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Using Deep Learning Technology to Analyze Physiological Data of Pregnant Women for Risk Assessment of Cardiovascular Diseases during Pregnancy and Postpartum Period

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Abstract: *Pregnancy and postpartum period are the most obvious stages of physiological changes in pregnant women, during which pregnant women are more likely to suffer from cardiovascular diseases. Traditional evaluation methods have certain limitations, therefore a more efficient and accurate evaluation method is needed. This article aims to explore the feasibility of using deep learning technology to analyze physiological data of pregnant women for risk assessment of cardiovascular diseases during pregnancy and postpartum period. Deep learning technology can explore and mine features and patterns related to cardiovascular disease in pregnant women, improving evaluation accuracy. This article explores the application effects of deep learning technology from three aspects: model selection, feature extraction, and data enhancement, and conducts a series of experiments. The experimental results indicate that a recurrent neural network should be selected as the training model, and convolutional neural network methods should be used for feature extraction. By combining appropriate data augmentation techniques, the accuracy of maternal cardiovascular disease risk assessment can be improved.*

Keywords: *Cardiovascular Disease, Deep Learning, Risk Assessment, Recurrent Neural Networks, Feature Extraction, Data Augmentation*

1. Introduction

Pregnancy and puerperium are very special stages in a pregnant woman's life, during which the risk of cardiovascular diseases increases significantly, including hypertension, myocardial infarction, heart failure, and other diseases. It has an important impact on the health of both pregnant women and newborns. Therefore, it is crucial to closely monitor the physiological data of pregnant women and conduct risk assessments. The existing methods mainly rely on the experience and professional knowledge of medical staff, and are influenced by subjective factors of the diagnosis, lacking objective reliability. Moreover, traditional evaluation methods currently do not consider the relationship between different physiological indicators. Therefore, developing a physiological data analysis model for pregnant women based on deep learning technology can effectively assess the risk of cardiovascular disease in pregnant women, which has important practical significance. Deep learning technology has made remarkable progress in the fields of image, voice and natural language processing, but the research on its application in the medical field is not enough. This article would explore the use of deep learning techniques to analyze physiological data of pregnant women in order to better assess the risk of cardiovascular disease during pregnancy and postpartum.

Cardiovascular diseases complicate 1-4% of pregnancies, with a higher prevalence rate including hypertension, and are the main cause of maternal mortality. Ramlakhan Karishma P. studied how physiological adaptation during pregnancy can lead to cardiac metabolic complications or exacerbate existing cardiac metabolic diseases. On the contrary, how cardiac metabolic diseases can impair the adaptation to pregnancy and its expected purpose: fetal development and growth [1]. Cardiology and obstetrics refer to a team based approach to maternal care that includes interdisciplinary collaboration between maternal and infant medicine, cardiology, and other disciplines. Magun Ella attempted to describe the clinical characteristics, maternal and infant outcomes, and cardiovascular readmission of a group of pregnant women with potential cardiovascular diseases [2]. In addition to traditional risk

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factors for cardiovascular disease, women also face an additional burden of gender specific risk factors. The critical stages of female reproductive history may affect or reveal short-term and long-term cardiac metabolism and cardiovascular trajectories. O'Kelly Anna C. summarized evidence on the current association and mechanism between female reproductive history and cardiovascular disease risk, including menarche to menopause, infertility, and pregnancy. He reviewed how reproductive history can be further integrated into clinical practice and emphasized important issues and directions for future research [3]. However, these scholars did not assess the risk of cardiovascular disease in pregnant women during pregnancy and postpartum period based on deep learning technology, and only explored it from a superficial perspective.

In order to address the limitations of traditional assessment methods in assessing the risk of cardiovascular disease during pregnancy and postpartum period, this article explores the feasibility of using deep learning technology to analyze physiological data of pregnant women for risk assessment of cardiovascular disease during pregnancy and postpartum period. This article designs a deep learning solution that comprehensively considers model selection, feature extraction, and data augmentation. It aims to provide an efficient and accurate method for assessing the risk of cardiovascular diseases during pregnancy and postpartum period. The experimental results show that using recurrent neural networks as the main training model, supplemented by convolutional neural networks for feature extraction, can significantly improve the accuracy of risk assessment.

2. Application of Deep Learning Technology in Cardiovascular Disease Risk Assessment of Pregnant Women

Pregnant women's cardiovascular diseases mainly include various diseases such as hypertension, heart disease, and stroke, which can bring great health risks to pregnant women and fetuses. In modern medicine, conducting cardiovascular disease risk assessment for pregnant women has become a routine task, which can help doctors timely detect cardiovascular problems in pregnant women, take corresponding treatment measures, and effectively prevent and control the development of diseases [4-5].

However, traditional risk factor assessment methods have certain limitations, as they only consider the personal characteristics of pregnant women and certain known physiological parameters, making it difficult to fully utilize a large amount of medical data to predict disease risk. In addition, many pregnant women may have a potential risk of cardiovascular disease, but due to unclear early symptoms, it is difficult to detect them in a timely manner [6-7].

Deep learning technology can utilize a large amount of medical data to automatically extract features and establish models for predicting and evaluating the cardiovascular disease risk of pregnant women [8-9]. The following would explore the application effect of deep learning technology in pregnant women's cardiovascular disease risk assessment from three aspects: model selection, feature extraction, and data enhancement.

2.1 Model Selection

Deep learning models include convolutional neural networks (CNN), recurrent neural networks (RNNs), and deep neural networks, among which RNNs have advantages in processing sequence data, such as long and short-term memory networks. Given the time series nature of the development of cardiovascular diseases in pregnant women, using RNN models as the main training model would be more appropriate [10-11]. In addition, it should be noted that overfitting should be fully considered when training the RNN model, and overfitting can be avoided by adding regularization terms or using dropout and other methods.

In the risk assessment of cardiovascular disease during pregnancy and postpartum, the RNN model can be used as the main training model to process time series data of cardiovascular disease in pregnant women [12-13]. The RNN model is a recursive neural network that can be used to process sequence data.

$$h_t = tanh(W_{hh}h_{t-1} + W_{xh}x_t + b_h) \quad (1)$$

$$y_t = softmax(W_{hy}h_t + b_y) \quad (2)$$

Among them, h_t represents the hidden state at time t, x_t represents the input at time t, W_{hh}, W_{xh},

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W_{hy} represent the weight matrices between hidden states and between input and output, respectively, and b_h and b_y are bias vectors.

2.2 Feature Extraction

The deep learning model requires input features as training data. For physiological data of pregnant women, traditional feature extraction methods include routine physiological data such as electrocardiogram and blood pressure. However, these traditional feature extraction methods are difficult to fully utilize a large amount of medical data, so using feature extraction methods based on CNN models can better explore potential information and patterns in the data.

The use of feature extraction methods based on CNN models can better explore potential information and patterns in the data. In the risk assessment of cardiovascular diseases during pregnancy and postpartum period, the features of input physiological data can be extracted through convolutional layers [14-15]. In the CNN model, convolutional layers are used to extract features from input data. The formula is as follows:

$$y_{i,j,k} = \sigma\left(\sum_{l=1}^{L}\sum_{m=1}^{M}\sum_{n=1}^{N} x_{i+1,j+m,n} w_{l,m,n,k} + b_k\right) \quad (3)$$

Among them, $y_{i,j,k}$ represents the response of the k-th convolutional kernel to the input feature map at position (i, j). $x_{i+1,j+m,n}$ represents the pixel values at positions (i+l, j+m) on the input feature map. $w_{l,m,n,k}$ represents the weight of the kth convolution kernel, b_k represents the offset term, and $\sigma(\cdot)$ represents the activation function.

2.3 Data Enhancement

When training deep learning models, data augmentation is one of the important means to improve model performance. In the risk assessment of cardiovascular disease in pregnant women, random cropping, rotation, translation, and other methods can be used to expand the dataset. However, it should be noted that data augmentation may lead to longer training times, so it is necessary to choose appropriate data augmentation techniques based on actual needs to achieve the best results. In the risk assessment of cardiovascular diseases during pregnancy and postpartum, data augmentation is one of the important means to improve the effectiveness of the model [16-17]. The dataset can be expanded through random cropping, rotation, translation, and other methods.

3. Experimental Results of Cardiovascular Disease Risk Assessment during Pregnancy and Postpartum Based on Physiological Data of Pregnant Women

The incidence of cardiovascular diseases significantly increases during pregnancy and postpartum period [18-19]. Therefore, assessing the cardiovascular health status of pregnant women has important clinical significance. Traditional evaluation methods mainly rely on doctors to manually record and analyze various indicators, which have problems such as high labor costs, low efficiency, and susceptibility to human factors. With the continuous development of deep learning technology, cardiovascular disease risk assessment based on physiological data of pregnant women has also been greatly improved [20]. This article aims to explore the application effects of different deep learning models, feature extraction methods, and data augmentation techniques in cardiovascular disease risk assessment through comparative experiments, providing some reference for the rational application of deep learning technology.

3.1 Experimental Design

(1) Dataset preparation

This article collected 2000 sample datasets from patients during pregnancy and postpartum period. These data cover multiple physiological parameters, including age, weight, blood pressure, heart rate, etc. The paper preprocess the collected data, including data cleaning, missing value filling, and normalization, to facilitate subsequent model training. This article conducted 5 training sessions for each scheme.

(2) Experiment 1: The impact of different deep learning models on the risk assessment of cardiovascular disease during pregnancy.

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This article applies convolutional neural networks and recurrent neural networks to the training of physiological data of pregnant women, and evaluates the accuracy and recall of the model. In the specific implementation, a random partition cross validation method is used to divide the sample dataset into a training set and a testing set.

(3) Experiment 2: Comparison of performance between traditional machine learning algorithms and deep learning algorithms in cardiovascular disease risk assessment during pregnancy and postpartum period.

This article compares traditional machine learning algorithms and deep learning algorithms for the classification task of physiological data of pregnant women in the risk assessment of cardiovascular diseases during pregnancy and postpartum period. The specific implementation is the same as Experiment 1.

(4) Experiment 3: Using different feature extraction methods to classify the risk of cardiovascular disease during pregnancy and postpartum period.

This article applies traditional feature extraction methods and convolutional neural network extraction methods to the training of physiological data of pregnant women, and evaluates the accuracy and F1 score of the model.

(5) Experiment 4: Comparison of performance of different data augmentation techniques in cardiovascular disease risk assessment during pregnancy and postpartum period.

This article applies three different data augmentation techniques, namely rotation, distortion, and cropping, to the training dataset, and then performs classification tasks for deep learning models. At the same time, record the accuracy changes and training time of the model during the training process.

3.2 Experimental Results

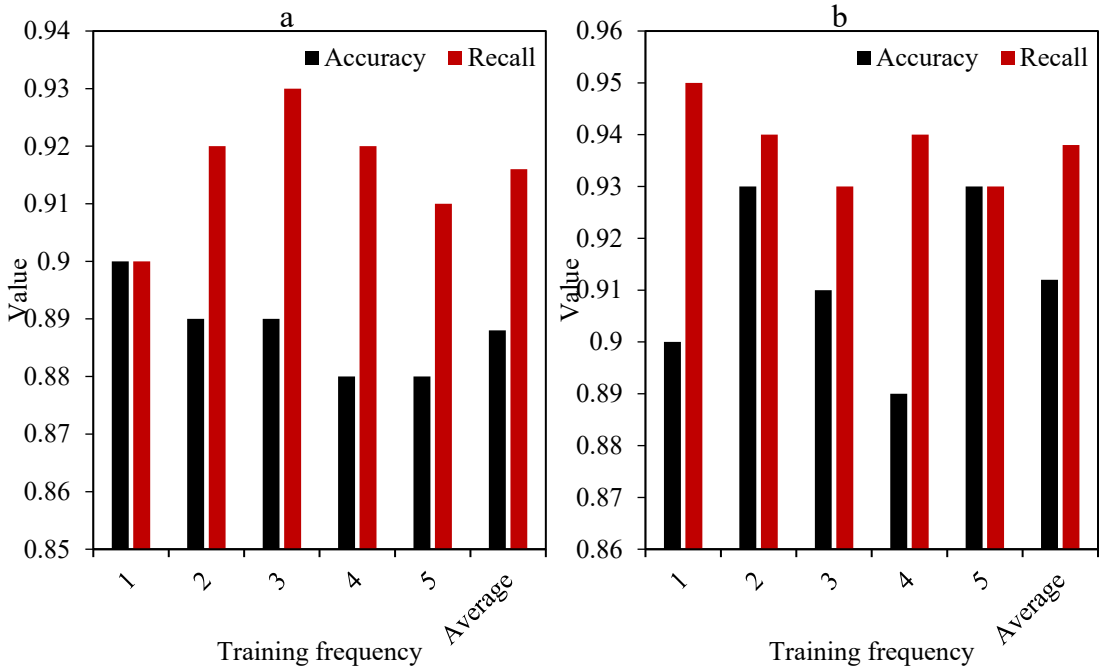

Figure 1 (a) shows a convolutional neural network *Figure 1 (b) shows a recurrent neural network*

Figure 1: Shows the comparative performance of different deep learning models in the risk assessment of cardiovascular disease during pregnancy

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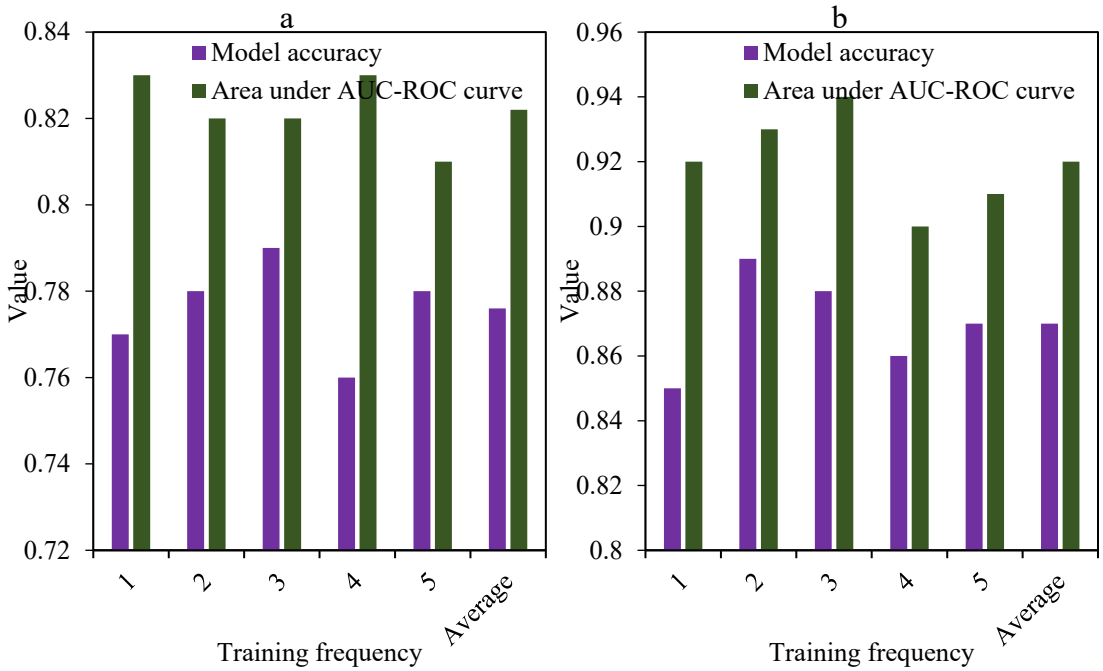

Figure 2 (a) shows the traditional machine learning algorithm
Figure 2 (b) shows the deep learning algorithm

Figure 2: Comparison of performance between traditional machine learning algorithms and deep learning algorithms in cardiovascular disease risk assessment during pregnancy and postpartum period

(1) Comparison of performance of different deep learning models in risk assessment of cardiovascular disease during pregnancy

This article uses two different deep learning models, convolutional neural networks and recurrent neural networks, to train physiological data of pregnant women and classify the risk of cardiovascular disease during pregnancy. Different deep learning models exhibit different performance in assessing the risk of cardiovascular disease during pregnancy. Among them, recurrent neural networks perform better in accuracy and recall compared to convolutional neural networks. As shown in Figure 1, the performance comparison of different deep learning models in the risk assessment of cardiovascular disease during pregnancy is shown. Figure 1 (a) shows a convolutional neural network, and Figure 1 (b) shows a recurrent neural network. In the convolutional neural network model, its accuracy is 0.89 and recall is 0.92; In the recurrent neural network model, its accuracy is 0.91 and recall is 0.94.

(2) Comparison of performance between traditional machine learning algorithms and deep learning algorithms in cardiovascular disease risk assessment during pregnancy and postpartum period

This article compares traditional machine learning algorithms and deep learning algorithms for the classification task of physiological data of pregnant women in the risk assessment of cardiovascular diseases during pregnancy and postpartum period. Compared to traditional machine learning algorithms, deep learning algorithms perform better in both model accuracy and AUC-ROC (Area Under Curve Receiver Operating Characteristic) curve area. As shown in Figure 2, the performance comparison of traditional machine learning algorithms and deep learning algorithms in cardiovascular disease risk assessment during pregnancy and postpartum period is shown. Figure 2 (a) shows the traditional machine learning algorithm, and Figure 2 (b) shows the deep learning algorithm. In traditional machine learning algorithms, the model accuracy is 0.78 and the area under the AUC-ROC curve is 0.82; In the deep learning algorithm, the model accuracy is 0.87, and the area under the AUC-ROC curve is 0.92.

(3) Comparison of performance of different feature extraction methods in cardiovascular disease risk assessment during pregnancy and postpartum period

This article uses traditional feature extraction methods and convolutional neural network extraction methods to train physiological data of pregnant women and classify cardiovascular disease risks during pregnancy and postpartum. The convolutional neural network extraction method performs better in both accuracy and F1 score. As shown in Figure 3, the performance comparison of different feature

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extraction methods in cardiovascular disease risk assessment during pregnancy and postpartum period is shown. Figure 3 (a) shows the traditional feature extraction method, and Figure 3 (b) shows the convolutional neural network extraction. When using traditional feature extraction methods, the accuracy is 0.71, and the F1 score is 0.74; When using convolutional neural networks for extraction, the accuracy is 0.85, and the F1 score is 0.89.

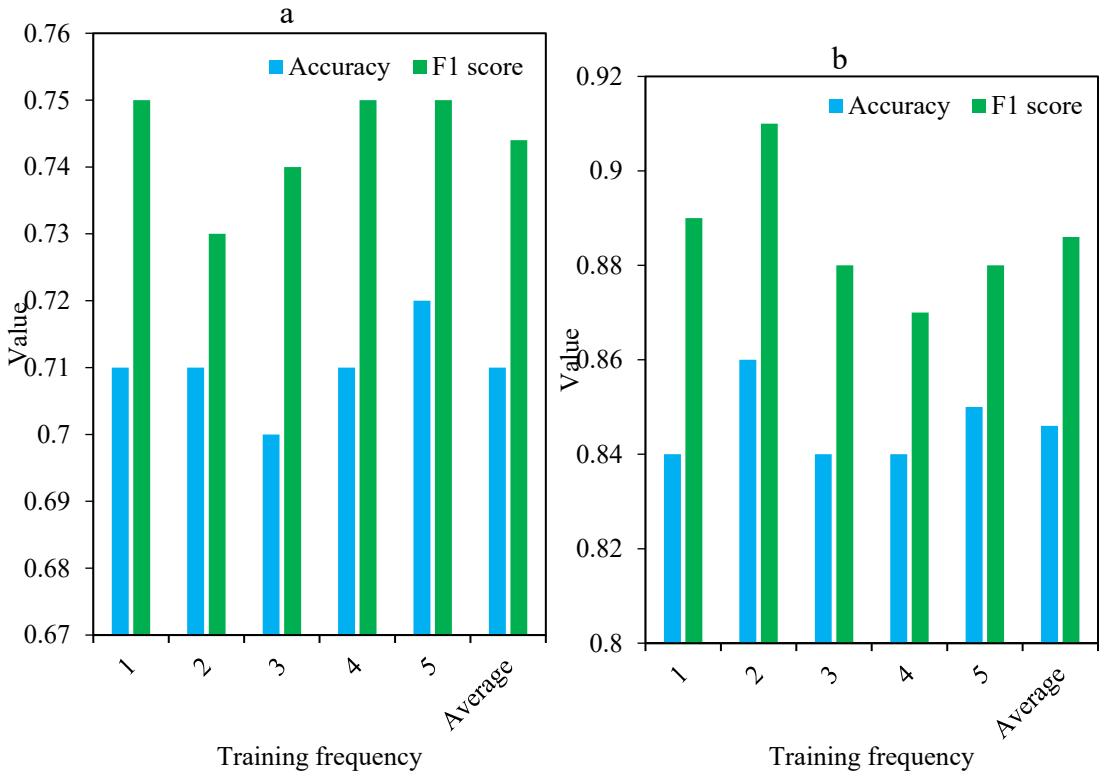

Figure 3 (a) shows the traditional feature extraction method
Figure 3 (b) shows convolutional neural network extraction

Figure 3: Comparison of performance of different feature extraction methods in cardiovascular disease risk assessment during pregnancy and postpartum period

(4) Comparison of performance of different data augmentation techniques in cardiovascular disease risk assessment during pregnancy and postpartum period

This article uses three different data augmentation techniques, including rotation, distortion, and cropping, to process and enhance raw maternal physiological data, and then uses deep learning models for classification. With the continuous increase of data augmentation techniques, the accuracy of the model in cardiovascular disease risk assessment during pregnancy and postpartum is gradually improving, but it also leads to an increase in training time. By balancing model accuracy and training efficiency, the most suitable data augmentation technique can be selected to improve classification performance. Table 1 shows rotation techniques, Table 2 shows twisting techniques, and Table 3 shows cropping techniques. Among them, under the processing of rotation techniques, the model accuracy is 0.82 and the training time is 1.2 hours; Under the processing of distortion techniques, the model accuracy is 0.85 and the training time is 2.5 hours; Under the processing of cropping techniques, the model accuracy is 0.87 and the training time is 3.1 hours.

In summary, for the risk assessment of cardiovascular diseases during pregnancy and postpartum, recurrent neural networks should be selected for training; Compared with traditional machine learning algorithms, deep learning algorithms have better performance; In terms of feature extraction, convolutional neural network extraction methods are superior to traditional feature extraction methods; Data augmentation techniques can help models achieve better classification results, but they also increase training time. Therefore, when using deep learning technology to analyze physiological data of pregnant women for risk assessment of cardiovascular diseases during pregnancy and postpartum period, appropriate deep learning models, feature extraction methods, and data augmentation techniques can be selected based on actual needs. At the same time, it is necessary to pay attention to the changes in training time and the balance between model performance and training efficiency.

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Table 1: Rotation

	Model accuracy	Training time (hours)
1	0.83	1.3
2	0.82	1.2
3	0.82	1.2
4	0.82	1.2
5	0.83	1
Average	0.82	1.2

Table 2: Twisting

	Model accuracy	Training time (hours)
1	0.85	2.7
2	0.87	2.5
3	0.85	2.5
4	0.84	2.6
5	0.84	2.4
Average	0.85	2.5

Table 3: Cropping

	Model accuracy	Training time (hours)
1	0.86	3.1
2	0.89	3.1
3	0.88	2.9
4	0.87	3.3
5	0.86	3
Average	0.87	3.1

4. Conclusions

Pregnant women's cardiovascular diseases are affecting more and more women's health globally, and also have a significant impact on the health of fetuses and newborns. In recent years, with the rapid development of information technology, more and more medical data has been collected and utilized, providing scientists with better research tools. Deep learning technology can identify patterns and patterns hidden behind a large amount of data through learning and modeling. In the medical field, deep learning technology can be applied to medical image analysis, medical signal processing, and bioinformatics, helping to improve doctors' diagnostic accuracy and treatment effectiveness. This article explores the application effects of different deep learning models, feature extraction methods, and data augmentation techniques in pregnant women's cardiovascular disease risk assessment through experiments. The experimental results indicate that recurrent neural networks should be chosen for training, and compared to traditional machine learning algorithms, deep learning algorithms have better performance; The convolutional neural network extraction method is superior to traditional feature extraction methods; Data augmentation techniques can help models achieve better classification results, but it is necessary to pay attention to changes in training time and choose the most suitable data augmentation technique based on actual needs. These results provide important references for the rational application of deep learning technology in the risk assessment of cardiovascular disease in pregnant women.

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