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Recreational physical activity and cognitive abilities

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Abstract

Cognitive processes occurring in the nervous system involve the acquisition, processing of information from the environment, as well as its use for a specific purpose. The quality and speed of the occurrence of this process will determine the interaction with the environment, and about it the accuracy of responses to stimuli. Physical activity has a positive effect on the volume of selected parts of the brain and the presence in the blood of such substances as BDNF and IGF proteins, which has a positive effect on the quality of cognitive processes taking place in the central nervous system.

Keywords: Recreational Activity, Cognitive Function, Humans Brain, Health.

Introduction

Physical activity has been written into the human genotype since its creation. In the beginning, it was associated with the need to undertake movement for very basic purposes, such as getting food or finding a place to live. The need for a certain amount of movement is also evidenced by the fact that if you abandon activity and at the same time use your muscles, you will lead to their gradual atrophy. Movement also has a significant impact on the proper functioning of the cardiovascular system, improves the overall efficiency of the body, and also brings a number of benefits related to the quality of the mind's work, improves cognitive abilities, eliminates stress-induced tension and improves the level of impulse conduction, which simultaneously affects better processing and analysis of stimuli and increases neuromotor abilities. Physical activity in the current times marked by high dynamism and the need for perfect self-organization in the professional and private spheres can play a huge role in the context of maintaining balance. Recreational physical activity, not focused on competition with oneself, not marked by the need to achieve better and better results, is an ideal form of active rest and, contrary to appearances, a source of self-improvement. Although recreational physical activity means taking up movement, activity, due to the way it is perceived, the time devoted to it is characterized by a subjective slowdown and a break from routine duties. As it turns out, a number of positive changes take place in the nervous system, where cognitive abilities are improved, affecting better absorption of information, learning, as well as analytical and forward thinking.

The Impact of Physical Activty on Human Brain

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Physical activity can be a sphere considered from the level of social and neurobiological effects. The cognitive function responsible for processing information coming from the external environment and filtering it, so to speak, determines what will be assimilated, to what extent, and then another of the spheres relating to its use can be considered. From a health perspective, physical activity seems to be a necessary part of everyday life. The latest National Health Test reports that more than half of Poles do not engage in physical activity at all, and the average BMI is 26.7, which means overweight. A high percentage of weight problems is observed already at the elementary school level, in view of which one can speak of a negative trend when it comes to basic health care. Excessive weight gain, unfavorable body composition, higher amounts of body fat, LDL cholesterol have an inhibitory effect on motor skills, the quality of the nervous system, strain the heart and reduce performance. The best way to counteract such degenerative changes caused by, among other things, a sedentary lifestyle and emerging stress is regular exercise. Cognitive abilities themselves, on the other hand, can be assessed as an internal picture of the world, influencing attitudes toward the environment and determining the interactions undertaken. For this picture to be as complete as possible, it is necessary to have proficiency and involvement of the senses, which can be described in general as sensory. Attention is then distinguished as the ability to select stimuli from the environment, that is, to select or reject specific information. It is worth noting that without concentration on a specific stimulus, information, the ability to remember would not be possible. Memory, in turn, is the ability to store information. First, short-term memory associated with a specific stimulus must occur, and then it can develop into long-term memory. Memorization is aided by an emotional stimulus. It can be positive or negative, but the strength of the stimulus will interact with the assimilated information and influence whether it is remembered in the nervous system. A corollary of memory is a greater quality of logical thinking, or reasoning, where we use the information we have in a purposeful and directional way.

The brain is made up of neurons and glial cells. The latter mainly have metabolic and structural functions. Neurons are the most important cells, whose main task is to send signals. Specifically, these are neurochemical impulses that enable reactions to occur in other structural elements of the body. No reaction can take place without proper stimulation. Cells communicate with each other via synapses, and it is estimated that there are about 100 trillion of them in the human brain. Noteworthy, synapses are modifiable with respect to the signal being transmitted. That is, they are capable of changing the strength of the signal by the signal patterns that pass through them. It is this mechanism, or modification relative to the stimulus, that is considered the pattern of learning.

Physical activity primarily brings benefits related to the level of brain cell congestion, nutrition, oxygenation, and stimulation other than that resulting from, for example, routinely performed duties. In addition, a substance called BDNF, or Brain Derived Neurotrophic Factor, plays an important role in the context of learning. It is a protein secreted by neurons and is a nerve growth factor. It also plays an important role in synaptic plasticity, or the aforementioned ability to adapt and change synaptic connections in response to stimuli, learning. It turns out that a significant increase in the concentration of this protein occurs when aerobic, higher-intensity and systemic exercise is undertaken. This allows us to conclude that physical activity develops the nervous system and significantly affects the development of the memorization process. At the same time, such significant changes were not observed in the case of anaerobic exercise, which in turn points out that the duration of exercise is also important. In the structure responsible for memory, the hippocampus, BDNF levels were higher the longer the exercise time. Anaerobic exercise is a short-term exercise [1]. Among the beneficial effects of BDNF are the inhibition of apoptosis within neurons and the reduction of sensitivity and damage to nerve cells caused by oxidative stress. Indirectly, reduced BDNF levels have a degenerative effect on the nervous system, which can lead to dementia, neuropsychiatric and neurodegenerative diseases. In addition, studies have shown that BDNF levels are reduced in schizophrenic patients in an area of the brain associated with working memory [2,3,4].

It is worth mentioning that BDNF protein is also localized in cardiac muscle, skeletal muscle or the lungs, among others.

It is worth mentioning that BDNF protein is also localized in cardiac muscle, skeletal muscle or lungs, among others. One of its functions is to contribute to the development of stem cells and, due to its properties, also to cell regeneration [5,6]. Indirectly, the vascular endothelial growth factor VEGF, which is involved in the formation of new blood vessels and in building peripheral circulation, may be involved in the improvement of neurological function, allowing better nutrition and delivery of essential components to nerve cells. Studies have shown an increase in VEGF concentrations especially after intense exercise. Yet another component that contributes to improved neurological function is insulin-like growth factor IGF-1. This is a protein hormone involved in tissue and bone growth.

People who regularly engage in aerobic exercise (e.g., brisk walking - Nordic walking, swimming, running, rollerblading, cycling) perform better on neuropsychological and performance tests that measure specific cognitive functions, such as visual control, cognitive flexibility, working memory updating and capacity, declarative memory parameters, spatial memory and information processing speed [16,17]. Aerobic exercise is also a potent antidepressant and euphoric “agent” [7], so when taken consistently, it results in an overall improvement in mood and self-esteem [20].

Interesting conclusions emerged after conducting a 6-month study on a random sample of 86 women aged 70-80 with subjective findings of memory abnormalities. They were classified into groups: resistance training, aerobic training, and a control group. All participants performed the prescribed exercises twice a week for six months. Verbal memory and the learning aspect itself were assessed using the Rey Auditory Learning Test (RAVLT), as well as spatial memory tested using a computerized test performed before and after the study. It was discovered that the aerobic training group remembered significantly more items after the RAVLT test, compared to the control group after six months. In addition, both experimental groups showed improvements in spatial memory under conditions where they were required to remember the position of three items, compared to the control group [11,12,13,14].

Other studies have shown that regular aerobic exercise increases the volume of the hippocampus, the area of the brain where the memory center is located. Resistance training, balance training and exercises designed to strengthen muscles did not produce the same results. The benefits of exercise stem directly from a mechanism to reduce cellular resistance to insulin and stimulate the release of

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growth factors - chemicals in the brain that affect brain cell health, the growth of new blood vessels in the brain and the survival of new brain cells. Indirectly, exercise improves mood and sleep, reduces stress and anxiety, and problems in these areas often cause cognitive dysfunction [15].

In Stockholm, it was shown that aerobic training performed by running not only increased the volume of the hippocampus, but also had an antidepressant effect, which correlates with the previously presented set of information on neurotransmitter activation in the brain [15,16].

According to a study from the Department of Performance Science at the University of Georgia, even short exercises of 20 minutes support information processing and memory functions [16]. In a developmental context, research from UCLA has shown that exercise increases growth factors in the brain, making it easier for the brain to form new neural connections [17].

As it turns out, in people who exercise, the area of not only the midbrain cortex, where memory is located, but also the frontal cortex, responsible for constructive, logical thinking, increases. The latter aspect in sports also plays a huge role, especially in team games, where it is required to undertake not only physical effort, but at the same time to put together technical elements, analyze the behavior of opponents and partners on the playing field, and implement the chosen strategy during competition. Many other studies confirm that the parts of the brain that control thinking and memory (prefrontal and central cortex) have a larger volume in people who exercise, compared to those who do not engage in physical activity. It has been postulated that any form of exercise that affects the circulatory system holistically will conceal such properties [18].

Studies have also provided information proving that there was a positive correlation between hippocampal volume and cognitive performance in older people [19]. Erickson et al [20,21] tested 165 healthy individuals between the ages of 59 and 81. Their cardiorespiratory fitness was assessed using an exercise test, and hippocampal volume was measured using magnetic resonance imaging (fMRI) during tasks involving spatial memory. The results showed that higher performance was associated with higher hippocampal volume, which in turn influenced better spatial memory performance [22,23]. Given that the hippocampus exhibits degenerative changes during the aging process, these findings indicate that aerobic fitness may be an effective means of preventing negative factors associated with age and cognitive impairment [24]. Based on the results of a study [25] of 120 elderly subjects, it was found that the study group undertaking physical activity had a 2% increase in hippocampal volume. In addition, this group showed higher levels of BDNF in the blood and improved spatial memory. The control group showed no such changes in brain structure and cognitive structure performance, thus providing further evidence that physical training increases hippocampal volume in late life and has a positive effect on maintaining the highest possible quality of processes involving the memory sphere [26].

Another particularly relevant study [27] assessed the role of exercise in the process of neurogenesis in the hippocampus using a study group consisting of humans and mice. Two magnetic resonance imaging (MRI) studies were conducted, with the first analysis imaging the volume of cerebral blood in the hippocampal structure during mouse exercise. The results showed increased cerebral blood volume in the dentate gyrus, which was an area of the hippocampus observed to support neurogenesis in adults. The increase was then found to correlate with the process of neurogenesis observed after training [22]. In the second study, cerebral blood volume was measured in adult humans (mean age was 33 years), after 12 weeks of aerobic, or performance training. Similar to the mouse model, exercise had an effect on the ciliary valve, with cerebral blood volume correlating with cardiorespiratory fitness [22]. These results were further supported by improved cognitive performance in the Rey auditory learning test, which also correlated with cardiorespiratory fitness and cerebral blood volume [22]. These data suggest that within the hippocampus, the dentate gyrus is uniquely vulnerable to stimuli, and that increased exercise-related activity affects neurogenesis. In addition, BDNF levels are mentioned to be closely associated with increased hippocampal volume, which has been noted to affect learning and memory [20].

Thanks to advances in the aforementioned neuroimaging techniques, awareness of the effects of aerobic exercise on brain structure and function has grown rapidly over the past decade. In particular, a series of studies [20] have been conducted in older people to better understand the relationship between aerobic brain performance and cognition. Aging causes degeneration of brain tissue, with marked loss of tissue function demonstrated in the frontal, temporal and lateral lobes [24]. Consequently, it has been postulated that cognitive abilities, for which the aforementioned brain regions are responsible, deteriorate significantly compared to other aspects of mental functioning. In particular, age-related decline in gray matter volume resulted in a decline in a variety of processes categorized as cognitive control. This has been linked, for example, to higher error rates on the Wisconsin Card Sorting Test [25] and better memory encoding during a test of language learning by ear. The reduction in gray matter volume may be due to several factors, including loss of the number of neurons, neuronal shrinkage. In addition, the volume of white matter, which affects the transmission of information between neurons, decreases with aging. Loss of white matter volume is associated with reduced performance in many cognitive tasks [27] and may result from demyelination of axons, reducing the rapid and efficient flow of signals through the nervous system. Nevertheless, based on the results of animal studies, as well as the aerobic-related effects on cognitive control observed in studies, the researchers speculate that an active lifestyle may serve to maintain performance in brain regions that support cognitive control. Interestingly, these studies have shown similar benefits of exercise for maintaining brain health in people affected by various diseases, including dementia, Alzheimer's disease and schizophrenia [28,29].

Referring to the nature of exercise and dividing it into aerobic and anaerobic, it should be cited that the results of studies conducted indicate that an increase in the volume of selected parts of the brain, an increase in the amount of gray matter, as well as white matter in adults occurred when undertaking strength training. However, no such findings were found in the elderly in the group undertaking anaerobic exercise and those in the control group [28]. Specifically, those assigned to the aerobic exercise group showed increased gray matter in the frontal lobes, increased brain area responsible for motor skills, and increased efficiency of the brain's circulatory system. Positive changes also occurred in the temporal lobe [28].

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The effect on brain structure is also due to another effect. Most of the genes up-regulated after exercise are related to the function of the BDNF and IGF systems. Given the strong involvement of BDNF in neuronal excitability and synaptic function, the results seem to indicate a dominant effect of BDNF on brain area during exercise [29].

Prolonged exercise has been shown to gradually increase BDNF levels and make BDNF's effects also take place several hours after exercise. To evaluate the effect of exercise on the neurological realm, consider the effect taking place in the post-exercise period. A study of the effect of BDNF on the hippocampus after 3 weeks of exercise showed the highest BDNF concentrations immediately after the exercise period, moderate 2 weeks after the end of exercise, and it took 3 to 4 weeks for the hippocampus to return to baseline levels. In addition, taking exercise earlier seems to provide a basis for more easily inducing the body's response to exercise taken later in life. In addition, if a person is adapted to exercise, he or she will more easily obtain higher concentrations of the substance BDNF if the next workout is undertaken [19].Many studies over the past decade have shown that exercise is the strongest promoter of neurogenesis in the brain of adult humans, but also in rodents, leading to the conclusion that the process of neuronal development may contribute to the cognitive sphere observed during exercise. In addition to BDNF itself, the actions of IGF-1 and vascular endothelial growth factor (VEGF) are thought to be important for the angiogenic and neurogenic effects of exercise in the brain. Although observations of cerebral angiogenesis have been known for many years, only recent studies of the hippocampus have been linked to cognitive function. In addition, exercise-induced factors such as BDNF may also facilitate synapse function and affect other aspects categorized as neural plasticity [29].

Conclusions

Physical activity, also undertaken as a recreational activity, shows a number of positive properties in the context of the speed of the mind, improves the quality of cognitive processes, learning, and counteracts aging. Studies show that exercise increases the volume of selected parts of the brain, and has a beneficial effect on the content of BDNF and IGF proteins in the blood. Participants subjected to experiments related to undertaking physical activity showed greater efficiency in solving tests requiring mental engagement and cognitive control, demonstrating the beneficial effects of physical activity on cognitive control.

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