Acute exercise and cognitive function: Emerging research issues

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Abstract:

The effect of acute exercise, a single bout of exercise, on cognitive performance has attracted much attention. The first narrative review of this literature was conducted by Tomporowski and Ellis.[1] In their summary, the authors concluded that acute exercise facilitates cognitive performance; however, they emphasized that the studies at that time were atheoretical and suffered from methodological limitations, making the reliability of the conclusions uncertain. In a meta-analytic review conducted approximately a decade later, Etnier et al.[2] concluded that acute exercise results in a positive significant effect on cognitive performance that was of small magnitude (effect size, ES = 0.16).

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Editorial

Acute exercise and cognitive function: Emerging research issues

The effect of acute exercise, a single bout of exercise, on cognitive performance has attracted much attention. The first narrative review of this literature was conducted by Tomporowski and Ellis.[1] In their summary, the authors concluded that acute exercise facilitates cognitive performance; however, they emphasized that the studies at that time were atheoretical and suffered from methodological limitations, making the reliability of the conclusions uncertain. In a meta-analytic review conducted approximately a decade later, Etnier et al.[2] concluded that acute exercise results in a positive significant effect on cognitive performance that was of small magnitude (effect size, ES = 0.16).

Since these pioneering works, a substantial number of studies exploring the acute exercise effects on cognitive performance have been conducted and the positive effect of acute exercise on cognition has been confirmed by later narrative reviews,[3,4] meta-analyses,[5−7] and book chapters.[8−10]

In recent research, studies associated with acute exercise and cognition have moved away from simply attempting to establish cognitive benefits to focusing on the effects for particular populations, exploring the task-specificity of the effects, examining the influence of exercise modality, and using interdisciplinary approaches to expand our understanding of mechanisms. For example, studies have been designed to help further our understanding of the potential task-specificity of the effects. Examination of the type of cognition has been examined from basic information processing to higher levels of cognition (i.e., executive function),[11−16] and behavioral measures of cognitive performance have been complemented with the inclusion of neuropsychological assessments[11,17−19] to investigate the underlying neurocognitive effects. Furthermore, the target population has shifted from healthy young adults to other populations including older adults,[12,19−21] children,[18,22] and individuals with impaired cognition (i.e., attention deficit hyperactivity disorder, ADHD).[11,23] These studies have been conducted with the premise that these populations might benefit more from acute exercise than do healthy young adults. Recent investigations have used approaches that include behavioral evidence and evidence related to underlying mechanisms through the inclusion of neuroendocrinological (e.g., catecholamines, neurotropic factors),[24] neuromuscular (e.g., electromyography, EMG),[25,26] and neuroimaging measures (e.g., event-related potential, ERP).[18,19,22] Lastly, researchers have begun to focus not only on aerobic exercise, but also on resistance exercise[15,17,27] and exercise that involves more cognitive demands in term of exercise mode.[28,29]

We are pleased to organize a special issue entitled Acute Exercise and Cognitive Function: Emerging Research Issues in the *Journal of Sport and Health Science* (*JSHS*) to reflect the rapid developments and current status of research exploring the acute exercise effects on cognitive performance. In the special issue, five reviews and six empirical studies were included.

In particular, three of the manuscripts in this special issue address potential biological mechanisms of the effects of acute exercise on cognitive performance. McMorris and Hale[30] conducted a meta-analysis that examined the role of exercise intensity in predicting improvements in the speed of cognitive function. By comparing threshold studies (i.e., studies using exercise intensities at the catecholamine, lactate, or ventilatory threshold) with moderate intensity studies (i.e., studies using exercise intensities between 40% and 70% VO_{2max}), the authors tested the hypothesis that exercise must surpass a particular threshold of intensity to result in significant benefits. On the other hand, Piepmeier and Etnier[31] reviewed the role of brain-derived neurotrophic factor (BDNF) as a potential mechanism of the effects of acute exercise on cognitive performance. After providing evidence that BDNF is important to memory performance and that it is influenced by acute exercise, the authors reviewed studies which had tested the putative role of BDNF in the acute exercise benefits for cognitive performance. The authors also pointed out relevant methodological concerns and important directions for subsequent research in this area. Lastly, Davranche et al.[32] reviewed studies using single-pulse transcranial magnetic stimulation (TMS), a non-invasive technique used to probe the motor cortex, to explain the facilitation of motor processes associated with acute exercise. They discuss how submaximal and maximal exercise reduce intracortical inhibition which may explain benefits to speed of processing observed during exercise. These reviews provide evidence of current thinking regarding potential mechanisms of the effects.

This special issue also includes a review in which an integrated theoretical framework is proposed to explain the

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relationship between acute exercise and cognitive performance. Audiffren and André[33] adapted the "strength model of self-control" to explain the complicated relationship among acute exercise, chronic exercise, and executive function. This model suggests that changes in executive function associated with exercise, acute or chronic, may be explained by the capacity of self-control resources. On the other hand, Tomporowski et al.[34] focused on the exercise and cognition research in children. In this review, the authors considered the effects of exercise protocols that emphasize repetitive movement with minimal skill requirement (e.g., treadmill running) and the effects of exercise protocols that emphasize high cognitive effort and/or skill learning (e.g., exergames). The authors also proposed that researchers should consider the effects of exercise on meta-cognition as this may help us to understand the potential link between improvements in cognitive function and academic achievement in children.

This special issue also includes several empirical papers. Some of these focus on the task-specific nature of the effects of acute exercise on cognitive performance. For example, Davranche et al.[35] examined the alteration of cognitive control processes assessed by a Simon Task during acute exercise. Wang et al.[36] conducted two studies to test the effects of acute exercise on executive function as assessed by the Wisconsin Card Sorting Test. These studies extend our knowledge regarding the extent to which the relationship between acute exercise and executive function is modulated by the subcomponents of executive function.

Two empirical studies presented herein demonstrate the powerful contributions made possible by including neuroelectrical measures. Chu et al.[37] used ERPs (e.g., N1, P3) to investigate the potential mechanism from a neuroelectric perspective. Chuang et al.[38] used a different ERP component, contingent negative variation (CNV), which is believed to reflect physical arousal as well as preparation for signaled movements. By incorporating ERP measures, these authors provide insights into the influence of acute exercise on attentional resource allocation, motor response inhibition, and information processing.

Two empirical papers present evidence relative to the potential effect of acute exercise on cognition in individuals with ADHD. Both of these papers offer extensions to the literature by testing effects across several measures of executive function to allow for an understanding of the task-specificity of the effects. They also add to a very limited literature by comparing effects between persons with and without ADHD. Piepmeier et al.[39] tested the effects of a 20-min bout of moderate intensity exercise on executive function performance by children with and without ADHD. Gapin et al.[40] tested the effects of a 30-min bout of moderate intensity exercise on executive function performance by college students with and without ADHD. In addition to providing the first study of exercise in college students with ADHD, this study also includes measure of BDNF as a potential mechanism of the effect.

On behalf of this special issue of *JSHS*, we would like to express our appreciation to all of the established scholars and new investigators who have contributed to this diverse presentation of cutting-edge research and viewpoints in the area of acute exercise and cognitive performance. We believe the special issue not only advances our understanding of the acute exercise−cognition relationship, but also provides important insights that will undoubtedly stimulate further research in the area.

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