

Review

Exercise and children's cognition: The role of exercise characteristics and a place for metacognition

Phillip D. Tomporowski^{a,*}, Bryan McCullick^a, Daniel M. Pendleton^a, Caterina Pesce^b

^a Department of Kinesiology, University of Georgia, Athens, GA 30602, USA

^b Department of Human Motion and Sport Science, Italian University Sport and Movement, Rome, Italy

Received 30 June 2014; revised 22 August 2014; accepted 19 September 2014

Available online 24 December 2014

Abstract

Definitive conclusions concerning the impact of exercise interventions on children's mental functioning are difficult to ascertain because of procedural differences among studies. A narrative review of studies was conducted to evaluate the role of two types of exercise interventions on children's cognition. Acute and chronic exercise interventions were classified as quantitative or qualitative on the basis of manipulations of task complexity and, by inference, mental engagement. Both types of interventions enhance aspects of children's cognition; however, their effects on metacognitive processes are unknown. The role of metacognitive processes and their regulation of children's behavior and academic performance are highlighted.

Copyright © 2015, Shanghai University of Sport. Production and hosting by Elsevier B.V. All rights reserved.

Keywords: Academic achievement; Child development; Executive function; Intelligence; Memory; Mental engagement

1. Introduction

The importance of children's movement during physical and mental development has been of interest to both parents and academicians for over a century. The notion that physical and mental prowess are linked is part of cultural wisdom and is embedded as an assumption in western civilization. A cursory historical review of parenting practices and recommendations made by developmental specialists reveals the consensus belief that infants and children who are raised in stimulating conditions that provide the opportunity to move and explore come to learn about their environments. Growing evidence has been amassed over the past 2 decades that exercise, which is a subset of physical activity (PA) defined by methods that are planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective,¹ may promote improvements in mental function. Particularly

affected are those cognitive processes termed executive functions, which are involved in behavioral control. Recently, much has been made of the importance of the role of executive processes in daily life and how they benefit children's adaptive behaviors, intellectual functioning, and academic success.

Several quantitative and narrative reviews of research conducted to assess the effects of bouts of acute exercise and exercise training on children's cognitive function have been conducted. All have concluded that the weight of the evidence supports a benefit for both acute exercise bouts and chronic exercise programs. However, several important themes consistently emerge from these reviews. Reviewers who employ meta-analytic methods report that the strength of the relation is small and is moderated by multiple factors.^{2,3} Similarly, reviewers who have conducted narrative evaluations point out differences among study characteristics that make definitive conclusions concerning the impact of exercise on children's cognitive function difficult to ascertain.^{4–6} Virtually all reviewers recommend additional research that focuses on specific factors that may influence the linkage between exercise and children's cognitive function.

* Corresponding author.

E-mail address: ptomporo@uga.edu (P.D. Tomporowski)

Peer review under responsibility of Shanghai University of Sport.

Reviewers frequently point to the wide variation in the types of exercise interventions that have been employed and suggest that the variations in methods used to engage children in exercise may provide one potential explanation for inconsistencies in research outcomes. Pesce⁷ proposed a conceptual model that describes multiple ways in which task factors may moderate the outcomes of acute exercise activities embedded within chronic exercise training. Unique to this model is its emphasis on two inter-related phenomena: 1) learning that occurs during and immediately following acute bouts of exercise, and 2) how that knowledge is modified over the course of repeated exercise bouts. The model provides a way to conceptualize why some types of exercise would produce temporary changes in an individual's cognitive test performance and other types of exercise would produce relatively permanent changes in knowledge that would reflect in better mental functioning. The importance of identifying task conditions that separate effects that are temporary from those that are relatively permanent cannot be overstated. For instance, given that acute bouts of exercise or chronic exercise training results in improvements on tests of executive function, what are the consequences of exercise termination? If the effects of exercise are temporary, declines in performance would be predicted. Thus, a continuous regimen of exercise would be required to maintain exercise's mental boost.⁸ However, if the changes in mental processing and learning that occur during exercise reflect relatively permanent changes in knowledge, they would have to be available for an individual's use at later times and, perhaps, under different conditions.

The need to consider how specific characteristics of exercise interventions may influence cognitive function has been voiced; however, only recently have specific recommendations been published. Building on American College of Sport Medicine guidelines for exercise prescriptions developed by Garber et al.,¹ Pesce⁹ proposed that studies designed to assess the effects of acute and chronic exercise training can be differentiated into two broad categories: a) those that adhere to a quantitative approach and design their exercise intervention based primarily upon considerations of intensity and duration; and b) those that adhere to a qualitative approach and manipulate exercise in terms of exercise type and the mental engagement involved during exercise. The purpose of the present review is to evaluate examples of exercise interventions that are representative of these two research approaches. An in-depth analysis of representative studies may help identify contextual conditions that maximize the cognitive benefits of exercise interventions designed for children.

We consider the present review and commentary to be timely, as recent advances in cognitive psychology, coupled with neurophysiological data, provide contemporary researchers and theorists with increasingly clearer insight into the mechanisms by which mental enrichment interventions, such as exercise, may promote fundamental changes in the neural networks that lead to meaningful gains in cognition that are expressed in a wide variety of situations and contexts. The gains derived via specific types of interventions may be of importance for children, as neuronal networks of the central

nervous system are guided by both genetic and environmental factors.

2. Methods

Studies were categorized as either quantitative or qualitative on the basis of the degree to which the intervention was designed with a primary focus on considerations of intensity and/or duration or was designed primarily to promote mental engagement. Quantitative interventions were characterized as those requiring minimal skill, involving repetitive movements controlled with negligible top-down control (e.g., treadmill running, ergometer cycling, or calisthenics), and whose intervention fidelity was based primarily on indices of cardio-respiratory function (e.g., heart rate, oxygen uptake, or accelerometry). Qualitative interventions were characterized as those involving exercise with high cognitive effort and/or skill learning (e.g., exergames, multi-limb coordination games, or strategy/learning games), and whose intervention fidelity was based on indices of mental engagement (e.g., observational methods, self-report). Mental engagement was defined as behavior reflecting thoughtfulness and exertion of effort required to comprehend new information and to master new skills.¹⁰ Studies were restricted to those conducted with healthy, pre-adolescent children and to those that employed recognized outcome measures of cognitive function.¹¹ The primary goal of this review was to identify and highlight specific quantitative and qualitative exercise characteristics that may elucidate how PA benefits children's mental functions and contributes to classroom behavior and academic success.

3. Results

3.1. Quantitative exercise interventions

3.1.1. Acute quantitative exercise interventions

Most interventions that assess the acute effects of exercise on children's cognition have been designed based on the long-held assumption that change in physiological arousal alters mental functioning.¹² Several researchers have assessed the short-term after effects of exercise bouts on children's mental functioning. Most studies involved children performing moderately intense aerobic exercise for durations of about 20 min. The selection of these exercise parameters were typically based on exercise physiology evidence related to the metabolic changes that occur during and following exercise, or evidence from experiments showing that aerobic exercise performed below the lactate threshold for durations of 20–30 min reliably improved adults' mood states or cognitive performance. Both field-based and laboratory-based studies have been conducted. Research conducted in school settings has evaluated psychological test performance immediately following relays,¹³ paced walking,¹⁴ paced running,¹⁵ and shuttle runs.¹⁶ Research conducted in laboratory settings typically involves the measurement of children's information processing speed, executive function, or response accuracy^{17–20} following treadmill running or cycling at specified intensities for set durations.

Download English Version:

<https://daneshyari.com/en/article/1084079>

Download Persian Version:

<https://daneshyari.com/article/1084079>

[Daneshyari.com](https://daneshyari.com)