Physical Activity and Cognition: A Narrative Review

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Abstract

Introduction. Cognitive rehabilitation programs have traditionally focused on mental strategies targeting executive-functions, memory, and language. However, researchers are increasingly exploiting avenues to enhance benefits of cognitive training to facilitate neuroplasticity through integrative therapies. **Purpose.** The aim of this paper is to provide an overview of the evidence that supports addition of physical activity into traditional cognitive rehabilitation, creating a more integrated treatment approach. Specifically, the evidence focuses on increased levels of Brain-Derived neurotrophic factor (BDNF), a specific growth factor in neuroplasticity, following physical activity. **Method.** This narrative review chose a representative sample of the evidence that informs cognitive gains as a result of physical activity, with an emphasis on BDNF. A comprehensive review of the literature was conducted across PubMed, Cinahl, and PsycInfo, and a representative sample of the evidence was selected that informs the effects of physical activity on cognition, as well as the relationship with BDNF. **Conclusion.** The review supports the addition of physical activity into cognitive rehabilitation programs to enhanced cognition in clinical populations. However, more evidence is needed to support the duration and type of activity that would produce the most benefit.

Key words: *BDNF, Brain injury, Cognition, Cognitive rehabilitation, Physical activity*

Introduction

Genetic composition, environment, lifestyle factors including nutrition, physical activity, and comorbid diseases are just a few of the aspects that play a role in cognitive health.[1] Cognitive rehabilitation programs have traditionally focused on mental strategies targeting executive functions, memory, and language. However, researchers are increasingly exploiting avenues to enhance benefits of cognitive training to facilitate neuroplasticity through integrative therapies that further enhance cognition. Neuroplasticity refers to the neuron's ability to change, restructure, or create synaptic pathways when confronted with a new or changing environment such as an injury to the brain.[2] One such approach, to promote neuroplasticity, is the addition of physical activity to existing cognitive training paradigms.

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Recent research has supported the positive effects of physical activity on cognition.[3-7] Specifically, research is highlighting the association between physical activity and cognition by identifying the role of a specific growth factor, Brain-Derived Neurotrophic Factor (BDNF) that promotes neuroplasticity and structural changes in the brain following exercise. In other words, this approach of adding physical exercise/ activity to cognitive training proposes that motor and cognitive plasticity could work hand-in-hand during rehabilitation.

Physical activity is yet to be incorporated as a standard treatment strategy in cognitive rehabilitation. This integrative approach of incorporating physical exercise in cognitive remediation is highly relevant to therapists, specifically those working in neurorehabilitation. This knowledge could greatly impact therapy interventions and functional outcomes for individuals recovering from a brain injury. This narrative review highlights benefits of physical activity on cognition and suggests possible treatment guidelines that could be implemented in cognitive rehabilitation. Specifically, the review highlights the role of BDNF-levels post-exercise/activity

and its effect on cognition. The review summarizes selected literature that supports addition of physical activity into cognitive rehabilitation, creating a more integrated approach.

Brain-derived Neurotrophic Factor (BDNF)

Discovered in 1982, BDNF is a nerve growth factor protein.[8] The term "neurotrophic" means that the BDNF protein stimulates or promotes growth in nerve cells.[8] Because of its known ability to influence the growth and survival of neuronal cells, BDNF has been widely studied in the neuroscience field to gain a better understanding of the depth of influence.

Initial studies demonstrated BDNF as a key mediator in affecting pathways that enhanced neural plasticity and synaptic transmission.[9-11] BDNF is identified as a primary modulator important for synaptic transmission. Researchers discovered that an increase in the BDNF levels in the brain can activate molecular pathways important for neurogenesis, specifically in the hippocampus, which is responsible for learning and memory.[12-13] The key for improving BDNF levels is to increase blood flow, which has been linked to aerobic exercise and physical activity.

Methods

The narrative review of literature chose a representative sample of the evidence that informs cognitive gains as a result of physical exercise/activity, with an emphasis on BDNF. The review of the literature was conducted in a search including PubMed, Cinahl, and PsycInfo. Search terms included (cognition) AND (physical activity OR physical exercise) AND (brain-derived neurotrophic factor OR BDNF). Inclusion criteria included sources were written in English and was within the last 20 years (1998-2018). Exclusion criteria included pediatric and adolescent populations.

Effect of Physical Activity on BDNF Levels

Results from healthy control studies demonstrate benefits of physical activity in improving BDNF levels. Tang, [14] found short-term increases in BDNF levels lasting 25-50 minutes following exercise. Szuhany, Bugatti, and Otto[7] suggests that every session of exercise results in a 'dose' of BDNF activity, which can be increased in magnitude with each successive session of exercise. That is, regular physical exercise has a cumulative effect on BDNF, resulting in long-term benefits.

The key ingredient to stimulating the growth of BDNF is increasing blood flow, which can be achieved by participation in any kind of aerobic activity. Recreational and social activities of billiards, bowling, arts and crafts, and cooking are found to be as effective as treadmills and bicycles in increasing BDNF levels, and lead to improvements in memory and executive functioning, both in short-term and long-term.[15]

Research has found limited influence of strength training in increasing BDNF levels, memory, or overall cognition.[16-18] Further research to determine specific parameters of activity, including type and duration, and cognitive outcome measures are still required. This additional research may refine exercise paradigms to the optimal length and intensity to result in increased BDNF levels.[19-20]

Effect of Increased BDNF Levels on Cognition

Increased levels of BDNF due to physical activity have been shown to improve cognition. Erikson[21] discovered that an aerobic exercise program increased BDNF levels and also reversed the age-related hippocampal volume loss as well as improved memory function in healthy older adults. This supports other research illustrating that exercise can have positive effects on the hippocampal region of the brain, an area vulnerable to both age-related decline and dementia. Additional research has demonstrated effects of physical activity on increased BDNF levels in the entorhinal cortex and memory function,[22] improved executive functioning in older adults.[5,23] The global cognitive gains experienced from exercise have also been found in populations with multiple sclerosis, panic disorder, and survivors of stroke.[15, 24-25] We propose the following visual schematic (Figure 1) to illustrate the impact of physical activity on cognition.

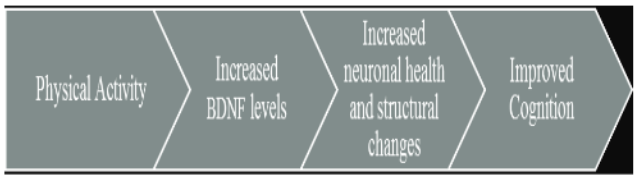

Figure 1: Effects of Physical Activity on Cognition

A positive correlation was found between BDNF levels and cognition in older adults with a mild cognitive impairment.[26] The results indicated increased cognitive performance in visual learning, speed of processing, and working memory, particularly in the groups with the combined cognitive and aerobic training.[27] Physical activity was also found to be successful in improving cognition and ADLs in individuals with dementia.[28] In this systematic review, researchers found that the addition of general exercise into older adult's routines may slow the advance of cognitive decline and in turn, reduce the dependence with ADLs.

Effect of Increased BDNF Levels on Psychological Health

The BDNF pathway is one of several known pathways associated with depression and cognitive impairments in older adults.[29] Decreased BDNF levels are associated with deficits in functioning as noted in individuals with depression, schizophrenia, cognitive impairments, and panic disorder.[25, 27] Significant gains were reported following four weeks of integrative therapies (i.e., cognitive plus aerobic training) versus exclusively cognitive training in adults with psychiatric illness (e.g. schizophrenia, major depressive disorder).[27] Older adults with lower BDNF levels are at an increased risk for depression.[6] A recent study on neuronal function including cognition and mood, examined individuals with depression and utilized the international American College of Sports Medicine standard of 150 minutes per week of moderate to vigorous exercise. This resulted in improved neural efficiency due to increased cardiovascular fitness, positively affecting aspects of cognition and associative memory. This neurocognitive increase was associated with an increase in Add Major Depressive Disorder (MDD) BDNF levels.[30] In a recent study, individuals with MDD are shown to have lower levels of BDNF as compared to healthy adults. The researchers found that when individuals with MDD were treated with a combination of SSRIs and physical activity, BDNF serum levels increased nearly to those of the healthy population.[31] Research is continually showing the benefits of increased BDNF levels associated with physical activity in the MDD population.

Discussion

Residual cognitive, psychological, and physical impairments are often attributed to discouraging functional outcome in chronic stages of recovery post brain injury.[32] Therefore, researchers and clinicians are beginning to recognize the benefits of integrative approaches to mitigate chronic long-term functional challenges. That is, physical exercise such as aerobics and other fitness regimens are integrated into cognitive training programs. These integrative approaches have demonstrated gains in both preservation (in healthy adults) and enhancement (in adults with brain injuries) of cognitive and psychological function.[33-35] This review highlights the therapeutic interplay between cognition and physical activity. We propose integration of physical activity as a critical component in cognitive rehabilitation approaches in clinical populations (Figure 2).

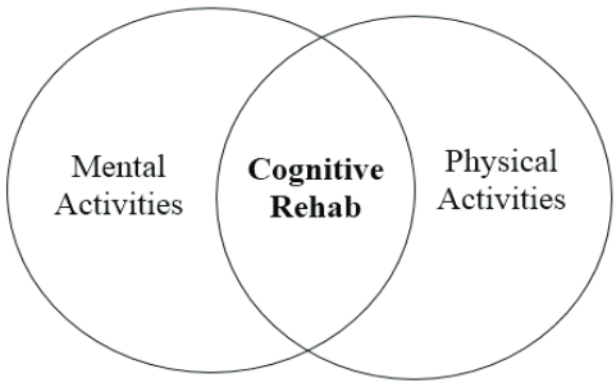

Figure 2: Proposed components of Cognitive Rehabilitation

Integrating physical activity and exercise into the traditional cognitive rehabilitation training is a way to further benefit outcomes for multiple clinical populations. As the research has shown, benefits from increased BDNF levels following physical activity have been present in many populations including stroke, MS, MDD, schizophrenia, and panic disorder. In sum, evidence from both healthy adults and clinical populations show promise in cognitive gains following physical exercise/activity.

Limitations and Future directions

The narrative review is a broad overview of a specific topic of interest, with no predefined protocol. Therefore, the selection of articles is selective to summarize the benefits of physical exercise on cognition. The results may be biased as we did not systematically examine all evidence that critically analyses the benefits of physical exercise on cognition. Further research is needed to precisely understand the dosage and frequency of physical exercise that can cause positive long term changes in cognition. Furthermore, the gains of physical exercise on cognition in different clinical populations needs to be discerned.

Clinical Implications

Physical activity/ exercise could increase production of BDNF levels, which has been linked to cognitive benefits. Although more research is needed to determine specific exercise/activity modalities and parameters to accompany cognitive programs; the evidence present has significant implications for practitioners.

What can the addition of physical activity in cognitive rehabilitation programs look like to a practitioner? Based on the literature reviewed, the following are intervention strategies that supplement cognitive training with physical activity. Have a client walk or jog for 10 minutes prior to cognitive activities, alternate between physical activity and cognitive tasks, or combine cognitive tasks with physical activity rather than performing tasks on a tabletop. For instance, training in problem solving strategies could incorporate walking during a scavenger-hunt versus doing a paper-pencil worksheet. Engaging clients in functional tasks increases activity naturally, and physical activity can be easily added into programs through treadmills, standard walking, ellipticals, or bikes to name a few modalities. Adding physical activity is a simple way to build on the benefits of cognitive retraining, these strategies require little more than creativity added into therapy sessions.

Additional research is needed to lend knowledge to practitioners about specific boundaries for inclusion of physical exercise/activity in cognitive rehabilitation programs. At this time, the evidence summarized in this paper identifies generalized exercise as a course for increasing BDNF levels to facilitate cognitive gains.

Conclusion

Integrating physical exercise to enhance cognition is a feasible, cost effective and potentially valid treatment paradigm in cognitive rehabilitation. This review provides evidence of the benefits of physical activity on cognition and supports the initiative to incorporate physical exercise/activity into cognitive training. Further research on duration and types of exercise/activity is warranted to provide clinicians with evidence-based protocol for implementing physical activity in cognitive rehabilitation.

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