submitted: 02 May 2016

Accepted: 31 May 2016

Published: 01 June 2016

ISSN: 2379-0571

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OPEN ACCESS**Keywords**

- Physical literacy
- Motor skill
- Cognition
- Early childhood

Abstract

In this commentary, an argument for using physical literacy as a guiding framework for the design, implementation and evaluation of physical activity interventions targeting cognitive development in early childhood is offered. While physical activity and exercise have been shown to be positively linked to cognitive development, selecting the right kinds of activities for children, particularly in the first six years of life, is critical to ensuring children stay engaged and benefit from participation. The concept of “thinking movement” has been described before, where emphasis is placed not only on the importance of physical activity, but the combination of cognitive (e.g., problem solving) and movement based skills together as necessary for stimulating positive change in cognitive ability. Physical literacy offers great potential as a framework beyond thinking movement because it focuses not only on movement (motor skill) and physical activity, but also affective (fun) and motivational domains such as competence and confidence. The intersections of motor skill, positive affect and motivation are the core elements required to ensure children want to be active and are critical for maintenance of physical activity across the life-course.

ABBREVIATIONS

LTAD: Long-Term Athlete Development; PA: Physical Activity

INTRODUCTION

There is growing interest in the effect of PA on cognition in children [1] and adults [2]. In physical education and pediatric exercise science, there has also been a resurgence in interest in the concept of physical literacy [3,4]. This paper considers the practical implications of linking these two literatures together. In particular, it is argued that physical literacy, rather than PA, should serve as the guiding framework for interventions

targeting cognitive ability in early childhood (defined here as children between the ages of 0 to 6 years). Previous research has argued for interventions involving “thinking movement”, rather than movement per se, when the outcome of interest is executive functioning [1,5]. Physical literacy, though, incorporates affective and motivational domains that, when combined with “thinking movement” [5], provides an even more powerful framework for designing interventions, especially with young children, aimed to improve overall development and particularly cognitive function.

Physical Literacy

The formal definition of physical literacy varies depending

on the source. In 2009 Mandigo et al. described physically literate people as “individuals who... move with competence in a wide variety of physical activities that benefit the development of the whole person” [6]. Physical literacy is defined by the United Nations Educational, Scientific and Cultural Organization’s (UNESCO) as the ability, confidence, and motivation to engage in life-long PA [7]. A more philosophical definition of physical literacy comes from Margaret Whitehead’s research. Whitehead conceptualizes physical literacy as encapsulating competence of the entire embodied experience; this includes motor skill proficiency in a wide array of environments yet also positive acknowledgement and attitude towards physical activity as a means of achieving one’s full potential in all aspects of their development to maximize quality of life [8]. A final physical literacy consensus statement has been generated and describes physical literacy as the “motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life” [9]. Common to all definitions is the core understanding that physical literacy is about having the requisite motor skills required to successfully accomplish a range of everyday occupational and recreation activities from household chores to participation in sport. Each definition also acknowledges that motor skill, though, is not enough; a physically literate person also has the competence and confidence to engage in wide array of activities, in different environments (snow, ice, water, air) and derives both pleasure and an enhanced sense of self through their movement experiences.

Cognitive Ability: Executive Functioning

Cognitive ability is a general term that refers to mental processes related to thinking, reasoning, perception, judgment and awareness [10]. In the PA and cognition literature, the aspect of cognitive ability that has received the most attention is executive functioning. Executive functioning comprises a set of cognitive abilities including: 1) inhibitory control, which refers to the ability to ignore distractions and resist competing stimuli to stay focused on a task; 2) working memory, which is the ability to temporarily hold and manipulate information in one’s mind; and 3) cognitive flexibility, which allows one to switch between and consider multiple perspectives and concepts at once [11]. These three executive functions form the foundations upon which higher-order executive functions such as problem solving, reasoning, and planning develop [11]. Executive functions begin to develop in early childhood and continue to mature into adolescence. They are influenced by a multitude of external factors [12], and themselves influence various aspects of health and overall quality of life [11]. Empirical work has shown clearly that deficits in executive function are associated with unhealthy weight [13] and addiction issues [14], and that high levels are associated with academic achievement [15] and overall quality of life [16]. These relationships highlight the critical role executive functioning plays in development, behaviour, and health and demonstrate why executive functions are a commonly-selected primary outcome in studies on PA and cognition.

Relationships between PA, Physical Literacy and Cognitive Ability

Physical literacy is often viewed as fundamental to PA, in that,

developmentally, becoming physically literate in childhood is essential for lifelong participation in sport and PA [17]. This is most readily apparent in relation to both phylogenetic and orthogenetic movement skills that are needed for both survival and socially inclusive human movement: A person who cannot execute these foundational skills will find it difficult to participate in a variety of sport and physical activities (as outlined in the LTAD) and to subsequently develop increasing more complex motor skills [18]. However, it would be wrong to view this solely in the context of movement skill. If a child does not enjoy movement or derive a sense of competence and confidence from the experience, it is unlikely that these skills will be practiced and therefore refined, or that the child will participate in activities such as sport. The importance of physical literacy is demonstrated by the role played by physical competence and enjoyment in predicting PA in children and youth [19].

The importance of these distinctions becomes evident when we consider the role that PA plays in cognition, particularly in children. There is a growing literature which shows that acute bouts of exercise (e.g., 20 minutes of exercise) have a positive effect on executive functioning, especially in relation to inhibitory control and attention [20]. While most of this research has focused on school-aged children [20,21], there is also limited research on the impact of PA on cognition in preschool children. Robinson and her colleagues (2013), in a rare study on this group, showed improvements in sustained attention after a single, 30-minute bout of exercise [22]. While there is a paucity of evidence on the causal relationship between PA and executive functioning in early childhood, it is critical that research continues to investigate this relationship in this age group. From birth up to age four marks a period of rapid brain development characterized by high neuroplasticity [23]. During this period, the brain is highly sensitive to environmental stimulation, which affects the pattern of neuronal development (e.g. neuronal activity, synaptic production, and pruning) [24]. Early childhood experiences therefore are critical because they can potentially enhance or harm brain growth [25].

Despite the lack of evidence in this age group, we do have research examining the impact of PA at another time when the brain is highly plastic – in utero. There is at least some evidence that maternal PA during pregnancy is positively associated with cognitive and academic achievement in their children [26,27]. Evidence from animal models suggests that the mechanism of this effect may be through enhanced neurogenesis in central learning areas of the brain (e.g., hippocampus) [24]. Together, evidence from school-aged children and children in utero, suggest that the period of early childhood would not be exempt from the positive effects of PA on cognitive performance. There is compelling evidence that PA can have an important impact on executive function from very early childhood through to adolescence and beyond [24,28,29].

Relationship between Motor Skill and Cognition

One of the interesting things that differentiate Robinson’s study from the others reviewed in the previous section was the specific exercise stimulus that was used. While much of the experimental literature uses exercise protocols such as running on a treadmill or pedaling on stationary bike [20,30], the stimulus

in Robinson's study was actually movement-skill based: children participated in active games, which targeted both phylogenic and orthogenic movements skills and included running, hopping, skipping, and object control [22]. The authors of the study argue this was necessary to ensure the ecological validity of their intervention: the kinds of activities they selected were consistent with the games and unstructured play typical of young children (a five year old would likely not tolerate running on a treadmill for 20 minutes). What is equally compelling is that it may actually be the practice of these fundamental movement skills in a fun and motivating environment that is eliciting positive changes in cognitive ability (among other outcomes), even over short durations.

Such a perspective is wholly consistent with our current understanding of the neurological connections between areas of the brain associated with the development of movement skill (balance, motor control), viz., the cerebellum, and the prefrontal cortex, which we typically associate with cognitive ability [31]. The co-activation of both regions of the brain, especially prominent when the task is demanding and/or novel, highlights the importance of both regions for learning. It also suggests that tasks that involve both movement skill and cognitive demands are more likely to strengthen the connections, and thereby improve executive functioning. It is likely also the case that age-appropriate activities, which are both motorically and cognitively challenging, are far more engaging and appealing (and, we hope, fun) to young children, than simply exercising to achieve aerobic levels of performance; thus we might expect enhanced motivation to participate in these activities. Whether it is described as "cognitively-engaging PA"[1] or "thinking movement"[5], the idea is the same: having individuals think and move at the same time will have a much more potent effect on executive functioning than repetitive, non-cognitively demanding activities, and targeting the affective components of movement will only enhance this effect.

A Framework of Physical Literacy for Cognitive Development

The practical implications of this work suggest that cognitively-engaging PA should be the focus of interventions designed to improve both cognitive ability and health-related fitness in children. It is our contention, though, that viewing thinking movement through the lens of physical literacy holds additional value for the design and evaluation of effective interventions in early childhood by enriching movement experiences in ways that positively impact both movement skill development and brain functioning, especially the cognitive abilities essential for learning (executive functions). A physical literacy perspective, for example, reminds us of the affective elements that are essential for enjoying and sustaining participation, while maintaining a focus on the importance of developing fundamental movement skills. The thinking movements must be challenging enough to stimulate motor development: this can be in relation to the task, but also the task in context (e.g., the physical environmental demands on the motor task): indeed, it is best when the task interacts with different environments to lead to challenging and creative movement experiences.

Physical literacy-based interventions also explicitly target the

development of competence and confidence. Activities then must be scaled to the child's ability and the instructor (or any person administering the intervention) must ensure that opportunities for mastery are available so both competence and confidence are achieved. Allowances for a child's desire to own or personalize the activity, and to be creative through adaption, would also be viewed as essential conditions for a physical literacy enriched movement-thinking intervention.

Physical literacy also embraces the idea that movement must be perceived by the child as both fun and enjoyable. It is interesting to note that executive functioning (indeed the prefrontal cortex in general) is most negatively affected when a person is under stress and/or experiencing negative affect such as sadness [5]. Engaging in activities that are associated with positive affect will also contribute to positive brain development.

Lastly, it is important that physical literacy interventions also incorporate aerobic PA. As previously discussed, there is evidence supporting a positive relationship between aerobic PA executive function. Including this kind of activity should therefore maximize the benefits of a physical literacy enriched movement-thinking intervention.

While physical literacy can be useful in the design of thinking movement based interventions, the perspective is also useful for thinking through evaluation designs to test the efficacy and effectiveness of programs targeting cognitive ability in children. For example, to more fully understand the impact of an enhanced physical literacy intervention on executive functioning in young children, in addition to outcomes that measure inhibition, inattention and working memory, we would also need to measure enjoyment, improvements in fundamental movement skill, and perceptions of competence, to name a few. The inclusion of all these measures also affords the opportunity, analytically, to build more sophisticated statistical models, ones that include potential mediators and moderators that help us to better understand the pathways between thinking-movement activities and cognitive ability. Figure 1 provides one possible model. Here, positive affective states associated with cognitively engaging motor skill activities work synergistically to improve executive functioning. In other words, it is the combined, interactive influence of both positive affective states and movement skills designed to be

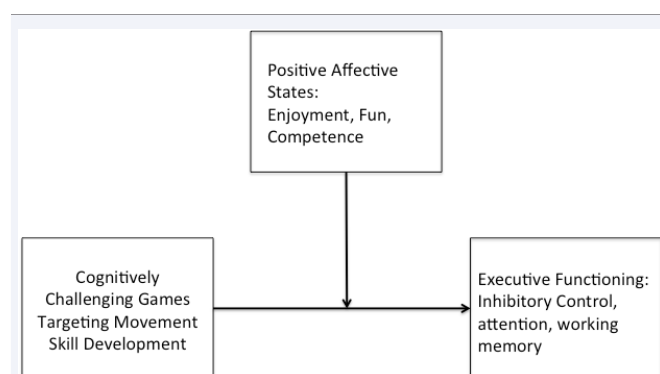


Figure 1 A model of the potential moderators of the relationship between thinking-movement activities and cognitive ability in children.

cognitively challenging that together lead to improved brain functioning. Such modeling is useful not only for understanding mechanisms, but for the design of future interventions.

CONCLUSIONS

Physical literacy provides a powerful framework from which to view movement in relation to both its fundamental movement skill elements, the environmental context in which those movements occur, and the positive affective elements that produce lasting connections of movement experiences to positive psychological states. When viewed specifically in relation to thinking movements, we have a powerful mix to guide to design of programs and curriculums that can enhance a child's physical, mental and cognitive development. Not only will this facilitate the design of ecologically valid activities, it will provide a framework for the evaluation of interventions to comprehensively model and test proposed mechanisms of effects.

ACKNOWLEDGEMENTS

Dr. Cairney would like to acknowledge the Department of Family Medicine at McMaster University for providing research support through an Endowed Chair in Family Medicine Research.

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Cite this article

Cairney J, Bedard C, Dudley D, Kriellaars D (2016) Towards a Physical Literacy Framework to Guide the Design, Implementation and Evaluation of Early Childhood Movement-Based Interventions Targeting Cognitive Development. *Ann Sports Med Res* 3(4): 1073.