

## Application of Electroencephalography in Sports Science Research-Taking Baduanjin as an Example

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**Keywords:** Baduanjin, EEG, Motion imaging.

**Abstract.** Objective: Qigong is a unique ancient method of health care and fitness in China. Baduanjin is a part of Qigong inherited from ancient China. It consists of eight sections. Because of its ancient and graceful body movements, it has become a favorite sport of the public. EEG recorded waves reflect the regular activity of the potential synaptic processes. In order to confirm the influence of Baduanjin on athletes' EEG, it is necessary to conduct long-term follow-up of the subjects for further study. In this paper, through literature search and analysis to explore the impact of Baduanjin on the physique and EEG of athletes, and to provide basis for studying the influence of Qigong on the physical and mental function of athletes. Method: Through consulting the Chinese academic journals, PubMed and other related to Qigong, exercise athletes and exercise related to the implementation of the EEG, Qigong training on the exercise of athletes under the influence of EEG and other related data were analyzed and sorted out. Identify the intrinsic link of research objects and thus draw conclusions. Result: (1) Compared with the quiet state, different forms of exercise, whether after professional training, the load intensity of the human brain have a certain impact on EEG.(2) There are only a few studies about motor EEG in terms of the number of articles published. Among them, there are only 5 articles in 2014 and about 2 articles a year before 2014. There is only one published volume per year since 2014, which shows that there is still a lack of research on the field of motor EEG. The vast majority of research institutions are universities, among them, Army Medical University issued a large number of papers, a few in the hospital; its research level involved is mostly engineering technology and Foundation and application basis. Its disciplines are mainly biomedical engineering, computer software and computer applications, etc .Most articles published in the university or biomedical journals. The research hotspot of motor EEG is not focused on "motor EEG", but analyzes the EEG through wavelet transform, feature extraction and so on from the perspective of brain-computer interface, including the crossover study of motor imagination. Conclusion: (1) Baduanjin exercises can not only improve the athletes' flexibility, sensitivity and muscle strength, but also relax the nervous nervous system and eliminate the nervous tension. (2) The research focuses mainly on the brain-computer interface and the movement imagination. However, the research on EEG in exercise is insufficiently concerned. One reason is that predecessors have proved that appearance and exercise have the same effect and motion imaging is easier. Second, The related researches of brain-computer interface are more mature

### Qigong, Baduanjin Overview

Qigong[1] is a form of exercise developed by China for thousands of years to prevent diseases and promote physical and mental health.

Although many treatments claim the role of Qigong, the basic concepts and principles of the whole are still not familiar with the treatment of Westerners. Qigong is based on three main principles to coordinate breathing, body and mind

Qigong consists of two Chinese characters. Qi refers to air, while Gong refers to skill or art. Qigong is translated as a breathing exercise in a foreign country. However, in the field of Chinese medicine, the term is used to indicate an energy or motivation to maintain and nourish life. Therefore, Qi is also called life energy. This important energy and circulation circulates through

small channels to all parts of the body. When the system is rich and free flowing, the human body has a relative health status. If Qi is poor or the flow is blocked, the human body will get sick. If this important energy disappears, the human body will die. In conclusion, Qigong can be more fully translated into a learning skill or art that can release, enhance and guide this important energy to cure diseases and promote the health of people at all levels. This skill or art is acquired through specific routine exercises, ongoing and long-term practices. Exercise is based on three main principles: (1) To coordinate or adjust breathing (2) To coordinate or adjust one's posture and body movements (3) To coordinate or adjust one's mind.

Baduanjin [2] is one of the forms of Qigong exercises in China, with a history of more than 1,000 years. It is characterized by an interaction between body posture and movement, mind and respiratory movements. Baduanjin is relatively easy to learn and has less physical and cognitive needs because it contains only 8 simple exercises which are created based on Chinese medicine theory. Its emphasis is to release internal body energy in order to produce various health benefits. Since the establishment of Chinese Health Qigong Association in 2004, the traditional Chinese martial arts techniques, including different forms of Qigong (such as TaiChi, Baduanjin and Wuqinxi) have become more and more popular all over the world.

A Baduanjin meta-analysis[3] shows that Baduanjin practice helps to improve the quality of life, sleep quality, balance, grip strength, trunk flexibility, systolic and diastolic blood pressure and resting heart rate. In order to confirm the influence of Baduanjin on leg strength, cardiopulmonary endurance and lung function (such as lung function), it is necessary to conduct long-term follow-up of practitioners for further study.

## EEG Overview

### Overview

**EEG Concept.** Neurons in the cerebral cortex produce a sustained rhythmic potential change without any significant external stimuli, even asleep, which is called spontaneous EEG activity. With some instruments to guide these weak brain electrical activity, and enlarged to 1 million times the tracing on the paper, into a bioelectric graph, is the EEG [4]. EEG is basically composed of frequency and amplitude, normal EEG is divided into four basic waveforms according to different frequencies:  $\alpha$  wave,  $\beta$  wave,  $\theta$  wave,  $\delta$  wave. The classification shown in Table 1.

Table 1. Brain wave classification.

Band	Frequency	Recording	Research related
$\alpha$	about8-12Hz	Awake relaxed state	Cognitive activity
$\beta$	18 — 30Hz	When the individual changes	Stimulate integration
$\theta$	4 — 8Hz	Happy activities after the suspension	Attention and hypnosis
$\delta$	0.5 — 4Hz	Extremely tired and lethargic or under anesthesia	Nervous tissue produces abnormal neural activity

**EEG Formation Mechanism.** Electric activity produced by nerve cells in the brain can reach the surface of the scalp. In 1929 Hans Berger discovered EEG by recording electrodes in the human scalp and recording EEG activity, providing a noninvasive method of recording scalp electrical activity. The electrode mounted on the scalp transmits the signal of the electrode into the amplifier to amplify the weak potential.

The waves recorded by EEG reflect the regular activity of the potential synaptic processes. This rhythmicity is thought to reflect the regular activity of a collection of large neurons driven by thalamic pacemaker cells, yet this explanation has been questioned. Different cortical areas produce a variety of different rhythms. The Fourier transform is usually used to decompose the signal into frequency bands and calculate the amplitude of each frequency band. The increasing of  $\alpha$ -wave activity is often the goal of biofeedback training, helping to improve athletic performance by increasing the subject's ability to stay focused to eliminate distracted stimuli, thoughts or feelings.

**EEG History of the Study.** In 1857, R. Caton, a young British physiologist, recorded EEG activity in rabbit and monkey brains and published an essay about the phenomenon of gray matter electricity but was not caused attention.

Fifteen years later, A. Beck's paper of EEG was published again setting off an upsurge in the study of EEG. It was not until 1924 that German psychiatrist H. Berger realized that the electric eel had sent out electrical signals and thought that the same phenomenon would inevitably happen to human beings. The human brain waves was really recorded and the human EEG was born. In 1947, the first International EEG Society held in London, since then, the EEG research institutions and related magazines have appeared one after another.

In China, the post-liberation EEG clinical and research work has made great progress, the report and the number of EEG continued to increase.

Nanjing Psychiatric Hospital first introduced the EEG instrument, and in 1951 the first EEG of an epileptic patient was delineated in China. Then National provinces and cities some hospitals have established the EEG examination room, EEG training courses and more and more professionals, EEG related conferences and magazines came into being.

### **EEG in the Field of Exercise Research and Application**

As an effective tool for indirect measurement of neural activity, EEG and its related event-related potentials (ERPs) are widely used in neuroscience, cognitive science, cognitive psychology, neural Scientific and psychophysical research. Its high temporal resolution can detect millisecond potential changes, but spatial resolution is relatively poor.

The use of electroencephalography in athletic practice to study athletes' advanced neural activity started in the early 1950s. Some scholars in the former Soviet Union first analyzed the electroencephalogram (EEG) of athletes when they were in the formation of motor skills, fatigue, or when the "pole" appearing. The research mainly analyzed the characteristics of brain function of athletes in different sports situations by means of the changes of the kinds of EEG waveforms with different frequency bands.

Research by Yang Maonan et al. showed that the change of  $\delta$ -wave and  $\theta$ -wave indices reflects the fatigue state of athletes training. Zhang Zhenmin et al. learned the influence of different exercise load on the central nervous system by studying the characteristics of brain waves continuously recorded by 14 famous women volleyball players in China under different load power cycling.

The changes of the  $\alpha$ -wave and  $\beta$ -wave indices reflect the concentration of attention of athletes during training and competition. Zhang Zhenmin found that athletes recalled a rhythm motor inhibition, the degree of inhibition related to the training level, by observing cyclists "action memories" on the impact of brain waves, which could be used to infer the extent to which athletes focus attention on the playing field, or to say, the degree of training of athletes. The change of  $\alpha$ -wave index reflects the difference of age and sex of athletes. According to the study of Huang Denghui, The  $\alpha$ -index,  $\alpha$ -frequency and  $\alpha$ -string of athletes have reached the adult level longer than adolescence and no correlation with age, The average and maximum amplitude of  $\alpha$  wave decreased with age, showing a moderate negative correlation. The quiet period then increases with age, showing a low positive correlation. And found that female athletes  $\alpha$  index,  $\alpha$  frequency,  $\alpha$  string eyes open,  $\alpha$  wave inhibition rate similar to that of male athletes. The average and maximum amplitude of female athletes increased significantly, indicating that their cerebral neurons have a greater metabolic intensity. Female athletes quiet longer than men (except for the 18-year-old group), suggesting that the protection of the brain stronger. The decrease or disappearance of  $\alpha$ -wave rhythm can be used as an important index for the diagnosis of brain injury in athletes. Chen Jinhuan found that, compared with normal EEG,  $\alpha$  wave significantly reduced and the slow wave significantly increased. Shi Zhijie found that  $\alpha$ -wave generalization rate was 57% by observing the EEG of the workers with no clinical symptoms, anomalous rate was 33% to 38%, and spikes and waves appeared in individual players. Most of these players after 1 to 4 years of rest or anti-epileptic treatment, EEG returned to normal. The application of EEG and EEG technology provides very valuable physiological indexes for sports training and scientific selection of athletes.

## Exercise and EEG

Qin Susong[5,6] found that the research results of athletes' EEG in the field of sports in our country clarified that EEG of juvenile athletes had the characteristics of adult electroencephalogram and can be used in projects with strong skills. Athletes increased excitability in the nervous system during exercise and had rapid recovery after exercise, which indicated athletes' adaptability. After exercise fatigue,  $\alpha$ -wave index increased significantly, especially in the area of right main brain movement. After over-training  $\alpha$  index decreased significantly, slow wave index increased with the amplitude increasing. Boxing, football and other sports can easily lead to brain trauma and electroencephalogram abnormalities, repeated injuries may cause permanent loss of nerve cells. The changes of EEG after exercise with different intensities of speed athletes and endurance athletes (each 10) in Beijing Sport University were tested which showed that from the EEG point of view, different types of athletes of different intensities of different tolerance to exercise.

Zhou Jing collected the EEG signal to analysis when athletes perform resting, motor imagination, visual imagination and mental tasks[7] and found that EEG characteristics did not to the professional level of sports training under resting and mental arithmetic tasks. While when completing the tasks of motor imagination and visual imagination, subjects showed a special mode of EEG activity change. We can grasp the law of EEG activity and development of athletes under professional sports training and inspire educators to use the results of brain science research in educational practice. By designing targeted teaching and learning activities and training specific areas of the brain, improve brain function in specific areas, develop brain potential, and train and select specialists.

In addition, the influence of Qigong on the automated processing of middle-aged and elderly women showed that the amplitude of MMN in Qigong group was significantly higher than that of the control group in quiet state. After Qigong exercised, the amplitude of MMN also increased significantly compared with the quiet state. Which indicated that Qigong could improve the ability of middle-aged and old-aged women to process their brain automatically, resist environmental interference and promote mental health.

The research on the characteristics of EEG changes during the appearance of athletes in different elite athletes showed that, the activities of senior nervous activities in various brain regions of track and field, badminton, archery and shooting athletes were roughly similar, with no significant difference in the quiet state. However, it was found that the activation of the brain was different between different locations in terms of motor appearance and mental state. The neurological activity of the brain in a quiet state between experts and novices was similar, left and right hemispheres in the process of motor representation did not appear brain side advantage. Differences between experts and novices appear in the left frontal area of the brain, left central area, left top area.

Yang Yuanyuan [8] indicated there was no significant difference in EEG activity between presentation and exercise, executive and preparation tasks, The athlete carries on the appearance training, can produce the same EEG activity effect in the athlete's brain before exercise, which is also good for the athletes to master the exercise skill and improve the training effect of the athlete's exercise.

Zou Beibei [9] found that in addition to  $\alpha$  wave, the EEG in other frequency bands also showed a tendency of rising after a long period of exercise in hot and humid environment, and the fatigue of central nervous system could not be judged by the change of  $\alpha$  wave only. In addition, comparing the awakening level with the relative energy of  $\alpha$  before and after exercise can determine the body's fatigue. Advantages Brain area has better anti-fatigue ability than non-area brain area. in this environment. Changes in brain electrical activity relate to heart rate, core temperature, normal temperature and other physiological changes, respectively,  $\theta$  wave relates to HR,  $\beta$  relates to body temperature. Long-term occurrence of exercise-induced fatigue in hot and humid environment is a common result of the interaction between somatic fatigue and brain fatigue.

The population of China's elderly population now exceeds more than 180 million, increasing at an annual rate of nearly 8 million. The aging situation [10] is worsening. Stroke is a sudden cerebral

blood circulation disorder that is one of the biggest threats to the health of the elderly. Most patients with hemiplegia or limb movement dysfunction, life is extremely painful and inconvenient, which is a heavy burden to the family and the community.

How to help these patients in effective rehabilitation is an urgent problem to be solved in today's society and is a hot research topic in many interdisciplinary fields such as artificial intelligence and rehabilitation engineering. Brain-Computer Interface (BCI) is a communication control system that is independent of the normal output pathways of the peripheral nerves and muscles of the brain. Motor Imagery (MI) can promote repair of injured motor conduction pathways or reconstruction and make part of the dormant synaptic wake up and play a compensatory role. Therefore, the BCI fusion imaging task (MI-BCI) can induce and promote neuronal plasticity of the brain, which can stimulate the patient's active motivation, and to achieve the active rehabilitation of patients with hemiplegia found.

### **Summary**

In the 1990s, Zhang Zhenmin and Yang Xirang et al. studied the actual operation of EEG about athletes. Nowadays, except a few master's graduates' thesis, most studies are motor imagination, brain-computer interface to promote rehabilitation and psychological cognition research, such as Tianjin University, Shanghai University of Sport Zhou Chenglin, etc. Most of the research levels involved were engineering technology, foundation and application, and its disciplines mainly include biomedical engineering, computer software and computer applications. However, few studies have been conducted on the EEG effects of exercise or exercise on the human body. This article attempts to analyze the related researches of Baduanjin and EEG to explore the changes of EEG during Qigong exercise, and to explore its research hotspot and future development trend.

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