Prediction model of physical activity level and diabetes mellitus based on artificial neural network

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Abstract. Objective: clinical practice shows that the control and treatment of chronic diseases, in addition to drugs, exercise health management is more significant, but also the cheapest, no side effects, thorough intervention. It has been proved many times that exercise can control and prevent chronic diseases. Through the related research of sports intervention, because the researcher selects the experimental object and the movement type difference, thus obtains the different research conclusion. Different types of people use different types of exercise, to achieve different exercise results, especially in the group of chronic patients. Therefore, to discuss the establishment of evaluation and selection system of exercise mode in chronic disease exercise management is the time requirement of health promotion for the aged patients. Methods 1242 patients with different degrees of diabetes in Henan Province were selected and their informed consent was obtained. Using the physical activity scale (IPAQ) and the long form questionnaire, the questionnaire was issued and collected from July 1, 2020 to December 31, 2020 by the uniformly trained physical examination physician, the data were analyzed by artificial neural network. Results: this study has found a certain correlation between diabetes and physical activity level whose data is incomplete, but has showed an overall positive correlation.

1. Introduction
Along with the development of the population ageing, the World Health Organization has developed the concept of healthy ageing, which emphasizes the individual health, physical health, mental health and good social adaptation of the elderly, the control and prevention of chronic diseases is one of the important connotations of healthy aging. In 2020, China's elderly population will rapidly increase to 260 million, until 2030, 2050, China will enter the most severe stage of aging. At the same time, the number of people with chronic diseases is increasing with the aging of the population. China's chronic disease prevention and control plan (2012-2015) shows that the number of people diagnosed with chronic diseases has reached 260 million, accounting for 85 percent of all deaths in the country. The prevalence of diabetes, for example, is still on the rise and is getting younger. Therefore, the World Health Organization stressed: sit less activity is the current frequency of chronic diseases of the first independent risk factors. At present, 88% of adults in our country do not exercise enough, "less exercise"
has become an important risk factor of overweight, obesity and chronic disease. Clinical practice has shown that sports and fitness management have a more significant effect on control and treatment of chronic diseases except the drugs, which is also the cheapest and thorough intervention without any side effect. It has been proved many times that exercise can control and prevent chronic diseases.

2. Literature Review

Review the existing research results, regular exercise can achieve diabetes, hypertension, obesity, dyslipidaemia and other chronic disease control, while reducing the incidence of cardiovascular disease and mortality. As early as 1926, Lawrence reported on experimental studies in which exercise helped diabetics control their blood sugar. Subsequently, the Diabetes Treatment "troika" theory was proposed by American diabetes scientist Joslin, the "Troika" is exercise, insulin treatment, Diet Control. Along with the cognition and development of the diabetes treatment, gradually developed to the world recognized "five carriages" of diabetes treatment, namely Diet Control, exercise therapy, drug treatment, blood sugar monitoring, and diabetes education. Exercise, especially compliance exercise, is considered to be one of the most valuable methods for the treatment of diabetes, and is an important component of disease management in patients with type 2 diabetes. Exercise therapy not only plays an extremely important role, but is also a natural intervention without side effects. So the American Diabetes Association in the 58th annual meeting, "exercise is the best medicine to treat diabetes," the conference slogan, in the treatment of diabetes, exercise therapy is referred to a very high status. Bai Yongzheng (2007) et Al. (2007) found that long-term aerobic exercise has the same hypoglycaemic effect on Type 2 diabetes as drugs. Shen Wenqing (2018) has demonstrated that exercise and Metformin alone can control blood glucose concentration in type 2 diabetes Mellitus, but their combined effects on Blood Glucose concentration are contradictory, both promoting and inhibiting, [7] the molecular mechanism is not clear. In the study of blood pressure control by exercise, it is generally believed that aerobic exercise has a good effect of reducing blood pressure. The effect of single aerobic exercise can last for 24 hours, but the effect of resistance exercise is controversial. The main types of exercise include aerobic training (AT) and resistance training (RT), in which sugar and fat, as the main energy-providing substances, are broken down into water and carbon dioxide with sufficient oxygen supply, is a long time, low intensity, long distance periodic movement [8] . RT is the use of muscle contraction resistance to overcome certain external resistance movement, resistance is gravity, special equipment, elastic band from others or their own force [9]. At present, the duration of exercise intervention for prediabetes is shorter (3 ~ 6 months). The long-term effect of AT and RT on reducing the risk of cardiovascular disease in prediabetes needs to be further clarified. Diabetic Peripheral neuropathy disease (DPN) is a common and common chronic complication in patients with diabetes Mellitus. Sensory and motor, neurological impairment in patients with DPN, characterized by abnormal sensation at the extremities, numbness of the extremities, impaired tendon reflexes and other symptoms [12], resulting in decreased proprioception, impaired balance, increased risk of falls and injury. Recent studies at home and abroad have shown that exercise is an irreplaceable means of rehabilitation for patients with DPN. Reasonable exercise can regulate insulin sensitivity, lower blood sugar, improve lipid metabolism, lower body weight, improve body VO2 Max, increase heart and lung function, improve exercise function and balance ability.

Through the related research of sports intervention, because the researcher selects the experimental object and the movement type difference, thus obtains the different research conclusion. Different types of people use different types of exercise, to achieve different exercise results, especially in the group of chronic patients. Therefore, to discuss the establishment of evaluation and selection system of exercise mode in chronic disease exercise management is the time requirement of health promotion for the aged patients.

3. Study subjects

In this study, 1242 patients with different degrees of diabetes were selected from the Physical Examination Department of Henan People's Hospital, and their informed consent was obtained.
4. research methods

4.1. Questionnaire survey method
The questionnaire was distributed and collected from July 1, 2020 to December 31, 2020, using physical activity scale (IPAQ), which is suitable for 18-65-year-old adults and divided into five parts, the first four sections asked about occupations, housework, transportation schedules, the frequency and duration of moderate and heavy physical activity in leisure time, and the fifth section asked about sitting times during the working and rest days. Using a long form of questionnaire, to check everyone to fill in.

4.2. Law of documentation
Through China Knowledge Network, Wanfang database, PubMed, SCI, Baidu academic and other databases, combined with offline libraries and other search of physical activity level, diabetes and other key words of domestic and foreign journals, research reports, books and other materials, forming the theoretical basis and research design. The data of 1242 patients with different degree of diabetes in Henan Province were obtained from the medical examination data of Henan People's Hospital.

4.3. Artificial neural network method
LSTM can effectively solve the long-term dependence of RNN on gradient explosion and gradient disappearance, and can also predict the modeling problem on Long Time Series, the retention and long-term memory of time series. The Gate structure of LSTM has the ability of deleting and adding information, so we can use the effective information in the experiment data efficiently.

Figure 1 LSTM network structure

The basic theory of LSTM network: The main structure of LSTM memory unit is gate and memory cell, gate also includes: input gate, output gate, forgetting gate. Gate structure can effectively retain and filter information, so memory cells can be maintained and updated.

Forgetting Gate takes the input information $x^{(t)}$ of the current time and the hidden state of the previous time $h^{(t-1)}$ as the input of the activation function sigmoid, thus producing the weighted output value $f^{(t)}$ between $[0, 1]$. The weight value is the probability of the cell state above the memory cell forgetting door, which controls how much information is retained $f^{(t)}$ by multiplying the cell state above $C^{(t-1)}$ the memory cell.

$$f^{(t)} = \sigma(W_f[h^{(t-1)}, x^{(t)}] + b_f)$$

(1)
The input gate uses the sigmoid activation function and the Tanh activation function to control the value of the new input information that can enter the cell state. Where the Tanh activation function generates new memory cells $C(t) = \tanh(W_a \cdot [h^{(t-1)}, x^{(t)}] + b_a)$ (3) and the sigmoid activation function generates a weight between $[0,1]$ that controls the amount of information entering the cell state. We can effectively combine an input gate with a forgetting gate to create a new cellular state $C(t)$.

$$i(t) = \sigma(W_i \cdot [h^{(t-1)}, x^{(t)}] + b_i)$$ (2)

$$C(t) = f(t) \cdot C^{(t-1)} + i(t) \cdot \tilde{C}(t)$$ (4)

The output gate uses the Tanh activation function to process the current cell state $C(t)$ to get the information value of the cell state to the next moment, and uses the sigmoid activation function to get the weight value $o(t)$ to control the filtering degree of the cell state, and eventually get the hidden message $h(t)$ of the next time.

$$o(t) = \sigma(W_o \cdot [h^{(t-1)}, x^{(t)}] + b_o)$$ (5)

$$h(t) = o(t) \cdot \tanh(C^{(t-1)})$$ (6)

4.4. Logical analysis

Comprehensive Questionnaire Survey and research results, combined with Literature Review, logical analysis of the problems and phenomena, concluded the research conclusions.

5. Research findings

5.1. Regression between the prevalence of diabetes Mellitus and the level of physical activity

| Risk of diabetes | Regression Coefficient | Standard error | Z value | P>|z| | 95% Conf.Interval |
|------------------|------------------------|---------------|---------|------|-------------------|
| Gender           | 0.5870338              | 0.1383051     | 4.24    | 0.000| 0.3159608 0.8581068|
| Age              | 0.0098026              | 0.0045707     | 2.14    | 0.032| 0.0008441 0.018761|
| BMI              |                        |               |         |      |                   |
| Obesity          |                        |               |         |      |                   |
| Overweight       | 5.712798               | 1.004575      | 5.69    | 0.000| 3.743866 7.681729 |
| Normal           | 9.016002               | 1.046786      | 8.61    | 0.000| 6.96434 11.06766 |
| Thin             | 7.034542               | 1.678711      | 4.19    | 0.000| 3.744328 10.32476 |
| Physical activity|                        |               |         |      |                   |
| Low              | -7.086492              | 1.014925      | -6.98   | 0.000| -14.1729850       |
| High             | -10.89414              | 1.090233      | -9.99   | 0.000| -21.7882840       |
| Constant term    | -0.957048              | 0.3058311     | -3.13   | 0.002| -1.9140960        |
Table 1 clearly shows that there is a significant correlation between the level of physical activity and diabetes.

5.2. Batch increase model for predicting the risk of diabetes by physical activity level

![Batch increase model diagram](image)

Figure 2 Batch increase model diagram

It can be seen from the loss function that the Loss value gradually decreases as the Batch becomes larger, the loss value drops the fastest at [0,200], the loss value drops relatively slowly at [200,600], and the Loss value tends towards [600,1000] in a stable state, this indicates that the model training is stable. The smaller the Loss value, the closer to zero, the better the model's predictive ability.

5.3. The prediction model of physical activity level for predicting the risk of diabetes

![Diabetes test data set](image)

Figure 3 Diabetes test data set

Select 55 cases of diabetes samples as the test data set, the red is the standard result, and the blue curve is the predicted result. From the figure, we can see that the difference between the prediction method
used in this article and the actual result is small. The data can effectively predict the occurrence of diabetes.

5.4. **ROC of the predictive model for predicting the risk of diabetes by the level of physical activity**

When the artificial neural network is calculated, it is divided into diabetic and non-diabetic patients, so the roc curve is used to describe the prediction result. For the true positive rate on the ordinate and the true negative rate on the abscissa, the closer the enclosed area is to 1, the better the prediction result. The ROC value of this model is 0.92, which shows that the prediction effect is better.

![ROC curve diagram](image)

Figure 4 ROC curve diagram of the prediction model of the level of physical activity predicting the risk of diabetes

6. **Discussions**

The regression analysis of the different physical activity levels of diabetic and non-diabetic people shows that the level of physical activity is highly correlated with the prevalence of diabetes. At the same time, through the deep learning and training of the artificial neural network, it is known that the level of physical activity and the diabetes risk prediction model are highly reliable. This conclusion provides a certain reference for the clinical prediction and management of diabetic patients, and reminds people to pay attention to the problem of disease prediction. At the same time, this study still has certain shortcomings, such as the age difference of patients and the body composition has not been analysed, and further research is needed.

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