Chronic exercise and cognitive function: An update of current findings

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Abstract:

It has long been known that regular participation in exercise, also known as chronic exercise, has beneficial effects on multiple aspects of physical and mental health. In more recent years, the positive effects of chronic exercise on cognitive function have been a focus of research, and our understanding of this relationship has grown rapidly in the past two decades.

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Article:

It has long been known that regular participation in exercise, also known as chronic exercise, has beneficial effects on multiple aspects of physical and mental health. In more recent years, the positive effects of chronic exercise on cognitive function have been a focus of research, and our understanding of this relationship has grown rapidly in the past two decades.

Although several narrative reviews of the literature were published in the 1950s to 1980s (Clarke, 1958; Folkins & Sime, 1981; Gruber, 1975; Weingarten, 1973), the first meta-analytic review of this literature was not published until 1997. Etnier et al. (1997) included 134 studies in their meta-analysis, and results from the 45 studies on chronic exercise showed a significant positive effect on cognitive function that was of moderate size (ES = 0.58). Similar findings were reported in additional meta-analyses that were published in the early 2000s. Results showed that chronic exercise had significant positive effects on cognitive performance for children (Sibley & Etnier, 2003), older adults (Colcombe & Kramer, 2003), older adults with/without cognitive impairment (Heyn, Abreu, & Ottenbacher, 2004; van Uffelen, Chin, Hopman-Rock, & van Mechelen, 2008), and in the general population (Etnier, Nowell, Landers, & Sibley, 2006; Smith et al., 2010).

In recent years, the focus of the research has evolved with the dual goals of enhancing our understanding of how exercise benefits cognitive performance and of appreciating the nuances of these benefits. Examples of studies focusing on understanding how exercise benefits cognitive performance include those that have focused on potential mechanisms such as changes in cerebral structure (Colcombe et al., 2003), cerebral function (Chang, Tsai, Chen, & Hung, 2013; Colcombe et al., 2004; Davis et al., 2011), and biological markers in the blood (Erickson et al., 2011; Voss et al., 2013). Examples of studies focusing on the nuances of these benefits include those that have examined the influence of exercise modality (Dai, Chang, Huang, & Hung, 2013; Fong, Chi, Li, & Chang, 2014), those that are designed to understand which particular cognitive domains are most impacted (Hillman et al., 2014; Scudder et al., 2014), and those focused on identifying if certain populations that might be expected to have cognitive challenges can still achieve benefits (Etnier et al., 2007; Liu-Ambrose & Eng, 2015; Pontifex et al., 2014; Uc et al., 2014). Importantly, the most recent research in this area is being published in the top journals in sport and exercise science (Nagamatsu et al., 2014; Tarumi & Zhang, 2015) and in prestigious journals in other fields including psychology (Prakash, Voss, Erickson, & Kramer, 2014), neurology (Uc et al., 2014), and cognitive neuroscience (Voss et al., 2013), suggesting the recognised value of this research and its multiple-disciplinary nature.

We are pleased to serve as guest editors of this special issue entitled "Chronic exercise and cognitive function: An update of current findings." The purpose of this special issue is to provide current reviews of the literature on chronic exercise and cognition. The special issue includes four narrative reviews, a meta-analysis review, and a commentary. We note that our contributors come from Italy, China, the United Kingdom, the United States, and Taiwan, reflecting world-wide interest in this topic. The provision of international perspectives is consistent with the mission of the *International Journal of Sport and Exercise Psychology* (*IJSEP*). *IJSEP* was the first academic journal published by an international society related to sport and exercise psychology and is the official journal of the International Society of Sport Psychology (ISSP).

The papers included in this special issue approach the topic of chronic exercise and cognitive performance from different vantage points, but all present current viewpoints and hence offer cutting-edge insights into the future of this research.

Slutsky and Etnier (2016) provide a review of the literature exploring how two lifestyle factors, caloric restriction and exercise, have been shown to benefit cognition and then they consider the evidence supporting their combined beneficial effect on cognitive function. In addition, the authors describe the potential mediating role of BDNF and the TrkB signalling cascade as they explain how these two lifestyle factors affect cognitive function from a neurobiological perspective.

Two of the reviews included here direct the reader towards neuroeletric approaches to understanding brain function (Alderman, Olson, & Brush, 2016; Chu, Chen, Pontifex, Sun, & Chang, 2016). Alderman et al. (2016) provide an overview of event-related potentials (ERPs) and then present research exploring how chronic exercise or cardiorespiratory fitness has been found to be associated with cognitive function from an ERP perspective. Importantly, the authors also discuss several methodological considerations that should be recognised by those interested in ERP techniques. A companion review is provided by Chu et al. (2016) who also discuss the

ERP evidence with respect to how cardiorespiratory fitness influences cognition. These authors organise their review based upon the types of health-related physical fitness that were studied (including muscular strength, muscular endurance, flexibility, and body mass index) and also consider academic outcomes that are particularly relevant for children and adolescents.

This provides a nice segue to the other two reviews in this issue which further consider questions related to exercise modality. One of these reviews takes a theoretical approach to this consideration (Pesce et al., 2016) while the other applies meta-analytic techniques to explore the moderating role of exercise modality on cognitive effects among children and adolescents (Vazou, Psece, Kimberley, & Smiley-Oyen, 2016). Pesce et al. (2016) provide a compelling argument regarding the importance of designing physical activity programming with a recognition of the value of motor skill development/learning. In particular, they point to the potentially critical role of variability of practice as a catalyst for cognitive benefits, and they remind us of the value of taking an interdisciplinary approach by simultaneously considering evidence from multiple bodies of evidence. Using meta-analytic techniques, Vazou et al. (2016) also emphasise the potential importance of more qualitative aspects of physical activity. They test the effects on cognition that can be achieved relevant to whether or not the physical activity programme included aerobic activities, motor skill development, cognitive engagement or a combination of these. Their findings support the importance of considering qualitative and quantitative (e.g. dose) aspects of physical activity.

McMorris (2016) provides a commentary of three of the reviews in this special issue (Chu et al., 2016; Pesce et al., 2016; Vazou et al., 2016) based upon his expertise and perspective. His viewpoint is much appreciated as he joins our contributing authors in calling for future research to strengthen our understanding of the relationship between physical activity and cognition among children and adolescents. A second commentary focused on Chu et al. (2016), Alderman et al. (2016), and Slutsky and Etnier (2016) and was provided by Hung (2016). Hung capably pulls together the messages from these three reviews by noting the importance of future research that integrates behavioural, neuroelectrical, and molecular levels to address not only "how" but also "why" chronic exercise impacts cognitive function.

We offer our thanks to the Editors of *IJSEP* for giving us the opportunity to develop this special issue for the journal. We also sincerely thank all of contributors for their outstanding reviews and commentaries. In light of their substantial effort, we believe this special issue will extend our understanding and serve as a bridge between the current status and future directions for research in the area of exercise and cognition.

Disclosure statement
No potential conflict of interest was reported by the authors.

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