Exercise and Brain Health

By Kevin Keys and Graduate Student Mentor, Eric Leslie

Introduction

The United States is not generally known to have a population of mentally and physically healthy individuals. According to the 2018 National Health Interview Survey, 53.3% of adults aged 18 years or older met the Physical Activity Guidelines for aerobic physical activity. On top of that, 23.2% of adults aged 18 years or older met the Physical Activity Guidelines for both aerobic and muscle-strengthening activity. As a refresher, the ACSM and CDC recommendations, on physical activity, state that: all healthy adults aged 18-65 years should participate in moderate intensity aerobic physical activity for a minimum of 30 minutes for 5 days a week, or vigorous aerobic activity for a minimum of 20 minutes on three days per week. Adults should also perform activities that maintain or increase muscular strength and endurance at least 2 times per week. While these guidelines are especially useful, they are focused on the physical aspect of health and not so much the mental health of an individual. This may be due to the fact that physical activity can benefit the health of an individual's brain and lead to better outcomes like reduced risks of some cancers and diseases. The purpose of this review is to evaluate and establish the variables that influence brain health. The evidence of physical activity and the influence on brain health has been observed for quite a while now, and the aspects of the following research should provide a guide for exercise prescription.

Development

According to a 2017 review done by Herting and Chu, "Few adolescents engage in the recommended levels of physical activity.", and perhaps more worrisome, "…daily exercise levels tend to drastically decrease throughout adolescence." While the literature is unsure of what the mechanisms of exercise are that lead to better cognitive function after adolescence, the review from Herting and Chu propose that aerobic exercise could be the key. Aerobic exercise stimulates the uptake and use of oxygen into the muscles to produce work, and the activity according to Herting and Chu has been linked to positive neurological and cognitive outcomes in children and older adults. According to a 2020 review done by Stillman et. al., "…the mechanisms of exercise may vary depending on factors such as age and health state." Many studies have shown a positive relationship between aerobic exercise and school performance, but

there are also a growing number of studies that link aerobic exercise with more discrete abilities like problem-solving, attention, planning, and inhibitory control.

Lifestyle Behaviors

While it is no secret that a brain deteriorates overtime, loss of or damage to grey and white matter, partaking in unhealthy things can further degradation; likewise, engaging in healthy behaviors may slow or reverse degradation. The healthy behaviors explored by Jackson et. al. in a 2016 review includes diet, physical activity, and cognitive activity. The findings from the review show dietary behaviors are a large aspect of behavior that can be modified to have a significant impact on health, both physical and mental. Simply by eating better, one could reduce the risk of developing a number of diseases and cancers. Things like more nuts, fruits, and vegetables are some of the most popular things to add to an existing diet for health benefits. According to the Jackson et. al. review (2016), higher circulating levels of polyunsaturated fats, found in some nuts, are associated with reduced white matter damage and grey matter atrophy in healthy 50-75 year old's. With health benefits ranging from increased vascular function, reduced inflammation, lower blood pressure, and improved cognitive function, simply changing some dietary behaviors could have a significant impact on both mental health and physical health.

Cognitive activity is classified as engaging in more cognitively stimulating leisure, social, and job activities that puts one at a lesser risk of cognitive decline. Such activities include things like crossword puzzles, reading, games, etc. For example, a study referenced in the Jackson et. al. review (2016) found that Nuns who recorded more time reading, writing, and other intellectually stimulating activities had a lower incidence of Alzheimer's Disease than their peers. The Jackson review (2016) stated that a variety of frequent stimulation, and not the duration of stimulation, seemed to be key. Engaging the brain through cognitive activity can lead to some of the same benefits achieved through physical activity, but cognitive interventions aimed at real-world skills tend to show greater improvement on functional outcomes, especially in older populations.

Effects of physical activity

It has been documented that physical activity has a positive association with executive functions, like attention and self-control, and overall cognitive functioning. While the mechanisms are not fully understood, physical activity like aerobic training has been shown to promote nuero- and synaptogenesis via increases in brain derived neurotrophic factor (BDNF)

and nitric oxide. The hemodynamic responses of exercise are related to the reduction of oxidative stress and inflammation in the brain allowing for better perfusion and aiding in the retention of cognitive functions. In the 2019 review by Di Liegro et. al., physical activity was shown to improve memory as well as cognition. Similarly, to previous reviews, the underlying mechanisms are not understood as the initial studies did not have a good enough design to establish stronger correlations. In addition to the benefit to memory according to Di Liegro et al. (2019), physical activity also boosts mood as it has an antidepressant effect with a sense of wellbeing. In the Di Liegro review (2019) it was found that activities involving open-skill exercise like tennis, or some other sports, increased the amount of BDNF compared to activities like just running or swimming because they can be ever-changing in situational decisions. It was also shown that well-trained individuals showed greater responses to increase BDNF levels than sedentary individuals that have little to even no response to increase BDNF levels.

Exercise and cognition across different age populations

Part of the reason why the mechanisms that link exercise to brain health are not fully understood is exercise and cognitive activity effect different age groups in different ways. According to the Stillman et. al. review (2020), one of the reasons identifying the mechanisms of exercise can be so challenging is, "we are trying to infer a path or paths by which behavior or intervention produces changes in an endpoint of interest." Another challenge when trying to determine the mechanism behind the links stated in the Stillman et. al. review (2020) is the lack of human trial for certain mechanisms as they are unethical to perform on humans, so animal models are used to infer information about human levels of activity. One large area of research in both human and animal modeling is the role of exercise on the health of the hippocampus. It was shown that exercise promotes cognitive functions in the hippocampus like learning and memory in aging rodents, and human studies have tried to home in on the gray matter volume to assess the relevance of the animal findings in humas. Other less studied areas in the brain that have shown to be influenced by exercise included the frontal, parietal, and temporal cortex. In these areas, the cortical volume and thickness changed throughout the lifespan and in different healthy populations leading researchers to look further into these areas.

Due to lack of research and randomized controlled trials, underlying mechanisms across all age groups can be challenging to find. As stated previously, exercise and cognitive activity affect different age populations in different ways. Some age groups are still seeing functional and

structural development of cognitive features while other populations might be seeing a decline in functional ability due to the loss of brain cells and the effects of ageing. While exercise has many positive effects on the body and mind, there is not enough evidence and research on all age groups to conclusively say how much exercise or what modes of exercise may be best as many models were based off rodents, and not yet in human trials. The molecular changes and physiological changes in the body induced by exercise contribute to a synergistic effect on physical and mental health as a whole.

Disease prevention and treatment

One widely studied area on the effects of exercise on health includes disease prevention and treatment. As expected, diseases that target or affect the central nervous system are in the spotlight for many studies. Dementia, or more the more common form of Dementia, Alzheimer's Disease, Parkinson's Disease, and Multiple Sclerosis are some of the more widely studied to see if physical activity can improve symptomology of these neurodegenerative diseases and provide the best protocols for patients. According to the 2020 review by De la Rosa et. al., dementia, being the most common degenerative disease, "…is attributable to a combination of 9 risk factors: low education level, later-life depression, diabetes, smoking, social isolation, and low physical activity." A meta-analysis included in this review found a 45% reduction in the risk of developing Alzheimer's Disease simply by regularly performing physical activity. On a molecular level, physical exercise can create lactate and BDNF which have been shown to have a stimulating effect on learning and memory processes (4). Parkinson's Disease is the second most common neurodegenerative disorder (4). While pharmacological interventions are lacking, they seem to be the go to for this disease, but exercise along with pharmacological therapy has been reported to manage both physical and cognitive decline associated with Parkinson's (4). Di Liegro and colleagues concluded that physical activity could give some benefits to Parkinson's Disease, but only if the activity was repeated habitually over time. Further research is needed to determine the best protocol for these neurodegenerative diseases as many uncertainties and variabilities exist, but new studies and methods are emerging to figure out the best combinations of exercise and drugs to slow down the disease and improve quality of life.

Exercise doses for brain health

While exercise protocols were not fully established for neurodegenerative diseases, the 2019 review by Cabral et. al. tries to lay out dose effects of exercise on the brain in aging adults

and animals where human data was not available. In one instance, a 12-week exercise intervention was shown to have no or insufficient improvement in hippocampal regional cerebral blood flow compared to a muscle stretching and relaxation intervention. Finally, a 16-week intervention in older adults, that had memory complaints, found improvements in bilateral hippocampal cerebral blood flow when compared with a group that received education and light stretching. Having noted the effects of stretching and relaxation interventions, more research looked to add such interventions with aerobic exercise. The interventions showed similar levels of white matter integrity in the frontal and temporal lobes, increased executive control, and short-term memory (6). In the review by Cabral et. al. (2019) it was also noted that individuals that saw increases in cardiovascular fitness also saw greater improvements in white matter integrity and short-term memory, seeing an average increase of 8% greater cardiovascular fitness led to an average of 2% increase in hippocampal volume. The review concludes by breaking the data into time sections, Short term (1 day to 16-weeks), Medium term (24 to 40-weeks), and Long term (52-weeks and beyond). The results for the Short term group determined that combining a moderate intensity aerobic and resistance training program had the most beneficial effects in the given time frame, as this would contribute to improved cerebral blood flow, improved brain structure, and neurobiological factors. The Medium term group saw the same findings related to aerobic exercise but got three new characteristics that seemed to have a greater chance of having benefits: 1. Including a progressive intervention that increased exercise intensity from moderate to high. 2. An exercise intervention with at least 150 weekly minutes. 3. Constant novelty like a dance or combination of exercise modes. The Long term group included things outside of aerobic exercise. Interventions combining aerobic coordination and other combined exercise interventions with moderate to high intensity seemed to improve neural efficiency (6).

Conclusion

Though this article and the research presented in the article was unable to establish some guidelines on exercise prescriptions, for brain health, for all populations, it still showed that activity of both physical and mental modes were beneficial for increasing mental cognitive ability and health. The lifestyles that were high in academic leisure and physical activity tended to see better brain health as these stimuli were linked with protection of brain structures, and even growth or improvements of some structures and functions. Brain health is correlated with exercise, more specifically cardiorespiratory exercise, and the recommendations provided can

boast improvements in brain health. As made evident by the research in this article, exercise improves brain function, but one topic that seemed to lead to greater benefit was a constant stream of new stimulation and actively involving oneself in academic endeavors. Combining many of these factors, like aerobic exercise and reading, one could improve current brain health and function, or one could improve current brain health and function as well as later in life.

Additional Elements

Apply it

- Variety of stimulation is key for the best brain health benefits.
- Aerobic exercise modes may be the best physical exercise for brain health benefits.
- Gradual lifestyle changes that are sustainable can help reach brain health goals.

Bridging the Gap

While the literature on the links between exercise and brain health is not without question, it does provide some basis on which to start. Simply engaging in more activities, both physical and academic, can increase brain health and lead to a longer lasting retention of skills and abilities. Different age populations may have different guidelines to follow but almost all populations can improve some aspect of their mental wellbeing. Simply being a well-rounded individual, physically and mentally, could allow for the best results of brain health.

Summary Statement

In short, brain health is correlated with both physical activity and academic engagement. Those that spend their time engaging their brain and exercising often will increase mental capacity and mental health.

Pulled text

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Bio

Kevin W. Keys, B.S., currently finishing his undergraduate in Exercise Science with plans to continue on a path to become a Physician Assistant. His interests include most sports and spending time with friends and family.

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