



EXERCISE EFFECT ON NEUROPSYCHOLOGICAL FUNCTION - A REVIEW

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ABSTRACT: Research documented that regular participation in physical exercise has a beneficial influence on various aspects of brain function. Human studies reported that cognition and mental performance can be improved with various types of exercise like aerobic exercise, resistance exercise and others. Participations in exercise not only improve the physical health, but also improve their academic performance, job/office performance, reduce illness and injury related to age related decline and also improve sports performance. This article features with the positive effects of exercise on cognition and brain function, at the molecular, cellular systems and behavioral levels. More research investigation on exercise related benefits for specific components of brain and cognitive function is clearly needed in all cross section of human population.

Keywords: Neuropsychology, Exercise, brain function, performance

1. INTRODUCTION

Neuropsychology is the study of the relationship among brain function, behaviour and psychological process. The field of neuropsychology is one which significantly contributes to the knowledge and understanding of the great spellbinder called brain. Fuelled by advancements in imaging technology, Neuropsychological thinking started to gather momentum during the 1950s and 1960s. It was during this era when research and findings from cognitive psychology and brain function physiology were integrated into a new field of study. Today, neuropsychology is trying to find out if brain functions are strictly localized in one area of the brain, or whether other regions or centres of the brain are interconnected. Neuropsychology believes that the brain coordinates a lot of cognitive function between several brain regions and biochemical processes.

2. NEUROPSYCHOLOGY AND EXERCISE

The roots of mind-body connection can be traced back to at least the ancient Greek civilization. The scientific investigation of the relation between physical activity and cognition began in the 1930s. Evidence for a relationship between physical conditioning and faster reaction time was during several decades [1-3] [although some studies indicated no such relationship [4] .The first



systematic examination of mind-body relationship began in the 1970s, with findings indicating that older adults who regularly participated in physical activity had faster psychomotor speed, relative to their sedentary counterpart, on simple and choice reaction time test. Interestingly no such relationship was observed in a comparable group of younger adults [5-7] suggesting that the benefits of physical activity on cognition were specific to older adults. With recent technical advancement, contemporary research has sought to understand the mechanism that underlies the influence of exercise participation on cognition. When it was established that participation in physical activity has been associated with the changes in cognitive function as well as executive control, researchers started experimenting with the effect of various types of exercise such as aerobic, resistance, flexibility, speed and many others on cognitive functions and they were also keen to find out exercise effect on various age groups such as children, young age and old age as well as in various professions like in academic performance, job/office and sports performance or in various illnesses.

Thus purpose of this review is to make an overview among various exercise intervention effects in different age groups and in different professions on brain functioning and cognition.

3. PHYSICAL EXERCISE EFFECTS ON BRAIN FUNCTION AND COGNITION DURING CHILDHOOD

A recent meta-analysis suggested a positive relation between physical activity and cognitive performance in school- age- children (aged 4-18 years) in eight measurement categories (perceptual skills, intelligence, quotient, achievement, verbal tests, mathematics test, memory, developmental level/academic readiness). A beneficial relationship was found for all categories, with the exception of memory, which was unrelated to physical activity behaviours [8], and for all age groups (although it was stronger for children in age ranges of 4-7 and 11-13 years, compared with the age ranges of 8-10 and 14-18 years) [8]. These findings suggested that although physical activity might be beneficial at all stages of life, early interventions might be important for the improvement and/ or maintenance of cognitive health and functions throughout the adult lifespan.

Recently research efforts have focused on the relation between physical activity and the academic performance of school age children. It was observed that aerobic fitness has a small but positive relation to academic achievement, where as body mass index (BMI) has a negative relation [9]. Studies have revealed that achievement in standardized tests of mathematics and reading was positively related to physical fitness scores, measured using progressive aerobic cardiovascular endurance run(PACER) test (a 20 meter shuttle run that increases in difficulty and is considered a field test of aerobic capacity), in school- age- children [10]. This relationship was selective to aerobic fitness, where as muscle strength and flexibility were unrelated to academic achievement. Similarly,



beneficial relationship has been observed between physical activity and academic grades in the classroom [11-13].

Results may be supported with the explanation that relevant neural networks have been identified for component processes that might be involved in mathematics and reading performance. Research that examined the functional neuroanatomy of reading comprehension revealed activation of the prefrontal cortex (PEC) and parietal posterior cingulate cortex (PCC) [14]. Likewise, mathematical calculations and numerical magnitude processing have been linked to bilateral regions of the intraparietal sulcus in children and adults [15-17]. However children also recruit the right dorso lateral prefrontal cortex. Given that both mathematic and reading elicit activations in the fronto parietal network; there is a sound basis for examining this structure in relation to academic performance. As fitness has also been related to the fronto parietal network [18-20], it would follow that children might derive benefits in school performance from increased participations in physical activity.

Finally, a few studies have indicated that physical activity is unrelated to academic performance. For example, a study that relied on the self reported teacher's perception of students' physical activity did not find a relation with academic performance [21].

4. PHYSICAL EXERCISE EFFECTS ON BRAIN FUNCTION AND COGNITION DURING ADULTHOOD

There is small body of literature that examines neurophysiological indices on the benefits of exercise participation on cognitive function in young adults. Most research has focused on younger adults merely for the purpose of comparison with older adults, to provide a basis for age related deficits in cognitive function and to better understand the prophylactic or ameliorative effects on chronic physical activity participations on cognitive aging. One obvious reason for this paucity of literature is that cognitive health peaking during young adulthood, suggesting that there is little room for exercise- related improvement to cognitive function during this period of life span. Now evidence is beginning to emerge that regular engagement in aerobic exercise might also be beneficial for executive functioning in young adults, despite such functioning peaking developmentally in that age group [22-24]. Some evidence indicates that higher physical activity levels are associated with better task switching when the upcoming switch is predictable. It also suggests that aerobic fitness is associated with top-down modulation of responses in tasks that rely on selective attention and inhibitory control that relates to the ability to gate task irrelevant information in the environment (i.e., interference control) and inhibit a prepotent response to allow selection of the appropriate response, and that regular aerobic exercise can improve the updating component of working memory, which is described as a sub set of process involved in the active storage, maintenance, and manipulation of information to be retrieved within a brief interval. Studies also supported that acute exercise facilitates cognitive processing via a general arousal level.



The Results may be explained as exercise was found to increase the amplitude of P3 component that reflects allocation of attention and context updating of working memory [25] resources and has also been shown to be proportional to the amount of resources allocated to a particular task or stimulus. Apart from that exercise also affects on information processing which incorporates changes observed in cognitive functioning in young adult. Other neurobiological changes which may influence the cognitive changes in young adults are increased blood flow, improved neurotransmitter functions and cerebral vascularization [26].

5. PHYSICAL EXERCISE EFFECTS ON BRAIN FUNCTION AND COGNITION DURING OLDAGE

Research on exercise and cognition with older adults started long ago. Recently the exercise-cognition relation in older adults has been influenced by various lifestyle factors including intellectual engagement, social interaction, diet and physical activity that are associated with the maintenance of cognitive function and in reductions in risk for age- associated neurodegenerative disorders, such as Alzheimer's disease and vascular dementia.

Physical exercise training appears to have both broad and specific cognitive effects: broad in the sense that various cognitive processes benefit from exercise participation and specific in the sense that the effects on some cognitive processes, especially executive control process (which include scheduling, planning, working memory, multi-tasking and dealing with ambiguity), are disproportionately larger. It is reported that older adults exercising aerobically showed increased brain volume [19] in frontal lobe regions implicated in higher order processing, attentional control and memory. Regular exercise also has a beneficial impact on depression, quality of sleep and cognitive functions in older adults. It is reported that high intensity resistance exercise training improved cognitive performance in memory and verbal concept formation among senior men [22]. Results also suggested that the effects of resistance exercise training on executive cognitive function appear to be selective; that is resistance training enhanced selective attention and conflict resolution in older women, but cognitive abilities associated with manipulating verbal information in working memory and shifting between tasks sets of instructions were not improved [27].

Currently there are three hypothesis explaining how exercise may affect executive control in older adults. First, exercise may increase oxygen [28] saturation and angiogenesis [29] in brain areas crucial for task performance. The second hypothesis suggested that exercise increases brain neurotransmitters such as serotonin and norepinephrine, facilitating information processing [30-32]. The third, and probably most well studied hypothesis that exercise up regulates neurotrophins such as brain derive neurotrophic factor (BDNF), insulin like growth factor(IGF-1) and basic fibro- blast growth factor (bFGF) that support neuronal survival and differentiation in the developing brain and dendritic branching and synaptic machinery in adult brain.



6. PHYSICAL EXERCISE EFFECTS ON INJURY AND ILLNESS RELATED TO HEALTH DECLINE

Evidence showed that increased physical exercise or reinstatement of normal levels reduces the risks of diseases like obesity, cardiovascular disease, type 2 diabetes, osteoporosis, cancer and depression [33-35]. It is also suggested that physical exercise may confer health protective benefits for several neurological diseases including Parkinson's disease [35], Alzheimer's dementia [36], ischemic stroke [37], as well as injuries from falls attributable to neuromuscular declines associated with physical inactivity among the elderly [38]. There is also emerging evidence about the adaptability of neurobiological systems and their influences on performance and health during physical exertion in adverse condition such as heat [39], hypoxia [40], and military combat [41-46].

7. CONCLUSION

Human research suggested that exercise, particularly aerobic exercise and resistance exercise can have a positive effect on multiple aspects of brain function and cognition. Data also supported that physical exercise may have beneficial effects throughout an individual's life span, even for those with neurodegenerative disease. Physical activity has been suggested to be a useful tool for the reduction of the risk for cognitive impairment related to aging. Finally, there is ample evidence at the molecular, cellular, behavioural levels that exercise participation is beneficial to brain function and cognition.

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