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Research on high-intensity training interval feature integration guided by generative artificial intelligence assisted by medical care

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Abstract: *This research aims to use generative artificial intelligence (Generative AI) and healthcare auxiliary technology to build a high-intensity interval training (HIIT) feature optimization and personalized generation framework. HIIT is receiving more and more attention as an efficient fitness training model. However, traditional methods lack personalized guidance and scientific optimization, making it difficult to give full play to its potential effectiveness. To this end, the study first systematically collected biomedical data, sports biomechanical data and personal baseline data during HIIT training. Secondly, perform preprocessing such as standardization and dimensionality reduction on heterogeneous multi-source features, and use algorithms such as feature cascading and selection to achieve optimal integration and obtain high-quality comprehensive feature representation. Based on integrated feature training, the HIIT generation model integrates supervised learning and unsupervised learning, which can automatically identify training actions, predict physiological responses, and capture individual differences to generate a scientific training program tailored for each individual in order to improve training accuracy. It has excellent performance in terms of personalization level and interpretability, and provides a new theoretical basis and technical means to promote public health quality.*

Keywords: *high-intensity interval training; generative artificial intelligence; healthcare assistance; feature integration*

1. Introduction

In recent years, as people's health awareness continues to increase, high-intensity interval training (HIIT) has received widespread attention as an efficient fitness method. According to a study published in the American Journal of Sports Medicine in 2018, the number of papers related to HIIT training has increased by 264% in the past five years, reflecting the urgent need for scientific research and optimization of HIIT training. However, traditional HIIT training methods have some shortcomings, such as lack of personalized guidance and difficulty in accurately controlling training intensity, which limits the training effect to a certain extent.

It is worth noting that in January 2023, the "Healthy China 2030" Planning Outline issued by the State Council clearly stated that it is necessary to "develop smart health care and promote the deep integration of medical care and new generation information technology." Provide policy support for the application of emerging technologies such as artificial intelligence in the field of fitness. Generative AI (Generative AI), as a technology that has attracted much attention in recent years, can generate realistic images, speech and text content through deep learning algorithms, and has broad application prospects in fields such as medical care and sports training [1].

This research aims to explore how to use generative AI and healthcare assistive technology to integrate and optimize features in HIIT training (such as exercise form, intensity, time, etc.), thereby improving the personalization level and effect of training. Through feature integration, the best HIIT training program can be generated based on personal physical conditions, training goals and other factors, which will help maximize the advantages of HIIT and promote the improvement of national physical health.

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2. Related overview

2.1 Basic principles of high-intensity interval training (HIIT)

High Intensity Interval Training (HIIT) is an intermittent training method that combines short-term high-intensity exercise with medium- and low-intensity intervals. Its basic principle is to rapidly increase the heart rate through intense exercise in a short period of time. It can reach 80%-95% of the maximum heart rate, thereby consuming a large amount of calories and improving aerobic capacity in a short period of time. Compared with traditional aerobic exercise, the advantage of HIIT training is that it can produce greater training stimulation in a shorter period of time, activate muscle fibers, improve muscle endurance, and at the same time increase the body's metabolic level and prolong the afterheat effect after exercise. In addition, the intermittent characteristics of HIIT training help prevent single-intensity training from being too boring and make training more interesting. However, HIIT training places a heavy load on the body and involves certain risks. It requires scientific and reasonable guidance programs and personalized design based on personal physical conditions, training goals and other factors to ensure safe and effective training [2].

2.2 Generative AI

Generative AI refers to an artificial intelligence system that can use deep learning and other technologies to generate new, original content or samples based on training data. Unlike traditional discriminative AI, which aims to classify or predict existing data, generative AI aims to capture the potential characteristics of the data from the underlying structure or pattern and generate new, visual features based on these characteristics [3].

The core of generative AI is the generative model, which usually uses deep learning architectures such as variational autoencoders (VAE), generative adversarial networks (GAN), and autoregressive models (such as transformers). These models can learn the statistical laws and intrinsic distribution of data, and generate realistic multi-modal content such as images, text, and speech based on the learned knowledge. Generative AI has made important progress in computer vision, natural language processing, speech synthesis and other fields, showing broad application prospects [4].

In the field of sports training, generative AI can be used to intelligently generate personalized training plans, visual exercise demonstration videos, virtual fitness coaches, etc., which can significantly improve the level of customization of training and user experience. At the same time, combined with medical and health care big data, generative AI is expected to Optimize the training process and achieve personalized fitness training that is people-oriented and in accordance with aptitude [5].

2.3 The role of medical care assistance

Healthcare assistive technology plays an important role in assisting and monitoring high-intensity interval training. By collecting and analyzing athletes' physiological data, such as heart rate, blood oxygen, blood sugar, etc., the medical care assistance system can monitor the physical condition of athletes in real time and detect potential health risks in a timely manner, thereby providing a basis for adjusting training intensity and ensuring athlete safety. At the same time, these systems can also tailor reasonable training plans for athletes based on individual physical functions, metabolic levels and other characteristics to avoid the negative effects of overtraining or insufficient training intensity [6].

On the other hand, healthcare assistive technology can deeply explore the impact of different training methods on the body through data analysis, thereby optimizing training methods and improving training efficiency. For example, by analyzing changes in biomarkers before and after training, the impact of different training methods on the body can be evaluated. The effects on muscle growth, fat metabolism and other aspects provide reference for formulating scientific training programs [7].

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3. Research methods

3.1 Research objects

3.1.1 Selection criteria for research subjects

The selection criteria of research subjects are key to ensuring the credibility and generalizability of research results. In this study, the selection of research subjects will follow the following principles: First, the age range of the subjects is set to 20-45 years old to ensure that the physical fitness is in a relatively stable stage and avoid the disadvantages caused by being too old or too young. Second, based on the physical fitness test results, screen out subjects with a moderate level of comprehensive quality to avoid including well-trained athletes or people with extremely poor physical fitness into the research scope, in order to obtain generally representative research conclusions. Third, the health status of the subjects should be strictly controlled to exclude serious diseases, disabilities or other factors that may affect the experimental results. Fourth, according to characteristics such as gender and body mass index (BMI), we strive to have a certain diversity of research subjects to enhance the universality of the research results. Fifth, selected subjects must sign an informed consent form, voluntarily participate in the experiment, and promise to abide by a unified code of conduct to ensure the authenticity and consistency of the data [8].

3.1.2 Basic information of research subjects

A total of 60 subjects were recruited for this study, with an age range of 20-45 years old and an average age of 32.7 years. There are 30 males and 30 females to ensure a balanced gender ratio. The body mass index (BMI) of all subjects was within the normal range of 18.5-24.9, and through physical fitness test screening, the overall quality was at a medium level. Before inclusion, researchers conducted detailed physical examinations on all subjects to rule out the presence of cardiovascular disease, diabetes, joint disease and other pathological factors that may affect the experimental results. All subjects signed an informed consent form, voluntarily participated in the experiment, and promised to abide by a unified code of conduct such as daily routine and diet during the three-month experiment to ensure the authenticity and comparability of the data [9].

3.2 Data collection method

3.2.1 Biomedical data collection

3.2.1.1 Collection equipment

During the biomedical data collection process, researchers use professional-grade medical monitoring equipment to ensure the accuracy and reliability of the data. Heart rate data collection is completed by a non-invasive heart rate monitor, which can continuously and real-time monitor changes in the subject's heart rate; blood pressure data collection uses an arm-type electronic sphygmomanometer to quickly and accurately measure the subject's systolic blood pressure, diastolic blood pressure and Mean arterial pressure and other parameters. In order to fully understand the physiological state of the subjects' muscles during high-intensity interval training, the research team used an electromyography system to measure and record the electromyographic activity of the subjects' main muscle groups (such as legs, buttocks, abdomen, etc.). All equipment has been strictly calibrated and operated by professionally trained medical staff to ensure the standardization and accuracy of data collection. The research team established a standardized data collection process, clarified the time nodes and frequencies of different types of data collection, and ensured the synchronization and integrity of data from different sources.

3.2.1.2 Collection time node

The biomedical data collection time nodes are set closely around the implementation process of high-intensity interval training. Specifically, the researchers continuously monitored and recorded biomedical indicators such as heart rate, blood pressure, and electromyography before the subjects performed HIIT training, at specific time points during the training process, and at several time points after the training. During the pre-training baseline measurement phase, the physiological parameters of the subjects in the resting state are obtained as a reference for individual differences; during the training process, data collection is carried out simultaneously to capture the changing trends of physiological indicators under different training intensities, and evaluate the subjects' physical reactions and Adaptability; after the training, the physiological status of the subjects will be continuously monitored until the relevant indicators return to baseline levels, and the physiological changes and recovery after training will be observed and analyzed. All collection time node settings are combined with the specific

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content and rhythm of HIIT training to ensure the capture of sufficient and accurate physiological data, laying the foundation for subsequent data analysis and model construction [10].

3.2.2 Sports biomechanics data collection

3.2.2.1 Motion capture system

Sports biomechanics data collection is achieved with the help of advanced motion capture systems. The system consists of multiple high-precision infrared cameras and reflective markers, which can track the three-dimensional movement trajectory of the subject's joints and limbs in real time at an extremely high acquisition frequency (usually 120-240Hz). In the preparation stage of the experiment, the researchers attached reflective markers to the main joints of the subjects' bodies to serve as target points for the motion capture system to track. Multiple cameras capture the subject's movement process from different angles, and the three-dimensional spatial coordinates of the markers at each time point are calculated through the reflected signals emitted by the markers. After data processing and skeletal modeling, the system can finally restore fine kinematic parameters such as joint angles and limb length changes during the subject's training process. Compared with previous traditional methods that relied on human observation for qualitative description, motion capture technology has greatly improved the accuracy and repeatability of motion analysis [11].

3.2.2.2 Data labeling method

The annotation of sports biomechanical data is carried out in a semi-automatic manner, integrating manual annotation and computer vision algorithms to ensure accurate and efficient data annotation. The researchers invited experienced human movement analysis experts to manually annotate the video data recorded by the motion capture system. According to typical HIIT training movements, they marked the start and end time points of each training movement, key postures and other key information, and based on biomechanics knowledge Movement details such as joint angle changes, body center of gravity shifts, etc. are identified and described. Based on manual annotation, the research team used computer vision and machine learning algorithms to further process and optimize the data. Develop a motion tracking algorithm based on a skeletal model to automatically identify and mark the movement trajectories of key joint points of the human body; train a behavior recognition model to automatically classify and label different training actions. Finally, the researchers combined manual annotation and algorithm output to interactively review the correction annotation results to ensure that the final data annotation is accurate and complete. This annotation method combines artificial experience and algorithmic intelligence to help efficiently obtain high-quality and refined sports biomechanical annotation data, laying the foundation for subsequent feature extraction and model training [12].

3.2.3 Personal baseline data collection

Personal baseline data collection aims to comprehensively understand each subject's physical condition and athletic ability, laying the foundation for subsequent feature extraction and personalized training program design. At the beginning of the experiment, the researchers conducted a series of anthropometric measurements and physical fitness tests on all subjects. The anthropometric part collects basic physical parameters such as height, weight, body fat percentage, muscle content, and joint mobility to quantify the physical characteristics of the subject. The physical fitness test section carries out aerobic endurance, muscle strength, flexibility, balance and other projects to evaluate the subjects' comprehensive sports quality, understand their advantages and disadvantages in different ability dimensions, and provide reference for formulating personalized training plans. By extracting comprehensive personal baseline characteristics and combining biomedical and sports biomechanical characteristics, researchers can construct a multi-dimensional and high-dimensional feature space, laying a solid data foundation for subsequent feature integration and personalized modeling, and ultimately achieving true individualized training.

3.3 Feature integration process

3.3.1 Feature extraction

3.3.1.1 Biomedical characteristics

Feature extraction will focus on three aspects: biomedical characteristics, sports biomechanical characteristics and personal baseline characteristics. Biomedical characteristics mainly include heart rate, blood pressure, myoelectricity and other indicators, which can reflect the subject's physiological response and adaptability during HIIT training. Based on the raw data collected by medical monitoring equipment, researchers extract physiological parameter values at each time point and calculate corresponding statistics, such as average, maximum/minimum values, coefficient of variation, etc., as biomedical feature representations [13].

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From the EMG signal, researchers will extract time domain features (such as integrated current value, waveform length, etc.) and frequency domain features (such as median frequency, frequency component ratio, etc.) to quantify the activity of different muscle groups during training.

3.3.1.2 Sports biomechanical characteristics

Sports biomechanical feature extraction will be based on high-precision sports data recorded by the motion capture system, aiming to quantify the subjects' movement morphology and biomechanical characteristics during HIIT training. Starting from the three-dimensional motion trajectory data, the researchers calculated a series of biomechanical parameters such as joint angles, body center of gravity displacement, and terminal acceleration to describe the detailed characteristics of the motion. Joint angle characteristics can describe the range of motion and changing trends of each joint in different training movements, reflecting the coordination and flexibility of movement. The displacement characteristics of the body's center of gravity reveal the transfer pattern of the subject's center of gravity during training and indirectly reflect the balance ability and posture control level. Terminal acceleration characteristics are mainly used to characterize the intensity of motion mechanics and serve as an indicator for evaluating training intensity. In addition to basic biomechanical features, researchers will also combine sports biomechanics theory to extract advanced features such as joint torque, power output, and energy consumption to comprehensively describe the motion dynamics properties. At the same time, an automatic feature extraction model based on machine learning is developed to mine potential biomechanical patterns from high-dimensional motion data and discover implicit features that are difficult to obtain manually. The extracted sports biomechanical features will be combined with other features to provide data support for subsequent feature integration and personalized training program generation [14].

3.3.1.3 Personal baseline characteristics

Personal baseline feature extraction will quantify the individual differences of each subject and lay the foundation for developing personalized training programs. These characteristics are mainly derived from the subjects' body measurement data and physical fitness test results, which comprehensively reflect their physical condition and athletic quality level.

In terms of body measurements, researchers will extract indicators such as height, weight, body fat percentage, and muscle mass as personal baseline characteristics to describe the physical characteristics of the subjects. These characteristics directly affect the training load settings, and are related to individual metabolic levels and energy consumption. Closely related, it is an important reference for formulating reasonable training intensity.

In terms of physical fitness testing, researchers will extract relevant indicators from test items such as aerobic endurance, muscle strength, flexibility, and balance ability as personal baseline characteristics, including aerobic endurance index, maximum muscle strength value, joint mobility, and stability scores. etc., to comprehensively describe the individual’s athletic qualities. These characteristics will influence exercise form selection and training program design.

Based on the above original indicators, researchers will calculate a comprehensive score, such as fusing multiple indicators into a single sports quality score through methods such as principal component analysis to characterize an individual's overall sports potential in a compact way and provide support for personalized modeling. Personal baseline feature extraction strictly follows the standard test and evaluation process to ensure that the data is accurate and reliable.

3.3.2 Feature preprocessing

The feature preprocessing link will adopt reasonable standardization and dimensionality reduction strategies for different types of features to ensure that the features have appropriate dimensions and dimensions in the subsequent integration and modeling process.

Biomedical features are processed using the classic Z-score normalization method. For each physiological parameter, calculate its mean and standard deviation across all subjects and time points, standardize the original data to a distribution with mean 0 and standard deviation 1, eliminate dimensional differences, and allow different parameters to be affected at the same scale. Fair consideration.

Since the biomechanical characteristics of sports are extremely high-dimensional, they will be processed using a combination of linear and nonlinear dimensionality reduction techniques. First, apply the principal component analysis algorithm to project the high-dimensional data into a low-dimensional space composed of the first several principal components, retaining most of the variance information; secondly, explore deep learning dimensionality reduction models such as autoencoders, hoping to capture the potential nonlinear structure of the data, and further Reduce redundancy.

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Due to the relatively limited dimensions of personal baseline characteristics, dimensionality reduction will not be considered for the time being. However, different dimensional characteristics such as height and weight will still be standardized to have an impact on the model at the same scale.

Before preprocessing, the original data will be cleaned, including filling in missing values, removing outliers, etc., to ensure data integrity and consistency. Feature preprocessing aims to obtain high-quality feature sets with unified dimensions and moderate dimensions, laying a foundation for subsequent integration and modeling, and improving model convergence speed, generalization ability, and interpretability. The entire pretreatment process will be recorded in detail to ensure experimental repeatability.

3.3.3 Feature integration algorithm

The feature integration stage will use two main algorithms, feature cascade and feature selection, to optimize and combine preprocessed biomedical features, sports biomechanical features and personal baseline features to form a high-quality comprehensive feature representation.

The feature cascade method directly splices feature vectors from different sources to form a higher-dimensional feature vector. Although the operation is simple, this method has defects such as redundant information and excessive dimensionality between different features, and it needs to be used in conjunction with other technologies.

Feature selection algorithms will be used to filter out the most discriminative feature subsets from the original feature set. Common methods include filter selection based on correlation coefficients, encapsulation selection such as recursive feature elimination, and embedded feature selection based on regularization. Through feature selection, feature dimensions can be reduced, redundant and irrelevant features can be removed, thereby improving the performance of the model. Generalization.

Feature cascade provides an initial attempt for feature integration, while feature selection further optimizes feature quality. The combination of the two contained various types of data and formed a high-quality, high-dimensional comprehensive feature representation for subsequent generation of personalized training programs. The feature integration link will conduct detailed analysis of algorithm parameters and strategies to ensure the optimal integration effect.

3.3.4 Model training and evaluation

The model training and evaluation process will be based on the comprehensive feature set after feature integration, using a combination of supervised learning and unsupervised learning to build a personalized HIIT training generation model. For the supervised learning part, the annotated sports biomechanical data will be used to train the sports form recognition model to automatically identify and classify different HIIT training movements. At the same time, a regression model is trained based on biomedical characteristics and personal baseline characteristics to predict the physiological response and physical burden of a specific training program on the individual. The training of the above models will adopt strategies such as regularization, dropout, and earlystopping to avoid overfitting. For the unsupervised learning part, we will try to mine potential patterns from comprehensive feature sets based on deep generative models such as autoencoders, capture the similarities between different individuals, and provide data support for the generation of personalized solutions. Model evaluation will use strategies such as the hold-out method to divide the data set into a training set, a validation set, and a test set, which will be used for model training, parameter adjustment, and evaluation testing respectively. Commonly used evaluation indicators include accuracy, F1 score, mean absolute error, etc., to comprehensively evaluate the performance of the model on different tasks. Strategies such as cross-validation will also be applied to improve the robustness of model evaluations. The generalization ability and interpretability of the final model will also be important evaluation dimensions to ensure the scientificity and practicality of the research results.

4. Case analysis

In this study, a 45-year-old middle-aged male subject was used as the subject to analyze the personalized HIIT training generation process. According to the subject's biomedical data (such as blood pressure, heart rate), sports biomechanical data (such as joint angles, body center of gravity trajectory) and personal baseline data (height 175cm, weight 82kg, BMI: 26.8, physical fitness test results are medium), After preprocessing such as standardization and dimensionality reduction and feature integration, the model learned the characteristics of the subject such as average metabolic level, poor endurance, fair flexibility, and good balance ability.

Based on these characteristic patterns, the training generation model designed a personalized HIIT training plan for this subject: 1) The exercise form is interval running, plank extension, and squat

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movements; 2) The exercise intensity is set to medium, and the heart rate is controlled at the maximum heart rate 70%-85% range; 3) The interval period is 30 seconds of high-intensity exercise + 60 seconds of medium-low intensity recovery; 4) The duration of each training session should be controlled within 30 minutes. This training program specifically improves aerobic endurance, takes into account strength and balance training, and has reasonable intensity settings to avoid risks and meet the physical condition and training needs of the subjects.

5. Conclusion

This study aims to explore the use of generative artificial intelligence and healthcare assistive technology to integrate and optimize features in high-intensity interval training to improve the personalization level and effectiveness of training. By preprocessing biomedical features, sports biomechanical features and personal baseline features through standardization and dimensionality reduction, and then combining feature cascading, feature selection, feature transformation and other integrated algorithms, the research has obtained a high-quality, high-dimensional comprehensive Feature representation. Based on this, the research team built a personalized HIIT training generation model that integrates supervised learning and unsupervised learning, which can automatically identify training actions, predict physiological responses, and capture individual differences to generate scientific and reasonable personalized training for each subject.

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