ANALYSIS OF BIOLO ARTIFICIAL NEURAL NETWORK IN PREDICTION OF AEROBIC EXERCISE INDEX BASED ON ALGORITHM

ANÁLISE DE REDE NEURAL ARTIFICIAL NA PREDIÇÃO DO ÍNDICE DE EXERCÍCIO AERÓBIO BASEADA EM ALGORÍTIMO

ANÁLISIS DE RED NEURONAL ARTIFICIAL EN LA PREDICCIÓN DEL ÍNDICE DE EJERCICIO AERÓBICO

ORIGINAL ARTICLE
ARTIGO ORIGINAL
ARTÍCULO ORIGINAL

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ABSTRACT

Objective: To study the relationship between aerobic activity and cardiac autonomic nerve activity by artificial neural network algorithm and biological image fusion; because of the artificial neural network model (ANN) problems, biological image processing technology is introduced based on ANN. Methods: An Ann under biological image intelligence algorithm is proposed, a classifier suitable for electrocardiograph (ECG) screening is designed, and an ECG signal screening system is successfully established. Moreover, the data set of normal recovered ECG signals of the subjects during the experimental period is constructed, and a classifier is used to extract the characteristic data of a normal ECG signal during the experimental period. Results: The changes in resting heart rate and other physical health indicators are analyzed by combining resting physiological indicators, namely heart rate, body weight, body mass index and body fat rate. The results show that the self-designed classifier can efficiently process the ECG images, and long-term regular activities can improve the physical conditions of most people. Most subjects' body weight and body fat rate decrease with the extension of experiment time, and the resting heart rate decreases relatively. Conclusions: Certain indicators can be used to predict a person's dynamic physical health, which indicates that the experimental research of index prediction in this research has a good effect, which not only extends the application of artificial neural network but also lays a foundation for the research and implementation of ECG intelligent testing wearable devices. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Biological images; Index; Image recognition; Neural networks, computer.

RESUMO

Objetivo: Com o objetivo de estudar a relação entre atividade aeróbia e atividade nervosa autonômica cardíaca por algoritmo de rede neural artificial e fusão biológica de imagens, tendo em vista os problemas existentes no modelo de rede neural artificial (RNA), é introduzida a tecnologia de processamento biológico de imagens com base em ANN. Métodos: um algoritmo de inteligência biológica de imagem Ann é proposto, um classificador adequado para triagem eletrocardiográfica (ECG) é projetado e um sistema de triagem de sinal de ECG é estabelecido com sucesso. Além disso, o conjunto de dados de sinais de ECG normais recuperados dos sujeitos durante o período experimental é construído e um classificador é usado para extrair os dados característicos de um sinal de ECG normal durante o período experimental. Resultados: As alterações na frequência cardíaca em repouso e outros indicadores de saúde física são analisadas pela combinação de indicadores fisiológicos de repouso, a saber, frequência cardíaca, peso corporal, índice de massa corporal e índice de gordura corporal. Os resultados mostram que o classificador autodesenhado pode processar com eficiência as imagens de ECG, e as atividades regulares de longo prazo podem melhorar as condições físicas da maioria das pessoas. O peso corporal e a taxa de gordura corporal da maioria dos indivíduos diminuem com a extensão do tempo do experimento, e a freqüência cardíaca em repouso diminui relativamente. Conclusões: Certos indicadores podem ser usados para prever a saúde física dinâmica de uma pessoa, o que indica que a pesquisa experimental de predição de índice nesta pesquisa tem um bom efeito, que não apenas estende a aplicação da rede neural artificial, mas também estabelece uma base para a pesquisa e implementação de dispositivos vestíveis de teste inteligente de ECG. ***Nível de evidência II; Estudos terapêuticos- investigação dos resultados do tratamento.***

Descritores: *Imagens biológicas; Índice; Reconhecimento de imagem ; Redes neurais de computação.*

RESUMEN

Objetivo: Para estudiar la relación entre la actividad aeróbica y la actividad del nervio autónomo cardíaco mediante el algoritmo de red neuronal artificial y la fusión de imágenes biológicas, ante los problemas existentes en el modelo de red neuronal artificial (ANN), se introduce la tecnología de procesamiento de imágenes biológicas basada en ANA. Métodos: Se propone un algoritmo de inteligencia de imagen biológica de Ann, se diseña un *clasificador adecuado para el cribado electrocardiógrafo (ECG) y se establece con éxito un sistema de cribado de señales de ECG. Además, se construye el conjunto de datos de las señales de ECG recuperadas normales de los sujetos durante el período experimental, y se utiliza un clasificador para extraer los datos característicos de una señal de ECG normal durante el período experimental. Resultados: Los cambios en la frecuencia cardíaca en reposo y otros indicadores de salud física se analizan combinando indicadores fisiológicos en reposo, a saber, frecuencia cardíaca, peso corporal, índice de masa corporal y tasa de grasa corporal. Los resultados muestran que el clasificador de diseño propio puede procesar de manera eficiente las imágenes de ECG, y las actividades regulares a largo plazo pueden mejorar las condiciones físicas de la mayoría de las personas. El peso corporal y la tasa de grasa corporal de la mayoría de los sujetos disminuyen con la extensión del tiempo del experimento, y la frecuencia cardíaca en reposo disminuye relativamente. Conclusiones: Ciertos indicadores pueden usarse para predecir la salud física dinámica de una persona, lo que indica que la investigación experimental de predicción de índices en esta investigación tiene un buen efecto, lo que no solo extiende la aplicación de la red neuronal artificial sino que también sienta las bases para la investigación. e implementación de dispositivos portátiles de prueba inteligente de ECG.* ***Nivel de evidencia II; Estudios terapéuticos- investigación de los resultados del tratamiento.***

Descriptores: *Imágenes biológicas; Índice; Reconocimiento de imagen; Redes neurales de la computación.*

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INTRODUCTION

With the continuous development of society, promoting healthy lifestyle causes the oxygen exercise to pay attention to public attention and widely used.[1] The dynamic heart rate is the most direct physiological signal that measures the intensity intensity, which is usually related to the intensity of exercise. In addition to heart rate, there is also blood pressure, body weight, body mass index, and body fat ratio.[2] Ann is the theoretical mathematical model established after the human brain mechanism. It consists of a large number of basic processing units that are connected to each other, and many of the basic features of human brain function can be reflected.[3,4] With the research work of artificial neural network deepens, there is excellent intelligence.[5,6] As a carrier, the biometric image processing technique is intended to handle the data and structure that cannot be observed by the naked eye, and cannot be automatically read from the computer to achieve its collection, interference removal is clearly optimized.[7,8] Due to its unique advantage, it has been brilliant in the field of medical diagnosis. Exploring the specific mode changes of magnetic resonance (MR) images of schizophrenia patients. Artificial neural network model and biomaterial processing technology have been widely used in medical fields, but few studies are combined in the medical field.[9] Based on artificial neural network model exploring the biological image algorithm, the screening system of ECG signal is established. In addition, the physical health indicators of the subject are predicted by combining physiological indicators of rest state health.

METHODS

Methodology

Artificial neural network model

Neurons, also known as nerve cells, the structure of neurons is shown in Figure 1. The unit is used to connect and integrate input information and send it. The process is divided into an axon, the shaft recipients information and decimal information, which transmits information to other neurons.

The structure of the MP model is very simple, as shown in Figure 2. Its constituent unit is neurons, and each neuron represents an excitation function, which belongs to the multi-input single output function. Among them, the vector xr (r=1,2...R) is the input vector of the neuron model. For the rth neuron in the network, it receives input signals from multiple other neurons. Each connection between neurons is weighted with the real coefficient Wi (i =1,2...N). The letter b is an additional threshold signal

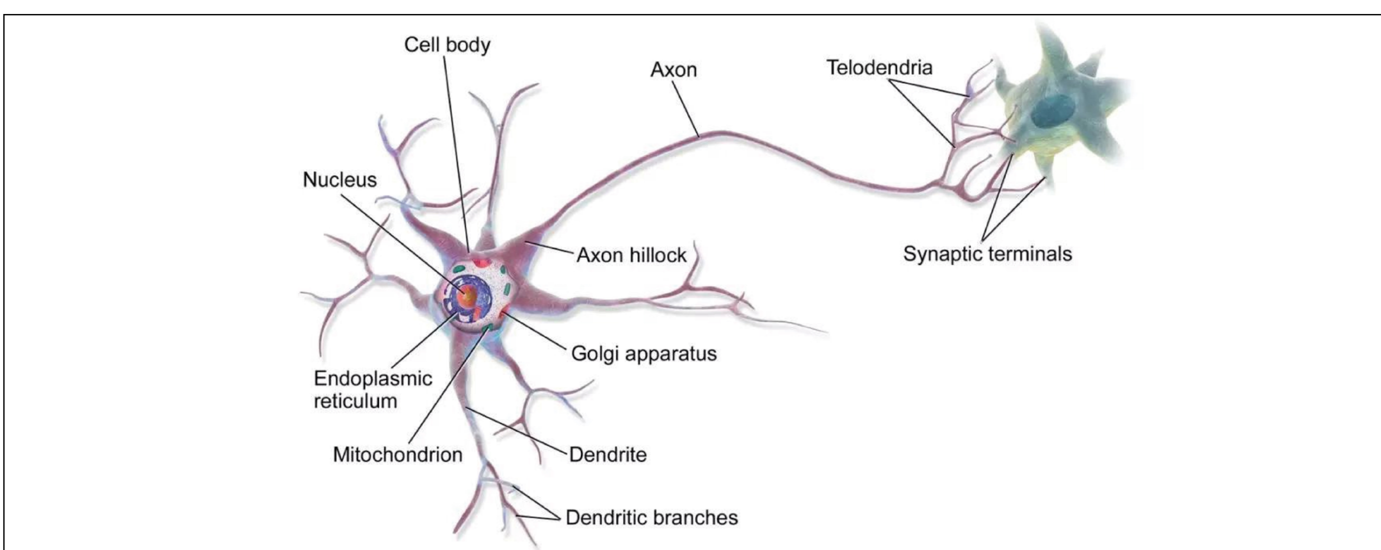

Figure 1. Schematic diagram of neuron structure.

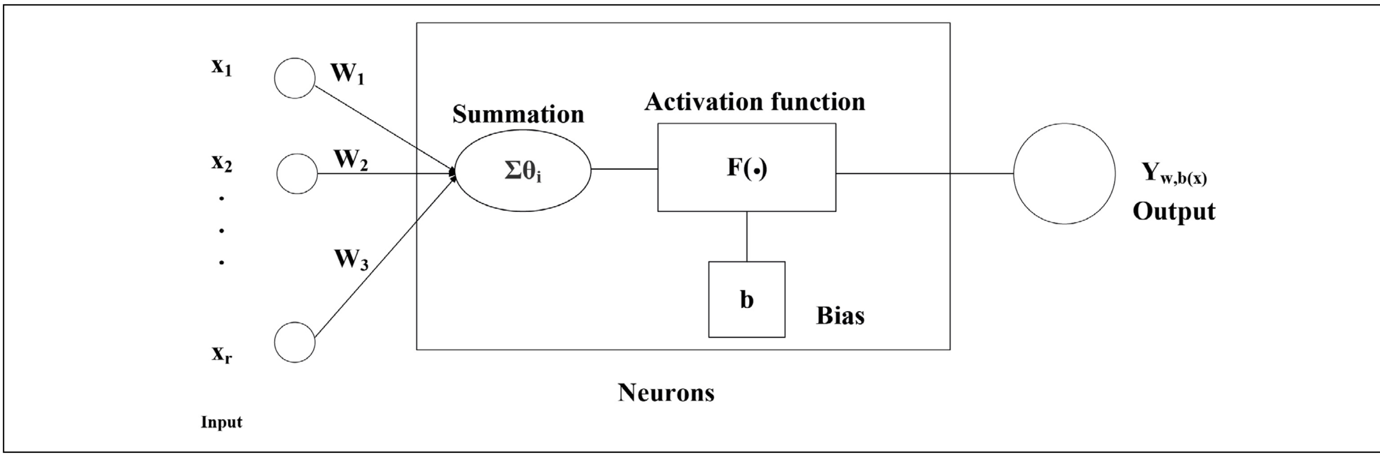

Figure 2. Artificial neuron structure.

added to the model, indicating the effect of factors within the neuron on the neuron output. Some operation is used to combine the functions of the input signal and give the total effect of the input signal, which is called the net input, expressed by Ii in the form of linear weighted sum, namely

$$I_i = \sum_r W_i x_r \quad (1)$$

The mathematical expression of the MP model is:

$$y_i = f\left(\sum_r W_i x_r - \theta_i + \mathrm{b}\right) \quad (2)$$

In equation 2, θi is the value of the valve, f(.) is the excitation function. The excitation function f(.) can be a linear function or a nonlinear function. There are three common excitation functions: threshold function, piecewise linear function and s-type function. In this research, threshold function is used for calculation, and the basic expression is as follows:

$$f(x) = \begin{cases} 1, & if \quad x \ge 0 \\ 2, & if \quad x < 0 \end{cases} \quad (3)$$

The basic hierarchical structure of a simple artificial neural network model is shown in Figure 3. It is an adaptive nonlinear dynamic system formed by many single artificial neurons connected to each other by certain rules. The output of one or more neurons in the upper layer is taken as the input of the next layer in the artificial neural network model. Multiple neurons in a single layer constitute a whole layer. The artificial neural network model consists of three layers, namely the input layer, the hidden layer, and the output layer. The layer that receives the input data is the input layer, which has three neurons; the layer that outputs the results is the output layer, including two neurons; the middle neuron is the hidden layer, which is composed of four neurons. The artificial neural network model is the earliest perceptron model, which can realize simple logic operation and solve the simple linear separable problem.

Physical indicators of exercise health

ECG signals are a series of intracellular and extracellular ion flows that occur when the heart conducts rhythmic systolic and diastolic activities, resulting in membrane potential changes, that is, potential differences. The effect of regular activities on heart rate is mainly discussed in the research. A series of changes will occur in ECG signals of subjects under different exercise loads. Through studying ECG signals of subjects, it is concluded that long-term regular exercise has an impact on the autonomic nerve activity of the heart.

The periodic waveform of normal ECG signals is shown in Figure 4. Normal ECG signal consists of a P wave, a QRS group, and a T wave. P wave is generated by atrial excitation, which reflects the excitation of left and right atria. The time width of P wave is within 0.11s. The P-R interphase is the whole interphase extending from the initial position of P wave to the starting point of the QRS wave group, reflecting the total duration from the beginning of atrial depolarization to the beginning of ventricular depolarization. QRS group is the interval between the start of Q wave and the end of the S wave, reflecting the three continuous and rapidly mutated waves generated during ventricular activation. The upper and lower directions under the crest correspond to Q-R-S waves respectively, and the duration is within 0.08 ~ 0.12s. S-T segment refers to the starting point of the QRS group extending from the endpoint of the QRS group to the start point of the T wave. At this moment, the ventricles are all in a state of depolarization

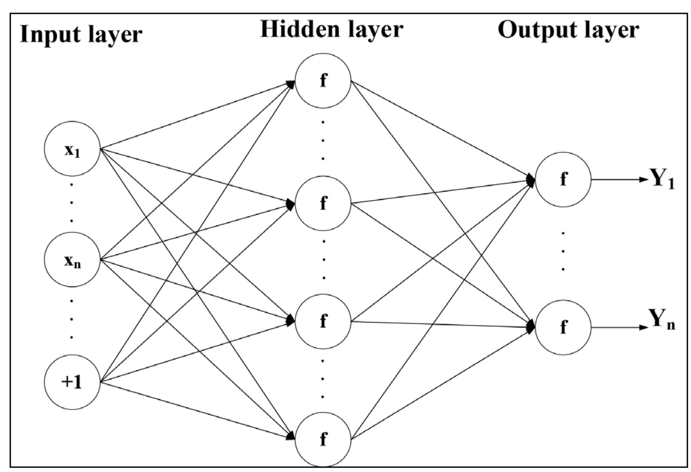

Figure 3. The basic hierarchical structure of the artificial neural network model.

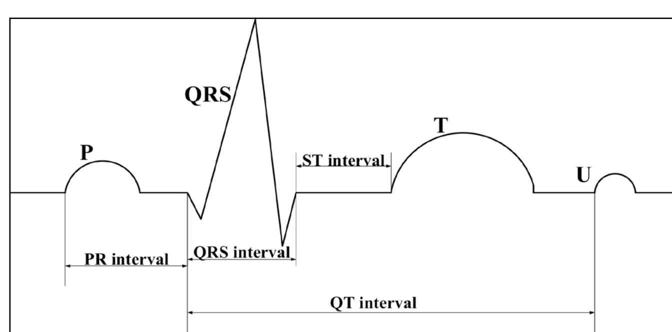

Figure 4. Normal ECG signal waveform.

with no potential difference. The S-T segment of normal people is close to the baseline. T wave represents the potential generated during ventricular recovery, which appears after S wave with long duration and low amplitude. The Q-T interval is the interval from the beginning of the QRS group to the end of the T-wave, representing the whole process of ventricular depolarization and repolarization. The larger the heart rate, the shorter the Q-T interval.

Body mass index (BMI) is an internationally recognized measure of a person's fitness. BMI is defined as weight in kilograms divided by height in meters squared in kg/m2. The calculation equation is as follows:

$$BMI = W / h^2 \quad (4)$$

In equation 4, W is for the weight (kg), h is for height (m).

Body fat rate (%BF) refers to the percentage of body fat in the total body weight. The calculation equation is as follows:

$$\%BF = 1.2 \times BMI + 0.23 \times a - 5.4 - 10.8 \times s \quad (5)$$

BMI is the body mass index (kg/m2), s is the gender, s=1 for male and s=0 for female.

RESULTS

ECG signal screening classifier based on biological image algorithm of artificial neural network

In the three-month jogging experiment in this research, the ECG data volume is too large, and the collection process is relatively complicated. It is also affected by other uncontrollable factors, such as the lack of accurate information collected by the test instrument due to the subjects' own sweat during the test, or the large signal interference caused by the friction between the subjects' clothes and the electrode patch. As a result, part of the data is invalid and can't be calculated. Therefore, the biological image algorithm based on the improved artificial neural network is used to construct a classifier suitable for ECG signal image screening, screen the tested ECG data, and obtain the effective ECG data that can be processed post-processing. Figure 5 is the screening flow chart.

Experimental test results

In this research, a three-month jogging experiment is designed. In the experiment, a total of ten participants are recruited. The male to female ratio is 1:1. They are between the ages of 20 and 24, with an average age of 22. All participants don't have any heart disease, smoke or drink too much alcohol, are healthy, and have not exercised regularly before the experiment. The subjects actively cooperate with the main subjects to carry out relevant tests during the experiment, and the subjects strictly follow the principle of autonomy and voluntarily in the recruitment process. Before the formal experiment begins, the main test subjects sign the informed consent form with the purpose of letting the subjects fully understand that the experiment was only to obtain the ECG and weight data during the experiment, which would not involve any privacy of them. In addition, all data obtained in the experiment are kept completely confidential and used only for experimental purposes. Subjects have the right to terminate the experiment at any time during the experiment without any responsibility. The acquisition of electrical signal data in the experimental center is realized by MP150 model 16-channel poly-channel physiological signal recorder and wireless ECG sensor produced by the American BIOPAC company. The frequency of the instrument is controlled at 400HZ during ECG data acquisition. Figure 6 is the electrocardiogram of two subjects, and Figures 7-10 respectively show the curve of weight, BMI, %BF and heart rate of 10 subjects over time in the three-month jogging experiment.

DISCUSSION

During the three-month jogging experiment, all participants are required to maintain the same diet as before, with no significant changes in food intake or sleep patterns. As the experiment goes on, the subjects' body weight generally declines. Therefore, under the premise of scientific and reasonable diet, long-term regular exercise can effectively promote weight loss. The BMI and body fat rate of most subjects decrease with the extension of jogging time.

The mean resting heart rate of the 10 subjects is divided into four stages, namely, before the experiment began, the first month, the second month and the third month. Figure 10 is drawn based on the data. The overall resting heart rate of the 10 subjects decreases as the jogging experiment progresses. With the passage of time, the resting heart rate of subjects 3, 4, 6 and 7 increases slightly in the second month. The resting heart rate of subjects 1, 5 and 8 is slightly higher than that of other subjects. These anomalies may have to do with changes in outside temperature or the amount of running load. Because in this experiment, subjects are required to go jogging at least 2-3 times a week for 30-40 minutes each time, the training intensity might be overload exercise for some subjects. Overall, in the three-month long-term jogging experiment, the statistical results show that long-term jogging improves the physical condition of most people.

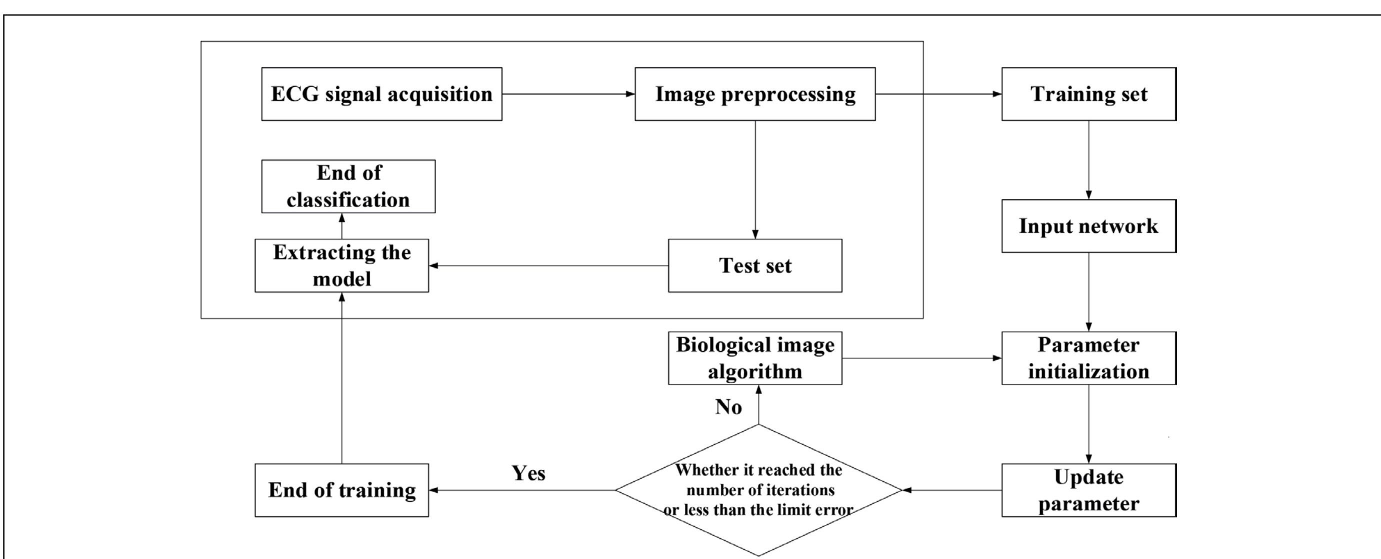

Figure 5. ECG signal screening flow chart.

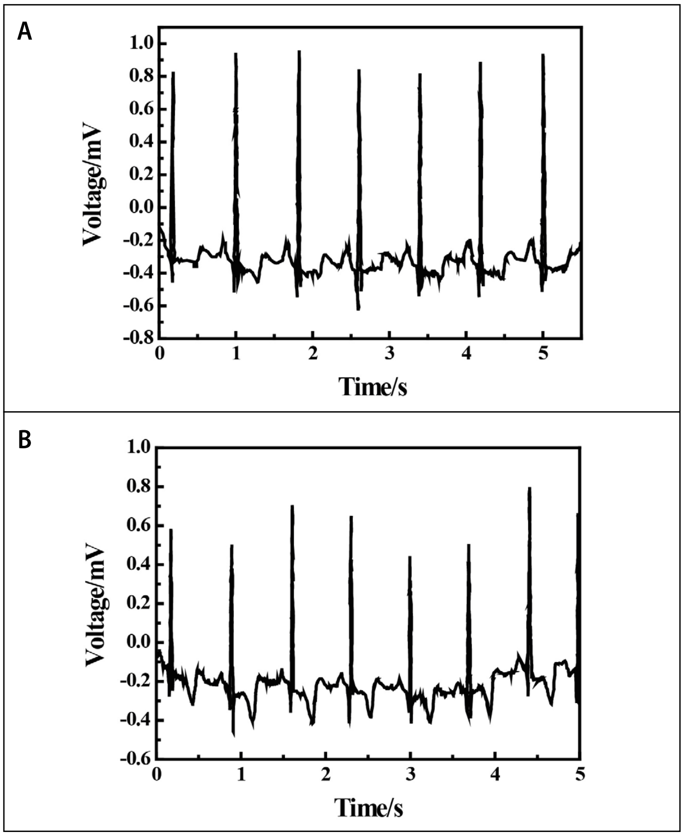

Figure 6. Subjects electrocardiogram.

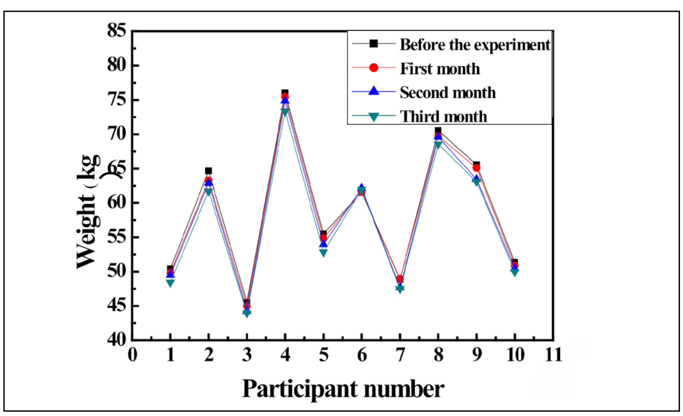

Figure 7. The change curve of body weight of the jogging subjects for three months.

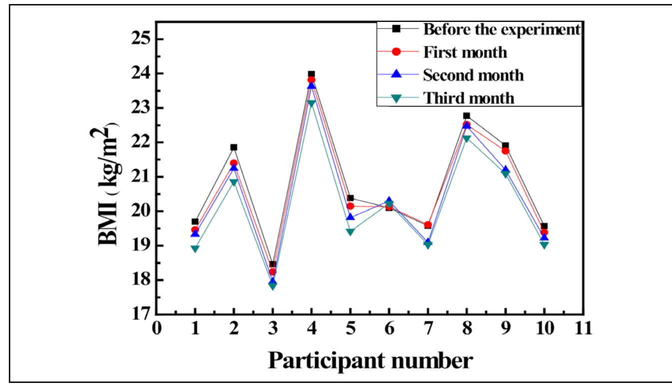

Figure 8. BMI curve of jogging subjects at 3 months.

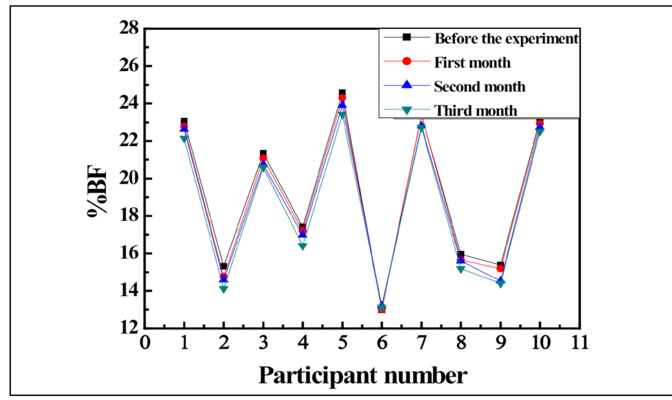

Figure 9. Curve of BF for 3-month jogging subjects.

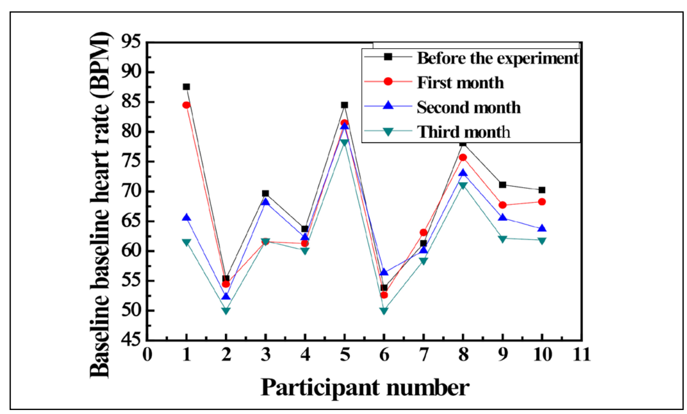

Figure 10. Baseline mean heart rate curve of jogging subjects at 3 months.

CONCLUSION

The results show that long-term conventional motion can improve the physical health indicators of most people. As the exercise time extension, the average stationary heart rate is slowly reduced, and then stabilized within the range. Weight, BMI and% BF show a decrease in trend. The predictive studies of aerobic exercise index conducted by this study can be based on MECG intelligent wearable devices, so that the physiological indicators of the general population during exercise have real-time monitoring.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made a significant personal contribution to the manuscript. Lei Ru and Jing Duan analyzed and explained the data. Guo Ru performed the experiment. Bin Zhang is the main contributor to the writing of the manuscript. Final manuscript read and approved by all authors.

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