A New Aerobics Training Method Based on Electroencephalogram

Xuehong Sun

ABSTRACT

Aerobics is a sport that can show continuous, complex and high-intensity complete movements under the accompaniment of music. It is a popular sport popular with the masses. At present, our country has made certain achievements in the aerobics competition project, and all the aerobics competitions both at home and abroad have made certain progress. In this process, the daily training work of the Aerobics athletes is very important, it is the basic way to improve the comprehensive quality of the athletes. In view of the current development of aerobics training, the brain wave technology is applied in this research to achieve the visualization, real-time detection and real-time feedback of aerobics training results. Combined with traditional research methods to improve aerobics training skills, an experiment is designed to verify that the aerobics training system based on EEG can improve athletes' concentration degree of aerobics training more effectively. The experimental results of this study provide some reference and reference for the research and development of the related fields in the future.

Key Words: Electroencephalogram (EEG), Aerobics Training System, Bluetooth Communication Module, EEG Aerobic Data Processing

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Introduction

Bioelectricity is one of the basic characteristics of life activities and brain wave is one of the many bioelectricity categories. The bioelectrical signals generated in the brain when humans are thinking are brain waves, which can be measured and studied by sensors placed on the scalp. Since the last century, people's understanding of the brain has been expanded and deepened through the study of brainwave signals (Porto *et al.,* 2015). In the future, if we can extract the characteristics of brainwave parameters of different people, we will be able to apply it in security (which will achieve higher security than the current methods such as fingerprint, sound ray and iris scan); the brainwave application technology can also serve disabled people, such as the brainwave-controlled smart wheelchair, etc., which requires only one thought to change the wheelchair's posture (Bowden *et al.,* 2011). Aerobics, as an international competitive sport, has been developing for many years. The innovative aerobics moves, diversified types, fluency, music style, cooperation with companions and athletic performance and appeal make the whole set of movements very artistic. Through these movements, the athletes give audience joy and pleasure, which is also a charm of the aerobics sport. The athletes' expressiveness consists of the artistic score and execution score, which means that two thirds of the scores in the aerobics competition are closely related to expressiveness (Devine *et al.,* 2016). So, when the difficulty score is the same, the expressiveness of an athlete directly determines the final score. The aerobics athletes in China often lack the explosive power

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when doing performance in competitions and the ability to infect and attract the audience.

When facing the referee and the audience, they cannot well convey their own feelings and musical connotations nor can they demonstrate enough passion. Based on the knowledge of brain waves, this paper designs and develops a new type of aerobics training method based on brain waves, analyses the components of aerobics expression and develops appropriate and specific training strategies for aerobics, which provides specific reference for improving athletes' expressiveness.

An Overview of Brain Waves

Current research status

EEG was discovered by a German scientist Hans Berger in 1929. It is mainly applied in diagnosis of diseases in clinical medicine, research on human brain functions under laboratory conditions, and EEG related diseases monitoring and treatment. In 1991, Wolpe *et al.,* proposed a new concept - EEG control technology, that is, establishing a communication and control method connecting the brain and the external environment so as to use brain signals to control engines and computers. Compared with voice control and manual control, it is more real-time but also more difficult to implement (Bowden *et al.,* 2011).

At present, EEG control technology has a broad prospect for research and application: pilots use EEG in the flight process to control the flight of the aircraft to reduce inconvenience in hand operations; and surgeons use EEG to control the equipment that monitor patients during surgery to save time. It can also be used to provide people with a new way of entertainment – controlling games with mind to free both hands. Now there are already many game products like this available, with great market potential (Arakawa *et al.,* 2015). EEG signals can also be combined with other physiological signals to develop physiological monitoring devices to monitor the mental state and psychological state of users. For example, drivers can monitor their degree of fatigue while driving and receive real-time feedbacks so as to reduce traffic accidents. In 2009, Mattel developed a small ball toy Mindflex by using the device from NeuroSky, which became the toy with top sales in the year. NeuroSky developed the first EEG signal device with a sales price of less than 1000 USD and provided the interface for secondary development, which laid the foundation for the extensive application of EEG (Castellano *et al.,* 2017). In recent years, the researches on EEG and aerobics have mainly focused on pilots and child aerobics, and few has been conducted on sports training. This paper mainly focuses on studying a new EEG-based aerobics training method.

Characteristics of EEG

Human brain is composed of tens of thousands of neurons, and brain waves are the electrical signals generated by the activity among these neurons. Some connections between these neurons are excited, and some inhibited and thinking activities are just a reflection of the connections between these neurons. Neurons in the brain receive signals from other ones, which generate brain waves when the energy accumulation of these signals exceeds a certain threshold (Chin *et al.,* 2014). In order to detect brain waves, electrodes are usually placed on the human scalp, and then related equipment are used to collect and process the brain waves. Brain waves are a kind of biological signals generated by the brain. Different kinds of thinking activities produce different types and frequencies of brainwave signals. When people are in different emotional states, doing different aerobics and under different mental states, brainwaves also change accordingly (Weinstein *et al.,* 2016). Through Fourier transform, the brain waves can be divided into the categories listed in Table 1 by frequency range:

Table 1. Frequency range of brain wave

Category	Delta wave	Theta wave	Alpha wave	Beta wave	Gamma wave
Frequency Range	<4Hz	4~8 Hz	8~12 Hz	12~30 Hz	>30Hz

Delta waves are usually active in adults during deep sleep, in infants and young children and mentally immature people.

Theta waves are more active when adults feel sleepy or are in meditation, and this wave band is also a major component of the brain waves of adolescents.

Alpha waves are more obvious when people are in deep meditation or quiet thinking. It mainly reflects the brain wave state when people are not interfered by the outside world.

Beta waves mainly reflect a person's mental state and are more obvious when people are excited, emotional or doing intensive aerobic exercise.

Gamma waves mainly reflect the deep state of mind, such as memory, impressions and so on.

Analysis of EEG signal acquisition methods

EEG signals are acquired by the acquisition system using physiological sensors, and then feature-processed and de-noised, etc. to become the signals for computer analysis and processing. Scalp EEG is adopted more often. Currently the most widely applied method is the international standard 10/20 system electrode placement method, which requires the electrode be placed in specific positions of the human brain. EEG lead methods are divided into unipolar lead and bipolar lead methods. The unipolar lead method is to place the movable electrode on the scalp, while the indifferent electrode placed on the earlobe (Smart and Steele, 2010). The bipolar lead method uses two movable electrodes on the scalp and no indifferent electrode. This method acquires the difference between the two electrode signals, thus reducing interference. Brain computer interface (BCD) is a kind of software and hardware system that uses brain waves to communicate with the surrounding environment. It collects human's EEG signals through sensors, and then processes the signals accordingly and converts them into control signals that control the external devices. The device was originally designed to help patients recover their neurological or muscular impairments, communicate with the outside world and restore their autonomous actions in order to relieve the patients' pain and family burden (Su and Roh, 2016). The brain machine interface system diagram is shown in Figure 1.

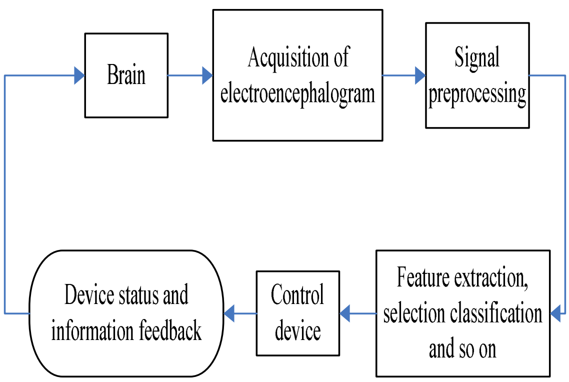

Figure 1. Brain-computer interface system diagram

Analysis of Aerobics Training Methods

All aerobics athletes attach great importance to the training of difficult movements in their daily exercise. Before such training, they must have some basis. The training of difficult movement mainly consists of three key stages – preparation, learning and movement practice (Li *et al.,* 2013).

Preparation stage

According to the systematic, gradual and all-round development requirements for sports, in the preparation stage, the coach needs to set clear goals and requirements for athletes and get them fully ready for the next stage. This includes training in three aspects:

(1) The coach and the athletes should initially determine and select the difficult movements together: the coach should first understand the most basic situation of athletes, such as physical ability and training level and must take into account whether it is possible for the athletes to master the movements and know how to select and determine the difficult movement. In the movement training, the coach needs to allow the athletes to fully recognize the purpose of this movement training and understand the whole process flow.

(2) Athletes need to know the structure, specifications, and techniques of the movements. How well the athletes know about the technical specifications reflects the depth and breadth of their understanding of the movements. The coach should carefully analyse each and every difficult movement, and at the same time adopt certain technical means to enhance the athletes' appearance awareness and make them have more in-depth understanding of different difficult movements. This is very important to improving their training effects.

(3) Athletes should carefully develop learning schedules and choose the methods to practice various difficult movements. Difficult movements in aerobics are diversified both horizontally and vertically. The coach should first develop appropriate learning schedules for the athletes, and then train them from the most fundamental to more advanced levels. To determine and select the appropriate method, the coaches need to clearly understand the specifications, structures and techniques of the movements. They should organize teaching activities and training methods and steps using pedagogy, psychology and formation rules of motor skills. Training methods need to be effective, clear and reasonable and must focus on the key and difficult points in training (Schmolesky *et al.,* 2013).

(4) Improving the physical quality of athletes: training of difficult movements is an

extremely complicated and systematic process, affected by many factors. In the process of learning, there will be circumstances where athletes cannot understand or well grasp the movements. Some of these problems are due to lack of physical fitness. Quality is a basic condition, but it can affect the entire development of athletes. Therefore, the athlete must have good physical quality before the training of difficult movements. Physical training is also an important part that every athlete must experience.

Learning stage

This stage is a concrete and crucial implementation stage of the difficult movement training to facilitate the learning of the difficult movements. It can improve the economy, effectiveness and predictability of the training process, and is more scientific and reasonable. In the training process, the coaches need to select appropriate and reasonable training methods, clearly understand the teaching steps for the difficult movements, give timely feedbacks for technical analysis and diagnosis and employ safeguards and other means to enhance quality training and improve the athletes' skills and physical fitness. In this way, the training process will become a purposeful, planned and directional controlled process and can finally achieve the training objectives.

Practice stage

The design of difficult movements in aerobics depends on the coach's artistic aesthetics and personal style. Such training must transition from the basic training stage to the practical stage, because these movements will have no meaning if they cannot be incorporated into practice. These movements must be highly artistic and enjoyable. A general set of difficult movements include lift, transition and other moves. When different movements are combined, they form a complete set of aerobics movements.

Design and Implementation of Aerobics Training System Based on Brain Waves

System architecture

The EEG-based aerobics training system is a large information system, which involves the whole process from information acquisition, transmission, integration to storage. Building a system architecture that is open, expandable, scalable, and dynamically adaptable to business needs is the key to the system implementation. The logic architecture of the system is shown in Figure 2.

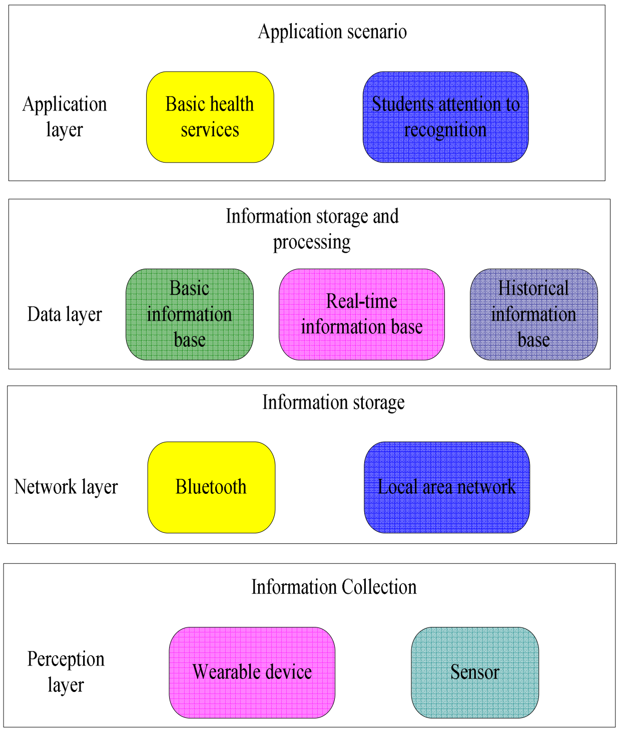

Figure 2. The logical structure of aerobics training system based on brain wave

The EEG-based aerobics training system is divided into four levels, namely the perception layer, network layer, data layer and application layer.

The perception layer consists of wearable devices worn by students, EEG and body temperature and other sensors, used to achieve the acquisition of various information. The network layer consists of the school LAN and Bluetooth, used to achieve data transmission between the perception layer and the server.

The data layer consists of a database management system and an application support platform, designed to achieve data storage and processing, and provide queries and calls for related applications.

The application layer is responsible for developing a variety of applications, visualizing the data and displaying them to the users through the physiological information feedback interface.

The main functions of the system include user login module, Bluetooth communication module, EEG attention and meditation drawing, EEG aerobic data processing and EEG historical data module. Block diagram of aerobics training system based on brain waves as shown in figure 3.

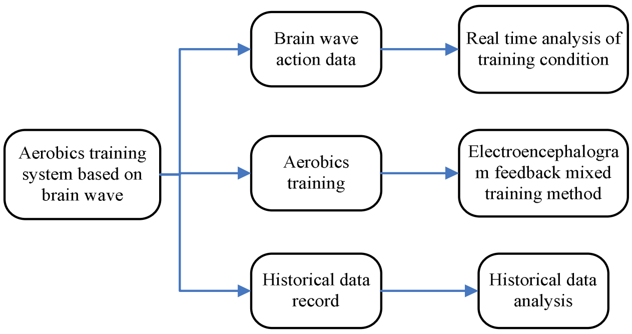

Figure 3. Block diagram of aerobics training system based on brain waves

The aerobics EEG feedback training consists of two parts: mobile and desktop applications provided by the aerobics training system and equipment; historical data records, which use the data stored in the database during training. At this time, there is no need to connect to the device. During data analysis, this study uses both Excel and SPSS data analysis software to complete the data processing and analysis.

EEG-feedback-based real-time training

(1) Implementation of device connection

The device is connected to the specified port by the ThinkGearWrapper method. Relevant connection strings are sent to the EEG headset, and the strings sent by the headset are analysed. If it is the eSense string, it means the computer is receiving the data about the aerobics attention and meditation degrees; if it is the eegPower string, the computer is receiving the power information of the device. If the device cannot be connected, check whether the headset is worn properly, whether the metal contact is in good contact with the ear and whether the Bluetooth module is communicating normally and within the effective communication range.

This page uses the ComboBox to select the baud rate and port number. A Button is designed to connect, disconnect, start and finish the recording device, and there is also a TextBox to store all EEG information, including brain attention and meditation degrees, battery power information, device-to-skin contact information, Delta and Alpha values, and blink intensity. These are listed to ensure that the device can accurately collect the signals required by this study and prevent the signals from being so weak as to affect the accuracy of data. The function block diagram is shown in Figure 4:

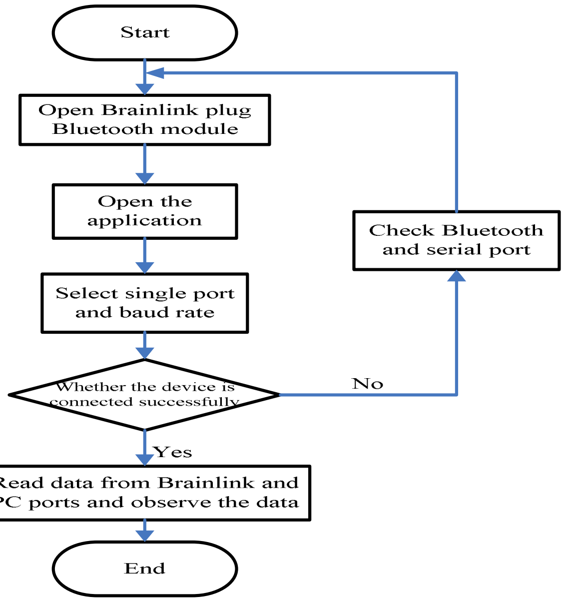

Figure 4. Device connection flow chart

Implementation of the textbox component: by using the BeginInvoke method and establishing a new thread, this study achieves the transmission of Brainlink data. By sending a thread, the data display in the textbox can be updated in real time. Before the end of the asynchronous call, the results are returned to the textbox to make sure that the program does not get stuck and can give real-time feedbacks; at the same time, check whether the string in the textbox is redundant.

After entering the system, select EEG aerobics data – connect the EEG device in the drop-down box of the menu. The values in the figure stand for: degree of attention and meditation, battery power, headset contact, raw EEG Delta values and Brainlink index values.

(2) Real-time data analysis

The system uses the EEG visual feedback technology, so the designed feedback interface should not be too complicated. In this way, the users will not have to interact too much with the computer or be disrupted by the diversified interfaces to result in inaccurate measurement results. Therefore, the design of the real-time interface should be simple and mainly present the changes in the attention and meditation degrees of brain waves. The purpose of this module is to draw curves reflecting the real-time dynamic changes, perform basic data analysis and extract features. The EEG real-time data analysis mainly includes the presentation of the brain waves reflecting the attention to aerobics and meditation; and the real-time efficiency analysis module needs to be connected to the EEG

Brainlink. After verification of different degrees of meditation and attention, it is found that the calculation methods used in this study can effectively reflect the uses' degrees of aerobics. Some calculation methods are presented as formulas (1) and (2).

Productivity=num_attention[i]* num_meditation[i]; (1)

prod_med_m_att+=med_m_att[i] (2)

The real-time analysis is as follows table 2: Length stands for all the aerobics points. In order to avoid occasionality, select each adjacent 10 points to calculate the averages of Meditation and Attention.

Table 2. The relationship between the mean and the state of thinking and the training of aerobics

Mean	Relaxation level	Concentration
80~100	Completely relaxed	Completely concentrated
60~80	Relax	concentrated
40~60	Relax a bit	A little concentrated
20~40	normal	A little distracted
0~20	tired	Distracted

The work efficiency changes are shown in Table 3, which are related to the attention to aerobics and the relaxation of mind. In this study, the Attention*Meditation value is used as criterion 1, and the difference between the average values of Attention and Meditation over a period of time as criterion 2. When the respective averages of the two are within certain ranges, the feedback page shows different colour changes.

This study uses various numerical changes and text descriptions to present the different attention to aerobics. These numerical and text descriptions vary with the changes in the athletes' attention. The work efficiency value is related to both attention and meditation. Only when the user is relaxed in mind and the aerobics movement training value is within a certain range will the work efficiency be high.

Table 3. The relationship between work efficiency and attention and mdition

Attention*Medition	Attention-Medition	Work Efficiency
>2500	No requirement	High
>1400 and <2500	<40	Medium
>800 and <1400	No requirement	Low
>0 and <800	No requirement	Quite low

Conclusions

The main work done in this study is as follows: The traditional aerobics training conducted in-depth research work, and comparative analysis of the selection of easy to implement, significant effect of brain wave training method as the research object, and summed up for aerobics training methods . A training system based on brainwave is developed. The real-time feedback of aerobics training is realized through the feature extraction of EEG signals. The collected signals are clear and stable, the interface is simple and easy to understand, and the relevant data are recorded for subsequent analysis historical data visualization, system performance and stability. For aerobics athletes design a reasonable training method, the use of this system for EEG feedback training, the training results are presented to the user. In this paper, aerobics training is creatively combined with the method of EEG feedback, and experimental groups are designed to analyze the positive effects of EEG feedback training on aerobics training. The method of combining EEG feedback with aerobics training test is more complete and credible to achieve aerobics training.

References

Arakawa T, Kobayashi M, Matsuo N. Development of aromatic image map and evaluation of aromatic oil based on brain wave. Journal of Biosciences & Medicines 2015; 3(5): 36-48.

Bowden D, Gaudry C, Gruzelier J. A comparative randomised controlled trial of the effects of brain wave vibration yoga, iyengar yoga and mindfulness training on mood and well-being. Neuroscience Letters 2011; 500(1–4): e24-e25.

Castellano CA, Paquet N, Dionne IJ, Imbeault H, Langlois F, Croteau E. A 3-month aerobic training program improves brain energy metabolism in mild alzheimer's disease: preliminary results from a neuroimaging study. Journal of Alzheimers Disease 2017; 56(4): 1459-68.

Chin LM, Chan L, Woolstenhulme JG, Christensen EJ, Shenouda CN, Keyser RE. Improved cardiorespiratory fitness with aerobic exercise training in individuals with traumatic brain injury. Journal of Head Trauma Rehabilitation 2014; 30(6): 382-90.

Devine JM, Wong B, Gervino E, Pascual-Leone A, Alexander MP. Independent, community-based aerobic exercise training for people with moderate-to-severe traumatic brain injury. Archives of Physical Medicine & Rehabilitation 2016; 97(8): 1392-97.

Li X, Yuan QJ, Wang L. Effects of Free Radical Mediator NF-κB Expression Change on Brain in Aging Mice after Various Load Aerobic Training. In Advanced Materials Research Trans Tech Publications, 2013; 749: 215-20.

Henrique de Gobbi Porto F, Martins Novaes Coutinho A, Lucia de Sá Pinto A, Gualano B, Luís de Souza Duran F, Prando S, Rachel Ono C, Spíndola L, Okada de Oliveira M, Helena

Figuerêdo do Vale P, Nitrini R. Effects of aerobic training on cognition and brain glucose metabolism in subjects with mild cognitive impairment. Journal of Alzheimer's Disease 2015;46(3):747-60.

Schmolesky MT, Webb DL, Hansen RA. The effects of aerobic exercise intensity and duration on levels of brain-derived neurotrophic factor in healthy men. Journal of Sports Science & Medicine 2013; 12(3): 502-11.

Smart NA, Steele M. Systematic review of the effect of aerobic and resistance exercise training on systemic brain natriuretic peptide (bnp) and n-terminal bnp expression in heart failure patients. International Journal of Cardiology 2010; 140(3): 260-65.

Su YC, Roh HT. Effects of aerobic exercise training on peripheral brain-derived neurotrophicfactor and eotaxin-1 levels in obese young men. Journal of Physical Therapy Science 2016; 28(4): 1355-58.

Weinstein AA, Chin LM, Collins J, Goel D, Keyser RE, Chan L. Effect of aerobic exercise training on mood in people with traumatic brain injury: a pilot study. Journal of Head Trauma Rehabilitation 2016; 32(3): E49-56.

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