Journal of the International Neuropsychological Society (2015), **21**, 743–744.
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doi:10.1017/S1355617715001149

Introduction to the *JINS* Special Issue: Physical Activity and Brain Plasticity

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A physically active lifestyle and greater cardiorespiratory fitness have long been associated with reduced morbidity and all-cause mortality (Blair et al., 1989; Kujala, Kaprio, Sarna, & Koskenvuo, 1998; Samitz, Egger, & Zwahlen, 2011). Whether a physically active lifestyle can also have neurocognitive benefits has been the subject of scientific interest for the past 40 years, stimulated by the seminal work of Spirduso and her colleagues (Spirduso, 1975; Spirduso & Clifford, 1978). As researchers and policy makers grapple with the expected increase in the number of older adults at risk for cognitive decline and dementia, the focus of attention has shifted to identifying interventions that prevent or slow down the rate of cognitive decline. A multidisciplinary panel of experts concluded that there is insufficient evidence to support the use of pharmaceutical agents, dietary supplements, or other lifestyle interventions, including physical activity, to prevent cognitive decline (Daviglus et al., 2010). However, the panel also noted the promising results from exercise and physical activity intervention studies.

The many well-documented protective effects of physical activity against metabolic and cardiovascular disease alone provide convincing evidence to support the recommendation that all people should be more physically active. However, there are many unanswered questions regarding the effects of physical activity on brain plasticity, and these questions must be pursued if physical activity is to be prescribed by clinicians to treat or prevent disorders of cognition and brain function. The 2015 Institute of Medicine (IOM, 2015) report on cognitive aging emphasized many unanswered questions regarding the effects of exercise and physical activity, including effects related to variation in the mode, intensity, and duration of acute exercise; the optimal length of exercise training, and if the benefits persist if one discontinues or maintains an exercise program; whether the age at which habitual physical activity is initiated makes a difference in the cognitive benefits that are obtained, and the potential synergistic effects of physical activity with other lifestyle behaviors. The pleiotropic nature of exercise and physical activity presents a challenge to understanding the mechanisms for precisely how and under what circumstances exercise and physical activity exert neuroplastic effects in humans. In this special issue of *JINS*, we address the extent to which single sessions of exercise, as well as exercise training interventions and participation in leisure-time physical activity, may result in brain plasticity. This collection of papers features a variety of perspectives and methodologies used to probe the intersection of exercise and neuropsychological sciences and its application to the study of healthy adults across the lifespan as well as clinical populations.

This special issue highlights the results from three exercise intervention studies, each using a different mode of exercise training. In the study by Barcelos et al., the effects of an exergaming intervention is reported to result in improved performance on the Stoop task relative to a low attention exercise control intervention. The structural integrity of the brain, and possible neuroplasticity due to exercise, is reported as greater preservation of white matter volume 12 months after older adults performed a resistance exercise intervention (Best et al.), suggesting durability of the protective effects in white matter. In regard to gray matter, Reiter et al. report that an increase in cardiorespiratory fitness after a walking exercise intervention was associated with increased cortical thickness in both healthy older adults and older adults diagnosed with MCI.

In the study by Basso and colleagues, the effects of acute exercise in younger adults are shown to affect performance on tasks of executive function mediated by the prefrontal cortex, but not hippocampus-related brain function measured by episodic memory and object recognition tasks. Several papers report on cross-sectional differences between physically active and physically inactive, or physically fit *versus* unfit, participants. The study by Schultz et al. reports that the negative relationship between amyloid burden and cognition is attenuated in older adults who possess greater cardiorespiratory fitness.

This special issue is notable in the inclusion of several manuscripts that focus on clinical samples from which little is known regarding the effects of physical activity, including benefits to executive function and greater putamen volume in individuals diagnosed with HIV for more than 10 years (Ances et al.), greater subcortical volume in older adults with a history of heart failure (Alosco et al.), and greater cortical thickness in first-episode schizophrenia patients (McEwen et al.). The studies by McEwen et al. and Reiter et al. further

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suggest that exercise and physical activity may protect gray matter from atrophy or neurodegenerative effects, and raise the possibility that neurotrophic effects of physical activity are applicable to individuals who are at greater risk for neurodegeneration or who have already experienced substantial cognitive decline.

Over the past 40 years, there has been an exponential increase in the number of publications regarding the effects of physical activity and exercise on human brain structure, brain function, neurocognitive performance, and neuroplasticity related to healthy cognitive function across the developmental period, and protection from age-related cognitive decline and all forms of dementia. While we have focused our attention to the effects of physical activity in humans, with a perspective on brain plasticity related to cognition, there is an equally explosive body of literature that uses animal models to document the mechanisms for exercise-induced neuroplasticity. Moreover, there are increasingly more papers that focus on the mental health and mood enhancing benefits of physical activity, particularly in regard to clinical affective and anxiety disorders.

The papers within this Special Issue make a substantial contribution to the growing body of literature in humans that point to the neuroprotective effects of physical activity in humans. The variety of approaches, from interventions to cross-sectional comparisons to the effects of acute exercise; the different durations, modes, and intensities of exercise and physical activity; the use of neurocognitive, neuroimaging, and electrocortical measurement tools; and the documentation of these effects within several different clinical samples that are at increased risk for neurodegeneration or disorders of brain function, will help to advance the field and to stimulate future investigations to address the as yet unanswered questions regarding physical activity and brain plasticity.

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