Brain Plasticity 1 (2019) 1–2
DOI 10.3233/BPL-199001
IOS Press

Editorial

Exercise Effects on Cognitive Function in Humans

Ozioma Okonkwo[a] and Henriette van Praag[b,*]
[a]*Department of Medicine and Alzheimer's Disease Research Center, University of Wisconsin School of Medicine and Public Health, WI, USA*
[b]*Department of Biomedical Science, Charles E. Schmidt College of Medicine, and Brain Institute, Florida Atlantic University, Jupiter, FL, USA*

Physical exercise improves memory function and mood, and may delay or prevent the onset of neurodegenerative conditions in older individuals. Understanding the effects of exercise on the underlying structural and functional neuronal mechanisms in the human brain is currently the focus of intense investigation. This Special Issue includes four research papers and three reviews addressing key issues in the human exercise and cognition field. The first article is a comprehensive review by Smith which focuses on the prevention of Alzheimer's disease and related dementias and discusses the main risk factors: physical inactivity, 'Western' dietary patterns (e.g. high intake of saturated fat and complex carbohydrates, and low intake of fruits and vegetables), and poorly controlled cardiometabolic risk factors. In particular, a very clear and detailed description of the different dietary interventions that may benefit cardiovascular and cognitive health is given. Overall, combining dietary changes and exercise may effectively prevent or delay the onset of Alzheimer's disease and related dementias [1].

The following research article by Schmitt et al. aims to understand how the relative intensity (low vs. high) of acute bouts of exercise might differentially modulate resting state functional connectivity (rs-FC) within different brain networks. The authors studied 25 trained male athletes who underwent individualized, graded fitness assessment on a treadmill. The participants also had brain MRI scans to determine rs-FC within diverse cognitive, sensorimotor, and affective networks. The study found that low-intensity exercise was associated with a significant increase in rs-FC in the left and right fronto parietal network, whereas high-intensity exercise was somewhat paradoxically linked to decreased rs-FC in the sensorimotor and dorsal attention networks, but increased connectivity in the left affective and reward network. This study is unique in being the one of the first to demonstrate differential effects of two individually-titrated exercise intensities on brain connectivity at rest. An important next step would be an elucidation of the potential neurobiological mechanisms underlying these exciting findings [2].

The second research paper in this Special Issue pertains to the link between cardiorespiratory fitness and executive function. Although it is well established that cardiorespiratory fitness conduces to improved performance on measures of executive function, an important knowledge gap relates to the potential neuronal mechanisms that support this fitness-executive function connection. To investigate this question, Peven et al. [3] recruited fifty young adults between the ages of 18 and 40 (mean age = 25.22 years, 56% female) who underwent graded maximal exercise test on a motorized treadmill and completed functional MRI scans during a Stroop color-word task. Analyses examined task-

*Correspondence to: Henriette van Praag, Department of Biomedical Science, Charles E. Schmidt College of Medicine, and Brain Institute, Florida Atlantic University, Jupiter, FL 33458, USA. E-mail: h.vanpraag@protonmail.com.

ISSN 2213-6304/19/$35.00

evoked functional connectivity of several brain regions. Specifically, they tested whether greater cardiorespiratory fitness would be associated with *increased* connectivity between brain regions that are involved with the processing of task-relevant stimuli dimensions (e.g., word color) versus whether higher cardiorespiratory fitness would be associated with *diminished* connectivity between brain regions that subserve the processing of task-irrelevant dimensions of the stimuli (e.g., word processing areas). They found greater support for the latter hypothesis, suggesting that one mechanism by which greater cardiorespiratory fitness confers better executive function is by suppressing the connectivity between brain regions that are involved with task-irrelevant sensory processing.

A subsequent research article furthers our understanding of the neural substrates underlying effects of exercise on sleep and cognition. As individuals age, they are often likely to encounter greater disruptions in the quantity and quality of their sleep. These changes in sleep, in turn, are linked with brain changes and poorer performance on cognitive tests. In contrast, greater physical activity, even in old age, is related to better brain health and cognitive function. In their study of thirty older adults, Won and colleagues [4] examined the association between acute exercise, several sleep indices, and performance on the Stroop task. They found that, after acute exercise, longer total sleep time (TST) was related to shorter response time on the Stroop, and that this association between longer TST and faster processing speed was mediated by greater caudate volume. These findings shed light on the potential manner in which distinct lifestyle factors, such as exercise and sleep behavior, may interact to favorably promote healthy cognitive aging.

In the final research paper of this Special Issue, Gaitan et al. [5] investigated the effects of exercise training on cerebral glucose metabolism (measured with FDG PET) and cognitive performance (episodic memory and executive function) in subjects with elevated risk for Alzheimer's disease. Specifically, they examined the extent to which aerobic exercise training positively affects glucose metabolism in the posterior cingulate cortex, a region known to show hypometabolism with advancing Alzheimer's disease. The authors found that improvements in cardiorespiratory fitness after the exercise training was associated with greater PCC glucose metabolism and enhanced executive function. The study concept and design is novel because participants in the intervention are relatively young older adults but enriched for high risk of Alzheimer's disease (familial or genetic). This research is important because it provides a basis for subsequent studies that evaluate effects of exercise during preclinical disease periods in populations that are at high risk of accelerated decline.

In their review article Boat and Cooper describe the relationship between exercise and self-control. They focus on two complementary aspects: the effects of self-control on exercise adherence and performance, and conversely how exercise may regulate self-control, as a component of executive function [6]. Finally, Gothe et al. provide a comprehensive review of the recent literature pertaining to the effects of practicing yoga on the brain. Positive effects are reported on the structure and function of brain areas such as the hippocampus, prefrontal cortex, cingulate and amygdala, responsible for memory function as well as mood regulation [7].

REFERENCES

[1] Smith PJ. Pathways of Prevention: A Scoping Review of Dietary and Exercise Interventions for Neurocognition. Brain Plasticity. 2019;5(1):3-38.

[2] Schmitt A, Upadhyay N, Martin JA, Rojas S, Strüder HK, Boecker H. Modulation of Distinct Intrinsic Resting State Brain Networks by Acute Exercise Bouts of Differing Intensity. Brain Plasticity. 2019;5(1):39-55.

[3] Peven JC, Litz GA, Brown B, Xie X, Grove GA, Watt JC, Erickson KI. Higher Cardiorespiratory Fitness is Associated with Reduced Functional Brain Connectivity During Performance of the Stroop Task. Brain Plasticity. 2019;5(1):57-67.

[4] Won J, Alfini AJ, Weiss LR, Nyhuis CC, Spira AP, Callow DD, Smith JC. Caudate Volume Mediates the Interaction between Total Sleep Time and Executive Function after Acute Exercise in Healthy Older Adults. Brain Plasticity. 2019;5(1):69-82.

[5] Gaitán JM, Boots EA, Dougherty RJ, Oh JM, Ma Y, Edwards DF, Christian BT, Cook DB, Okonkwo OC. Brain Glucose Metabolism, Cognition, and Cardiorespiratory Fitness Following Exercise Training in Adults at Risk for Alzheimer's Disease. Brain Plasticity. 2019;5(1):83-95.

[6] Boat R, Cooper SB. Self-Control and Exercise: A Review of the Bi-Directional Relationship. Brain Plasticity. 2019;5(1):97-104.

[7] Gothe NP, Khan I, Hayes J, Erlenbach E, Damoiseaux JS. Yoga Effects on Brain Health: A Systematic Review of the Current Literature. Brain Plasticity. 2019;5(1):105-122.