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The Mechanism of the Effect of Exercise Training on the Morphology of Neurons in the Caudate Putamen of the Mice

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Abstract: *The purpose of this article is to study the effect of exercise training on neuronal morphology of somatosensory regions and caudate putamen in the cerebral cortex of mice. In this paper, 20 female mice of Kunming species and 20 mice were paired and randomly assigned to the exercise group and the control group. The exercise group mice performed physical activities. After 8 weeks of exercise training on the exercise treadmill, in a quiet state, tissue sections of the somatosensory area of the cerebral cortex were prepared and HE stained. The changes in tissue morphology were observed under an optical microscope and cell counts were performed. The mice were sacrificed during sexual maturity and senescence, and seven morphological parameters in the frontal cortex neurons of two types of mice were measured by cytomorphometry. The test was used to compare the differences between the parameters of different groups. To a certain extent, it can promote the increase of 12% in the nucleolus of canine pyramidal cells in the sensory area of the cerebral cortex of the white mice, and the increase in the density of the spinal cyst spines in the middle pyramidal cells of the sixth layer and the middle astrocytes of the caudal shell. The conclusion shows that proper exercise can increase the activity of neurons in the caudate putamen of the rat brain, which is beneficial to the transmission of neurons and the release of transmitters, and promotes the function of the brain.*

Keywords: *exercise training, somatosensory of cerebral cortex, neurons of caudate putamen, mouse experiment*

1. Introduction

Long-term adherence to sports can improve the adjustment ability of the nervous system and enhance the function of the nervous system. The enhancement of its function must be accompanied by morphological changes [1]. The structure of the nervous system, especially the brain, is extremely complex. The transmission of motion information will inevitably have an impact on the brain, the highest center for controlling body movement. We know that the brain tissue is composed of a huge number of neurons, which transmit, store, and integrate information through synapses as the basis of neural activity. Dendritic spines are where synapses are formed [2]. Then, in studying the effect of different load exercises on brain tissue morphology, neuron size and dendritic spine density are two very important indicators. Therefore, this experiment selected the size of neurons and dendritic spine density as test indicators to study the effects of different load swimming training on brain tissue morphology in order to expand the understanding of scientific training [3]. In this study, only from the size of neurons and dendritic spine density, to explore the physical changes caused by the morphology of the cerebral cortex sensory area and caudate putamen neurons.

Organisms during growth and development, insisting on sports can enhance the function of the nervous system. So Holschneiderand others first proposed the brain positioning theory. He believed that the cerebral cortex is divided into many independent functional areas, corresponding to various functions [4]. In the second half of the 19th century, research on the functional location of the cerebral cortex gradually formed its climax. After a lot of clinical medical practice and scientific experiments, it is found that there is a certain correspondence between the brain area and behavioral movement [5]. Subsequently, the development of technologies such as positron emission tomography and functional magnetic resonance imaging made it possible to indirectly measure the activity of intracranial neuronal groups during specific external stimuli. Olatejuet alused tracers to study the projection groups associated with mice. Under the microscope, the electron microscope was used to clearly reveal the organelle structure and anatomical structure of neuronal synapses [6]. Studies at different levels of the

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brain have greatly helped to understand the structure of the entire neural network of the brain and have a profound impact on further understanding of brain function [7]. Martinez-de-la-Torre found through research that caffeine may change the expression of memory-related proteins in hippocampal neurons through various ways to play a central role, but whether its specific process is accompanied by structural changes in hippocampal neurons And the correlation between the two is not very clear [8].

At present, long-term and intensive training methods have been valued and questioned. Previous studies have shown that long-term adherence to systematic and scientific training can effectively improve the function of various tissues and organs of the body. Both in humans and animals have been fully verified [9-10]. However, most of the research focused on the effects of exercise training on the heart, liver, bones, joints, skeletal muscles and endocrine organs. And exercise on the nervous system. We tested the consistency of brain function in morphological regions related to personality traits. As a result, it was found that in areas with morphological changes, brain functional consistency activities also changed accordingly [11]. In particular, the research on the brain and cerebrovascular aspects of the central nervous system has been involved in recent years. But the number is small, so it is of great significance to study the effect of sports training on the brain tissue morphology cortical somatosensory area, and to make more Systematic scientific training methods to reduce the occurrence of sports diseases provide scientific theoretical basis [12].

The purpose of this article is to study the effect of exercise training on the morphology of the somatosensory area and caudate putamen neurons in the cerebral cortex of mice, and to further explore the possible mechanisms and ways for exercise training to play a central role. This study uses a cortical-based morphological analysis method. From both perspectives of voxel and brain area, it is found that the mouse trait has its corresponding brain structure foundation. At the same time, the results obtained at the two scales are inconsistent, and the reasons are analyzed. It may be due to the different calculation methods of the two scales. The voxel-based morphological analysis method is based on voxel as the unit for analysis and calculation, while the brain-based morphology analysis method is based on the brain region as the unit for analysis and calculation. Through experiments, it can be found that a large number of neurons in the somatosensory area of the mouse cerebral cortex are connected to each other in a complex and orderly manner through synapses, and the incoming information is transmitted, stored and integrated, showing the complex functions of the cerebral cortex. Synapses in the cerebral cortex usually change throughout the life of a mouse, and some disappearances and new formations occur simultaneously.

2. Proposed method

2.1 The effect of exercise training on the somatosensory area of the cerebral cortex of mice

The somatic motor center of the cerebral cortex is located in the central anterior gyrus and the front of the central lobe; the somatosensory center is located in the central gyrus and the posterior of the central lobule. The cortical somatosensory area, such as the memory of the computer, can be retained for weeks or months, and can be quickly extracted. Psychologists and neuroscientists believe that damage to the cortical somatosensory area usually makes it difficult to organize new memories (anterograde amnesia), and makes it difficult to search for past memories (retrograde amnesia). The concept of memory capacity. Studies in mice have shown that neurons in the sensory area of the cortex have spatial discharge areas. These cells are called place cells. The cells that generate electricity are particularly sensitive to the direction of brain movement. The cortical somatosensory area may play the role of "cognitive map" (neural reproduction of environmental patterns). The cortical somatosensory area plays an important role in finding shortcuts and new routes in a familiar environment.

From a biological point of view, taking normal mice as the research object, starting from the theoretical concepts of animal traits, exploring the brain structure mechanism corresponding to different mouse traits, preliminary exploration of the biological basis of animal traits, subjective to the theory The empirical animal trait theory provides a biological explanation, and provides a cognitive neurological basis for the current popular animal trait measurement methods. It is of great significance to understand whether the different types of animal traits have their corresponding brain morphological basis for understanding the biological mechanism of animal traits. On this basis, we have studied the changes in the functional activity levels of brain structural regions related to animal traits. This study is of great significance for exploring the co-variation of the structure and function of animal trait-related brain regions and correcting animal disorders. Finding evidence of co-variation of brain structure and function is conducive to understanding the relationship between brain morphology and function, and

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can better integrate personality trait theory, which has important scientific significance for the development and evaluation of animal theory in the future.

The array technology was used to detect the expression of 1176 genes in the brain after 3, 7, and 28 days of subjective exercise training. The Taqman probe RT-PCR (reverse transcription and fluorescence quantitative PCR biotechnology) experiment and ribonuclease experiment were used to select for expression. Quantitative analysis of the genes in the results showed that during the process of synaptic triggering in the central nervous system, the development of presynaptic transmitter release devices and the transport of post-synaptic receptors are particularly important. Experiments on adult rats (small rats) show that exercise training induces the shaping of the somatosensory regions of the cerebral cortex of adult rats (small rats) through BDNF media, and can accelerate the shaping process. Through time-domain observation of gene expression, it has been found that adult rats can open special molecular signal channels through long-term exercise training.TheCaM-K signal system can be activated after acute exercise training or chronic exercise training. However, the MAP-K system can only be activated after a long period of exercise training.

2.2 The effect of exercise training on the neuron morphology of the caudate putamen

The effect of different load exercises on the number of cells in the somatosensory area of the brain: neurons play a role in transmitting information in nerve tissue, glial cells play a role in trophic neurons, support neurons and immunity, mainly in the central nervous system There are astrocytes, oligodendrocytes and microglia. Due to the small magnification, we cannot distinguish the types of these glial cells. Therefore, the total number of glial cells was counted. The number of neurons and glial cells was significantly reduced compared with SC group and MT group. We speculate that overloaded exercise has caused damage and even death of neurons and glial cells. It is harmful to the transmission of information and immunity of nerve tissue, which is not conducive to the function of cerebral cortex. It shows that excessive load exercise will cause cerebral ischemia and hypoxia, and damage of neurons and glial cells, thus causing central fatigue and decreased exercise ability.

The swimming activity of rats will inevitably produce a large amount of stress stimulation to the V layer macropyramid cells in the motor area of the cerebral cortex. Touch more. As the number of dendritic spines increases, the axon-spine presynaptic neuron axon terminal branches will inevitably increase. This experiment only counted the number of dendritic spines in the large pyramidal cells of the cortical layer V of the somatic motor area, but the effect caused by the increase in input and output information is not limited to this. The pyramidal cells are subject to increased input and output information and can form new dendritic spines. Therefore, we believe that exercise can cause an increase in dendritic spines of many pyramidal cells in the human cerebral cortex. Therefore, physical exercise can improve the function of the cerebral cortex and can improve people's ability to respond.

The huge number of neurons in the cerebral cortex are connected to each other through synapses in a complex and orderly manner, transmitting, storing and integrating the information passed down, showing the complex functions of the cerebral cortex. Synapses in the cerebral cortex often change during a lifetime, some disappear, and new formations occur at the same time. Among various types of synapses, the axis-dendritic synapse has the highest plasticity, and the axis-spine synapse is the most sensitive and susceptible to change. 90% of the left synapses in the cerebral cortex of mammals are axis-spine synapses]. Dendritic spines are the post-synaptic component of the axis-spine. The number of dendritic spines in the cerebral cortex increases with the development of the infant, and the development of the infant with reduced intelligence is inhibited and decreases with the aging of the individual. The increase of dendritic spines is not only the increase of contact points, but also because of the role of dendritic spines to amplify the post-synaptic potential and adjust the synaptic efficacy, which makes the integration of neurons to pass on information more complicated. The experiment also proved that the mice living in the growth and development stage with multiple exercise equipments had enlarged dendritic fields and increased dendritic spines in the cerebellar Purkinje cells. This is mainly due to an increase in physical activity, which induces an increase in the stimulation activity of the cerebral cortex motor area and cerebellar cortex. Other scholars have proved through experiments on animals in growth and development that animals living in complex environments with multiple stimuli can cause changes in the structure of the central nervous system, such as increasing the cell body of Purkinje cells in the monkey cerebellar cortex. Dendritic branching becomes complex; the nucleus of cat visual cortical neurons becomes larger and the dendritic field expands. When the kitten loses its lighting from birth, obvious morphological changes (such as developmental defects of dendritic spines) appear in the visual cortex and the hypothalamus. The above results indicate that the fine structure of the central nervous system of the body during growth and development is plastic, and the reason for the

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fine structure of the central nervous system is the change in the amount of input and output information.

3. Experiments

3.1 Experimental data set

In this paper, 20 female mice of Kunming species and 20 mice were paired and randomly assigned to the exercise group and the control group. The exercise group mice were trained according to the modified Beford exercise load standard for physical activity. The rats were sacrificed after exercise training for 8 weeks on the treadmill, weighed, and the number of red blood cells was measured; the rat brain was taken and immunohistochemical method was used to detect the nNosimmunohistochemical positive product in the somatosensory area of the cerebral cortex. Tissue sections of the cortical somatosensory area were stained with HE. The changes in tissue morphology were observed under a light microscope and cell counts were performed.

3.2 Experimental environment

All data in this experiment were processed with SPSS21.0 data processing software. Taking the average fluorescence intensity of the saline control group as the standard, compared with the other groups, the ratio was calculated again as the statistical value ($x \pm s$), and the one-way analysis of variance (ANOVA) was performed using the least significant difference method (least significant difference, LSD) make a pairwise comparison, with $P < 0.05$ as a significant difference.

3.3 Experimental procedure

(1) Experimental animals and their grouping: In both experiments, 18-20-day-old Kunming male mice were used, two paired in the same litter, and randomly assigned to the exercise group and the control group. The feeding conditions of the two rats were the same. The exercise group carried out physical activities according to plan, and the control group lived freely in the feeding tray. Ten mouse pairs were used at the beginning of the two mouse experiments, but for various reasons, the mouse brain staining that met the requirements and could be paired with the litter was finally obtained. There are 4 pairs of mice in the first batch. 5 pairs of mice in the second batch.

(2) Physical activity of the mice in the exercise group; in two experiments conducted in two years, the mourning activities of the mice in the exercise group were carried out in the first Di experiment from July to August. The mice in the exercise group performed physical activities 55 Days, the first 10 days for adaptive activities, and the next 45 days for venue sports such as running, jumping, climbing, balancing exercises and other forms of movement. When the mice stop the activity to artificially promote their movement. In the second experiment, the mice in the exercise group performed physical exercise for 44 days, the first 10 days were generalized activities, and the 34 days were mainly venue sports.

4. Discussion

4.1 Results and Comparison of Mice before and after the Experiment

General observation: In the first 4 weeks of training, the two groups of rats were quiet, docile, lively and active, and their fur was bright and neat. Starting from the fifth weekend, the rats in the experimental group were mentally burnout, binocular blind, less active and irritable. After the training, the rats in the control group were quiet, with smooth skin and binocular eyes; the rats in the experimental group were tired, mentally depressed, decreased food intake, decreased reaction, dull and dull eyes, and obvious hair loss.

(1) Weight change: as shown in Table 1, the weight of the three groups of rats increased after the experiment: the weight of the rats in the experimental group in the fourth week was statistically different from that in the control group ($P < 0.05$). Compared with the control group, the weight of the rats in the group is significantly different. It shows that although moderate exercise can control body weight, it has little effect on body weight; excessive exercise can lead to severe weight loss as shown in Figure 1.

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Table 1. Effects of different exercise loads on body weight of rats

Experiment period	Test group	Control group
1 weeks	234.23±12.22	243.43±22.83
4 weeks	224.34±13.21	256.54±21.32
8 weeks	226.27±14.45	243.28±18.47

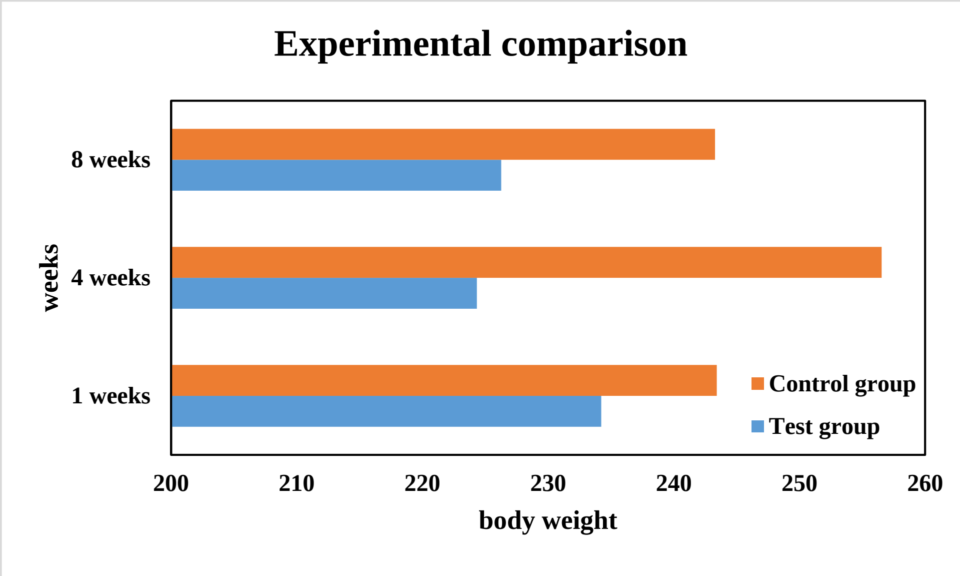

Figure 1. The effect of different exercise loads on the body weight of rats

(2) The effect of different exercise loads on the number of red blood cells in rats (Table 2). Compared with the experimental period, the number of red blood cells in the control group increased.After 8 weeks, the number of red blood cells in the experimental group decreased, and there was a significant difference compared with the control group as shown in Figure 2.

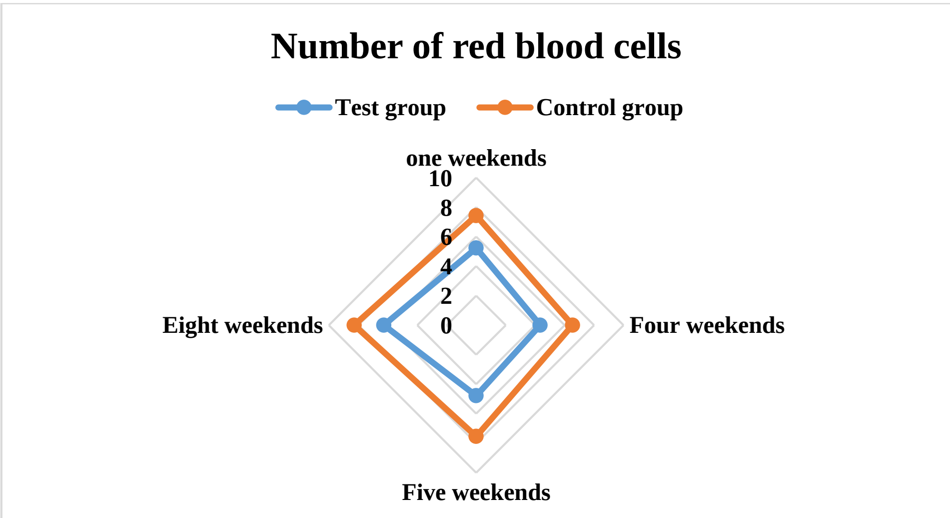

Figure 2. The number of red blood cells in rats with different exercise loads

4.2 The size of the large pyramidal cells of layer V in the sensory srea of the cerebral cortex

The lateral volume of nerve cells; on the clearer Nissl stained slides, select the neurons whose cell body and cell border is clearer and see the nucleolus for measurement. Under the light microscope 2000x oil microscope, the cell body and nucleus cross-sectional area of medium-level pyramidal cells in the sensory area layer VI and caudate putamen medium astrocytic cells were measured with a mesh eyepiece micrometer. 20 cells were measured per mouse .

(1) As shown in Table 2, due to the small nucleolus of medium neurons, it is not suitable to measure under the light microscope. Therefore, this experiment only measured the nucleolus of the large

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pyramidal cells of the V layer in the sensory cortex of the mouse. The result is The nucleoli of macropyramid cells in exercise mice increased by 17.4%, which was significant. As shown in Table 2, the exercise group increased 2.7%, the cytoplasm increased 5.7%, and the nucleus increased 1.5%. However, the differences were not significant. Sports maggot Eucalyptus kernel increased by 17.3%, the difference is very significant as shown in Figure 3.

Table 2. Comparison of the size of the large pyramidal cells of the V layer in the sensory area of the cerebral cortex of the two groups of rats

	Cut area of cells				
	Cell count	Cell body	Cytoplasm	Nucleus
Sports Group	80	170.28±23.32	31.23±3.94	78.65±17.62
Control group	80	160.21±25.41	29.82±4.36	75.43±13.82
difference		10.08	1.41	3.22
p		>0.05	>0.05	>0.05

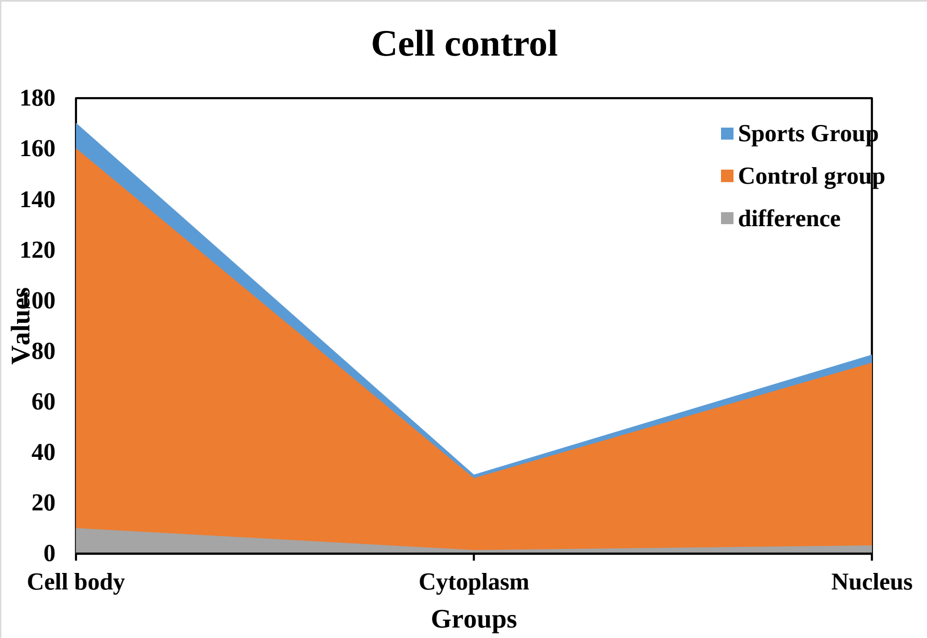

Figure 3. Cell changes in the sensory area of the cerebral cortex of the two groups of rats

5. Conclusion

In this experiment, the size of the cell was observed by the change of the cell cross-sectional area. The experimental results showed that there were no significant changes in the cell size of the large pyramidal cells in the somatosensory cortex, the medium pyramidal cells in the layer VI, and the medium astrocytes in the caudate putamen in the exercise group. The overall view of neurons should be enlarged, because neurons are composed of cell bodies and cell processes, and the multi-stimulated environment promotes the expansion of dendritic plexus of central neurons. From the nucleus, the nucleus of the middle astrocytes in the caudate putamen of the exercise group increased by 2.8%. The difference was significant, and the pyramidal cells in the V and VI layers of the cortical area were increased by 1.5% and 1.35%, respectively. The difference is not significant. From the perspective of intracellular cytoplasm. Under the light microscope, the cytoplasm of the large pyramidal cells was abundant, and the medium neurons (pyramidal cells and astrocytes were few, surrounded by a thin layer around the nucleus). The cytoplasmic reduction is 13%, which is extremely significant. The cytoplasm of the medium pyramidal cells in layer VI of the sensory area cortex is reduced by 2.3%, and the cytoplasm of large pyramidal cells in layer V is increased by 5.7%. However, the difference between the two is not significant. Only Zhongliang Liang had significant changes in the nucleus and strength of neurons, which requires further observation and research.

Morphological observation of the somatosensory area of the cerebral cortex of the injured mice in this experiment showed that the weight-loss plate group and the swimming group improved significantly, but the transfer group and the control group had similar morphology, and the

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improvement was not obvious. Similar to the previous research results of this group. The mechanism of physical fitness is that weight-loss plate training can induce the functional remodeling of the somatosensory area of the cerebral cortex of mice and promote the formation of lateral buds in axons. The cross-sectional area and diameter of muscle fibers in the weight-loss plate group were close to normal values, and the muscle atrophy in the swimming group also improved to a certain extent, but there was no statistically significant difference between the transfer group and the control group. This is consistent with the improvement of motor function, suggesting the synchronization of motor function recovery and neuromuscular function recovery after spinal cord injury in rats. In summary, from the comprehensive consideration of motor function, neuromuscular function recovery and safety after injury in rats, weight-loss treadmill exercise may be more suitable as an exercise training method for SCI rats. However, the setting of specific parameters such as exercise intensity, exercise time and exercise frequency in the training program still needs further research in subsequent experiments

Organisms during growth and development, insisting on sports can enhance the function of the nervous system. Morphological changes may include increased nucleoli of neurons in the sensory area of the cerebral cortex, increased numbers of spine spines in the sensory cortex and subcortical motor neurons, and these morphological changes have enhanced the function of the brain. Long-term adherence to physical exercise will enhance physical history, including improving brain function and promoting good morphological changes in brain neurons. This experimental study also provides a morphological basis for physical exercise to improve brain function from one aspect.

References

[1] Adeluyi, A., Guerin, L., Fisher, M. L., Galloway, A., Cole, R. D., Chan, S. S., ... & Turner, J. R. (2019) "Microglia Morphology and ProinflammatorySignaling in the Nucleus Accumbens during Nicotine Withdrawal", Science advances, 5(10), pp. eaax7031.

[2] Bechard, A. R., Cacodcar, N., King, M. A., & Lewis, M. H. (2016) "How does Environmental Enrichment Reduce Repetitive Motor Behaviors? Neuronal Activation and Dendritic Morphology in the Indirect Basal Ganglia Pathway of a Mouse Model", Behavioural brain research, 299, pp. 122-131.

[3] Wang, Z., Stefanko, D. P., Guo, Y., Toy, W. A., Petzinger, G. M., Jakowec, M. W., &Holschneider, D. P. (2016) "Evidence of Functional Brain Reorganization on the Basis of Blood flow Changes in the CAG140 Knock-in Mouse Model of Huntington's Disease", NeuroReport, 27(9), pp. 632-639.

[4] Holschneider, D. P., Guo, Y., Wang, Z., Vidal, M., &Scremin, O. U. (2019) "Positive Allosteric Modulation of Cholinergic Receptors Improves Spatial Learning after Cortical Contusion Injury in Mice", Journal of neurotrauma, 36(14), pp. 2233-2245.

[5] Rüb, U., Seidel, K., Heinsen, H., Vonsattel, J. P., den Dunnen, W. F., &Korf, H. W. (2016) "H untington's disease (HD): The Neuropathology of a Multisystem Neurodegenerative Disorder of the Human Brain", Brain Pathology, 26(6), pp. 726-740.

[6] Olateju, O. I., Spocter, M. A., Patzke, N., Ihunwo, A. O., & Manger, P. R. (2018) "Hippocampal Heurogenesis in the C57BL/6J Mice at Early Adulthood following Prenatal Alcohol Exposure", Metabolic brain disease, 33(2), pp. 397-410.

[7] Labus, J. S., Hollister, E. B., Jacobs, J., Kirbach, K., Oezguen, N., Gupta, A., ... &Savidge, T. (2017) "Differences in Gut Microbial Composition Correlate with Regional Brain Volumes in irritable bowel syndrome", Microbiome, 5(1), pp. 49.

[8] Martinez-de-la-Torre, M., Lambertos, A., Peñafiel, R., &Puelles, L. (2018) "An Exercise in brain Genoarchitectonics: Analysis of AZIN2-Lacz Expressing Neuronal Populations in the Mouse Hindbrain", Journal of neuroscience research, 96(9), pp. 1490-1517.

[9] Zhang, C., Ni, P., Liu, Y., Tian, Y., Wei, J., Xiang, B., ...&Guo, W. (2020) "GABAergicAbnormalities Associated with Sensorimotor Cortico-striatal Community Structural Deficits in ErbB4 Knockout Mice and First-episode Treatment-naïve Patients with Schizophrenia", Neuroscience Bulletin, 36(2), pp. 97-109.

[10] Wilhelm, I., Nyúl-Tóth, Á.,Suciu, M., Hermenean, A., &Krizbai, I. A. (2016) "Heterogeneity of the Blood-brain Barrier", Tissue barriers, 4(1), pp. e1143544.

[11] Ferrazzoli, D., Ortelli, P., Madeo, G., Giladi, N., Petzinger, G. M., & Frazzitta, G. (2018) "Basal Ganglia and Beyond: the Interplay between Motor and Cognitive Aspects in Parkinson's DiseaseRehabilitation", Neuroscience &Biobehavioral Reviews, 90, pp. 294-308.

[12] Avivi-Arber, L., Seltzer, Z. E., Friedel, M., Lerch, J. P.,Moayedi, M., Davis, K. D., & Sessle, B. J. (2017) "Widespread Volumetric Brain Vhanges following Tooth Loss in Female Mice", Frontiers in neuroanatomy, 10, pp. 121.