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Exercise Enhances the Grey Matter: An Approach to Deal with Neurodegenerative Diseases

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Abstract—*The fact that mature neurons cannot divide usually makes us assume, all the neurons used to build up an adult brain are originated during embryonic stage only. And this leads to the misbelief that no neurogenesis can occur in an adult brain. A group of scientists chose to question this assumption and brought up the term called as 'adult neurogenesis' into picture. Such production of new neurons at the later stage of life came as a boon to the patients suffering from depression, dementia and various neurodegenerative diseases like Parkinson's and Alzheimer's disease. Since the number of functional neurons fall rapidly in such conditions and patient suffers from memory loss. However, several studies talk about the role of physical exercise in aiding the production of new neurons in adult brain. Our review delves into the information about the impact of exercise on enhancement of adult neurogenesis and thereby the neuroplasticity of brain. We attempt to ascertain the clinical and functional relevance as well as the role played by the environment to enhance the cognition under the effect of exercise induced neurogenesis. We conclude that the physical and mental healths are inseparable. The comprehension of exercise-induced neurogenesis may suggest inhibitory as well as remedial opportunities in age-related cognitive disorders and depression.*

Keywords*: Neurodegenerative diseases, Grey matter, exercise, mental health.*

1. Introduction

A widely used concept, the healthy mind lives in a healthy body [1], explains that exercise is essential for mental health and physical well beings [2]. This was well established based on human healthy living experiences and facts. For the past 15 years, it has been reported repetitively that exercise intervention has helped in neurodegenerative diseases [3]. Research publications from the different fields showed physical exercise effectiveness in attenuating the neurodegenerative disease progression [4]. But it has been poorly comprehended from the biological point of view.

In healthy living, exercise is conceptualized broadly in two ways: physical and cognitive [5]. From a neurobiological point of view, how this kind of activity is an essential food for our brain is a fundamental question to boost up the mental health [6].

Hippocampal neurogenesis or simply the enhancement of grey matter of our brain has been affected structurally and functionally byphysical activities. Neurons are generated throughout life in the areas of the brain that provides the functional backbone for learning and memorizing [7]. But in neurodegenerative diseases, the aforementionedregionispoorly affected. This biological condition leads to an inferior social lifestyle and disbalance of mental health [8].

The most common neurodegenerative diseases are Alzheimer's and Parkinson's disease. The prevalence of the development of these diseases increases gradually with age, genetic makeup, and environmental factors. The conditions are progressive and irreversible in nature that results in cognitive disorders [9].

In developing countries like India, approximately 3.7 million people have Alzheimer's according to the world Alzheimer's report. Nearly 10 out of 100,000 people in India have Parkinson's disease as per the international journal of nutrition, pharmacology, and neurological diseases. Nevertheless, there is no homogenous and large epidemiological data on such diseases is available in context of India [10-11].

Animal experimentation has showed that voluntary exercise stimulates neurogenesis. Exercise has a strong effect on cell proliferation of newborn neurons as well as adult nerve cells. An activity works like a stimulus that induces precursor cells to divide, proliferate, and potentially influences the rateof neuronal growth [12][13].

A massive number of clinically significant cases motivate us to explore the area from the grassroots level. This narrative study aims to give an overview of impact of exercise on grey matter enhancement through neurobiological point of view from the existing empirical evidences.

2. Functional and clinical relevance

Exercise for grey matter enhancement has become a hot topic for many research domains, for instance, in psychology and psychiatry. Such research focuses our attention towards mental health and neurogenesis. Neurobiological concepts

suggest that neurogenesis is the core for the proper functionality of dentate gyrus. The dentate gyrus is the region of brain where sensory modalities collate to generate unique patterns and memories and play a crucial role in learning and memorizing [14].

However, there is no universal theoretical existence is yet reported about the new neuron contribution by dentate gyrus and clear understanding of hippocampal neurogenesis. Growing research evidences on neurogenesis and hippocampal functionality tell that adultneurogenesis might explicate the hippocampal operation to some extent [15].

In context to this study, clinical evidences have advised that the individual's level of exercise, whether physical or cognitive, at least antagonizes the neural impairment [16]. These findings explain that exercise can be considered relevant to some degree towards the functional contribution of neurogenesis.

3. Environment enrichment on neurogenesis management

Empirical evidence suggests that the environment has a significant effect on mental health management. Now, the question arises whether the effect is shown at the biological level or at psychological level only. Psychology explains this phenomenon as an environmental enrichment. Environmental enrichment is a brain stimulus by physical and social surroundings[17]. The brain at significant and efficient stimulating environments, shows more prominent synaptogenesis, high rate of dendrite absorbance that induces the brain functionality.

Research in neurology has evaluated that in the long run, environment enrichment influences the precursor cells. This phenomenon increases cell proliferation for an extended period. Empirical evidences depicted running wheels as a significant approach for environmental enrichment. A comparison of two distinct situations, for instance, short and long running time, might reveal the actual potential of the same. However, exercise solely does not illustrate the actual effects of environmental enrichment [18].

4. Voluntary exercise

For past century, voluntary wheel running is afrequently used method to observe an animal's particular activity and is recorded in detail for significant insights in research. We introduced the term 'voluntary exercise' for better understanding from different reader's perspectives as a part of the study[19]. Laboratory researchers observe the voluntary exercise in an animal cage, for instance, a mouse runs as much as 5-6 km per night(Voluntary exercise's experimental setup is shown in Figure 1). Generally, voluntary exercise has been seen to increase the stimulus for hippocampal neurogenesis in gnawers from young to old. Exercisecan minimize the risk of excessive reduction in neurogenesis in aged animals. It was found that exercise improves the learning capacity of aged gnawers [20].

Figure 1: Voluntary exercise setup of an albino mice in laboratory *(adapted from Penn State News)*

Numerous researches ongnawers has reported that voluntary exercise leads to an increase in brain-derived neurotrophic factor (BDNF). BDNF promotes neuronal growth. The existing studies have also suggested that cognitive engagement during exercise enhances thepopulation new neurons in an aging brain. The process of exercise derived new neuron enhancement is depicted in Figure 2.

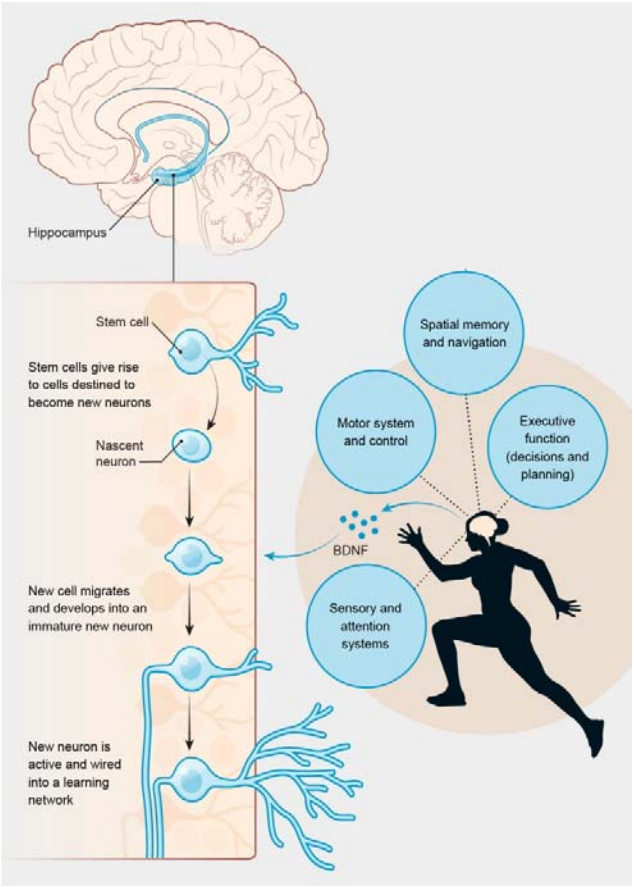

Figure 2: BDNF in the process of new neuron growth *(adapted from Scientific American Magazine)*

There are consecutive stages for grey matter development. Neuronal enhancement depends on the duration of exercise. Exercise for a prolonged period can maintain cell proliferation at advanced stages. But in absence of effective stimuli, the cumulative neurogenesis cannot be increased. These findings adequately explained that exercise is necessary for neuronal development, but it is significant only if it provides an appropriate stimulus [21].

In line with the above discussion, we report that the activity of neurons and neurotransmitters signaling has a significant effect on neurogenesis. For instance, receptor n-methyl-d-aspartate (NMDA) might be helpful in conducting a significant level of neurogenesis during exercise. NMDA dependent pathways showed the activity-dependent control of neurogenesis. The same level of effectiveness has been observed in in-vivo studies using NMDA [22].

5. Accomplishment of the grey matter enhancement

In most of the cases in animals, it is challenging to differentiate between locomotion and exercise. It was found that most of the learning approachable in a gnawer was due to its movement towards the outer world, for instance, search for food, shelter, and survival run. Such exercise needs the mental stability [23]. Sequentially, an exercise experiment in a laboratory experiment isn't an adequate justification for neurogenesis, as the activity is based on cognition [24]. An intuitive fact also supports the above phenomena, like navigation challenges in food catching birds are developed by a specific stimulus that remain only in a particular trait.

An essential interrogation arises whether this kind of connection is upheld in human beings too. Numerous epidemiological studies tried to capture the same; for instance, a study evaluated the cardiovascular phenomena of military person and correlated it with their cognition. Significant evidences confirmed that physical exercise changes the hippocampal volume [25]. But neurogenesis has not been studied yet in human beings. There is a lot of boundaries to conduct research on human beings due to safety and ethical concerns.

In acute settings, exercise led to grey matter enhancement; even a minimal amount could also increase cell proliferation [26]. In human, existing empirical evidences regarding the exercise on healthy brain mostly come from imaging technology experiments, for instance, treadmill and stair climbing exercise for three months have shown a significant enhancement of cerebral blood flow in the dentate gyrus [27]. This increase might improve neurogenesis in the hippocampus.

Another study observed that intense exercise for a year enhances the hippocampal volume up to two percent. Forty minutes of exercise training 3days per week increase the plasma concentration of neurotrophic factor in an aged person [28]. Aerobic exercise training enhanced the grey matter in the prefrontal and cortical region between 60 and 79 age persons. The same setting didn't give a positive output in nonaerobic exercise (e.g., stretching and toning) [29]. This kind of studies highly varied from the healthy to diseased person. However, it is quite challenging to propose a concrete hypothesis on brain health for human beings.

6. Conclusion

Physical and mental healths are inseparable, and vice versa, exercise improve cognition to a certain extent. From a neurobiological research point of view, exercise, as a grey matter enhancement factor, can be measured using environmental complexity and cognition assessment into a simple biological parameter. But in the same line, it is quite tricky to justify why any specific exercise is useful for a healthy brain, empirically. Future studies can assess the impacts of the frequency, duration, and intensity of various exercises on the different neurodegenerative disease to predict and provide effective exercise for grey matter management for healthy living.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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