THE EFFECT OF PHYSICAL EXERCISE ON BLOOD SUGAR CONTROL IN DIABETIC PATIENTS

O EFEITO DO EXERCÍCIO FÍSICO NO CONTROLE DO AÇÚCAR NO SANGUE EM PACIENTES DIABÉTICOS

EL EFECTO DEL EJERCICIO FÍSICO SOBRE EL CONTROL DEL AZÚCAR EN SANGRE EN PACIENTES DIABÉTICOS

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ABSTRACT

Introduction: Diabetes is a metabolic disease characterized by hyperglycemia. It is a metabolic syndrome in which blood sugar levels increase due to defects in insulin secretion or impaired function, or even both defects. Object: To understand the effect of diabetic patients in controlling blood sugar through physical exercise, the paper analyzes the correlation between the exercise status and physiological indicators of diabetic patients in our hospital. Methods: We randomly selected 41 diabetic patients and monitored their exercise. At the same time, we check the physiological indicators of the patients after the exercise is completed and analyze the control of blood sugar by sports. Results: After healthy physical exercise, the blood sugar level of diabetic patients tended to stabilize, and the glycosylated hemoglobin level decreased. The blood sugar levels of patients who did not participate in healthy physical exercises were not stable, and their glycosylated hemoglobin levels did not improve. Conclusion: Healthy sports is a simple, easy, safe and effective adjuvant therapy for the prevention and treatment of diabetes, and it is worthy of clinical promotion. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Exercise; Diabetes Mellitus, type 2; Walking; Blood Glucose; Glycated Hemoglobin A.

RESUMO

Introdução: O diabetes é uma doença metabólica caracterizada por hiperglicemia. É uma síndrome metabólica em que os níveis de açúcar no sangue aumentam devido a defeitos na secreção de insulina ou função prejudicada, ou mesmo ambos os defeitos. Objetivo: Para compreender os pacientes diabéticos no controle da glicemia por meio do exercício físico, o artigo analisa a correlação entre o estado de exercício e os indicadores fisiológicos de pacientes diabéticos em nosso hospital. Métodos: Selecionamos aleatoriamente 41 pacientes diabéticos e monitoramos seus exercícios. Ao mesmo tempo, verificamos os indicadores fisiológicos dos pacientes após a realização do exercício e analisamos o controle da glicemia pelo esporte. Resultados: Após exercícios físicos saudáveis, o nível de açúcar no sangue de pacientes diabéticos tendeu a se estabilizar e o nível de hemoglobina glicosilada diminuiu. Os níveis de açúcar no sangue dos pacientes que não praticavam exercícios físicos saudáveis não foram estáveis e os níveis de hemoglobina glicosilada não melhoraram. Conclusão: O esporte saudável é uma terapia adjuvante simples, fácil, segura e eficaz para a prevenção e tratamento do diabetes e merece divulgação clínica. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Exercício Físico; Diabetes Mellitus tipo 2; Caminhada; Glicemia; Hemoglobina A Glicada.*

RESUMEN

Introducción: la diabetes es una enfermedad metabólica caracterizada por hiperglucemia. Es un síndrome metabólico en el que los niveles de azúcar en sangre aumentan debido a defectos en la secreción de insulina o función alterada, o incluso a ambos defectos. Objeto: Para comprender a los pacientes diabéticos en el control de la glucemia a través del ejercicio físico, el trabajo analiza la correlación entre el estado de ejercicio y los indicadores fisiológicos de los pacientes diabéticos en nuestro hospital. Métodos: Seleccionamos aleatoriamente a 41 pacientes diabéticos y monitoreamos su ejercicio. Al mismo tiempo, verificamos los indicadores fisiológicos de los pacientes una vez finalizado el ejercicio y analizamos el control del azúcar en sangre mediante los deportes. Resultados: Después de un ejercicio físico saludable, el nivel de azúcar en sangre de los pacientes diabéticos tendió a estabilizarse y el nivel de hemoglobina glicosilada disminuyó. Los niveles de azúcar en sangre de los pacientes que no participaron en ejercicios físicos saludables no fueron estables y sus niveles de hemoglobina glicosilada no mejoraron. Conclusión: El deporte saludable es una terapia adyuvante simple, fácil, segura y eficaz para la prevención y el tratamiento de la diabetes y es digno de promoción clínica. ***Nivel de evidencia II; Estudios terapéuticos: investigación de los resultados del tratamiento.***

Descriptores: *Ejercicio Físico; Diabetes Mellitus tipo 2; Caminata; Glucemia; Hemoglobina A Glucada.*

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INTRODUCTION

With the development of the economy, people's living standards have improved, and their dietary standards have also improved. However, with the arrival of an aging population and changes in lifestyles, some chronic diseases have also followed. Minister of Health Chen Zhu emphasized that chronic diseases have brought a profound impact on the country's economic and healthy development and pointed out that since chronic diseases have a wide range of harmful factors, it is necessary to mobilize various grassroots governments to strengthen control and leadership, and strictly control chronic diseases. Preventive work can better take on this crucial task. From simple coarse grains to greasy meals, lousy living habits are becoming more and more common, and the time of manual labor is gradually shortening, which leads to the "prosperity disease." Diabetes has become the third leading cause of death in China, just behind cardiovascular disease and malignant tumors. According to data released by the International Diabetes Federation (IDF), more than 425 million diabetes patients worldwide in 2017.

Middle-aged and elderly diabetes are mostly non-insulin-dependent diabetes mellitus (NIDDM), often associated with obesity, hyperlipidemia, hypertension and cardiovascular and cerebrovascular diseases. For obese and non-insulin-dependent diabetes mellitus patients, maintaining regular exercise combined with diet therapy is an effective prevention and treatment measure. We observed the walking effect of 18 DM patients who volunteered to participate in the 6-week exercise.[1] The blood glucose and glycosylated hemoglobin levels before and after exercise were monitored to provide a basis for further community diabetes prevention.

METHOD

Experimental subjects

The experiment subjects were 41 cases of diabetic patients among the staff of the Ministry of Medicine, including 22 males and 19 females, aged 44-78 years old (male: average age 63±1.9 years old, female: 62.0±1.7 years old).

CONTENTS AND METHODS

Investigation of health status and comorbidities

Plasma cholesterol (TC), triglyceride (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL) detection kits were purchased from Beijing Zhongsheng Bioengineering High-tech Company. The comorbidities were counted by questionnaire survey.[2] The nutrition survey adopts the 3-day diet review method.

Detection of blood glucose and other parameters

Fasting blood glucose was measured with a simple blood glucose meter produced by Novo Nordisk. Glycated hemoglobin (HbA1C) was detected using the Boehringer Mannheim system kit made in Germany. The insulin radioimmunoassay kit was purchased from the Institute of Atomic Energy, Chinese Academy of Sciences.

The amount of walking exercise and its monitoring

The experiment requires the subjects to take more than 10,000 steps per day, wear a calibrated pedometer to record (provided by the laboratory), and use a "confidant" energy monitor to test their energy consumption.

Prediction of blood glucose concentration based on a support vector machine

Support vector regression is ultimately to find an objective function to minimize its loss function's mathematical expectation. The most accurate regression curve can be obtained to reflect the training set's data trend.[3] The regression algorithm mainly solves the problem of nonlinear regression prediction. Linear and nonlinear kernel functions can be used to perform regression on the training set. The regression problem can be formalized as Given a specific training set, its elements have an unknown distribution $p(x, y)$, and the observations are:

$$X = \{(x_1, y_1), (x_2, y_2), \cdots, (x_i, y_i)\}, x_i \in R^n, y_i \in R \quad (1)$$

And a family of functions:

$$F = \{f \mid f; R^n \to R\} \quad (2)$$

$$R_{ridge} = R_{emp} + k\|\omega\|^2 \quad (3)$$

For the linear function set:

$$F = \{f \mid f(x) = (\omega, x) + b, \omega \in R^n\} \quad (4)$$

Introduce the following structural risk function:

$$R_{reg}[f] = C \cdot R_{emp}{}^{\varepsilon}[f] + \frac{1}{2}\|\omega\|^2 \quad (5)$$

Among them, $\|\omega\|^2$ represents the complexity of function $f(x)$, and C is a constant. Its function is to make a compromise between model complexity and empirical risk. At the same time, an ε–insensitive loss function is designed.[4] According to formula (6), the function regression problem can be transformed into the following optimization problem:

$$\min[\frac{1}{2}\|\omega\|^2 + C\sum_{i=1}^{N}(\xi_i+\xi_i^*)] \quad (6)$$

$$s.t.\begin{cases} f_i - y_i \le \varepsilon + \xi_i \\ y_i - f \le \varepsilon + \xi_i^*, 1 \le i \le N \\ \xi_i, \xi_i^* \ge 0 \end{cases} \quad (7)$$

Here C is the constant to be determined, ξ_i, ξ_i^* is the slack variable, and the value of ε must be set first. According to the KKT condition, the linear fitting equation can be obtained:

$$f(x) = \omega^T x + b \quad (8)$$

For nonlinear regression, keeping the above strategy unchanged, first, use a nonlinear mapping Φ to map the data from the original space R^n to a high-dimensional feature space Ω, and then establish a linear regression function in the high-dimensional feature space Ω, namely:

$$f(x) = \omega^T \phi(\cdot) + b \quad (9)$$

The kernel function $k(x_i, y_i)$ corresponds to the inner product of the data mapped to the feature space, namely:

$$k(x_i, y_i) = \varphi(x_i).\varphi(x_j) \quad (10)$$

Therefore, the nonlinear function can be expressed as follows:

$$f(x) = \sum_{i=1}^{N}(a_i^* - a_i)K(x_i, x_j) + b \quad (11)$$

Here the coefficient $a_i^*, a_i \in R$ is determined by solving the quadratic programming problem. The point (x_i, y_i) of $a_i^* - a_i \neq 0$ is called the support vector and b is obtained by the KKT condition.

Statistical analysis

The study results are expressed as $\overline{x} \pm s$ and percentages, and comparisons between samples are performed by t-test.

RESULTS

Body mass index (BMI), body fat level and comorbidities of diabetic patients

Body mass index (BMI), body fat level and obesity rate

The BMI index is an international standard for measuring human obesity or whether it is in good health. It is an index that uses height to evaluate one's weight. The World Health Organization (WHO) pointed out that 19-25 is the BMI index's usual range. Chinese puts forward the limit value of the BMI index for Chinese people in the "Guidelines for the Prevention and Control of Overweight and Obesity in Chinese Adults." Table 1 shows that the incidence of obesity in diabetic patients is as high as 50%.

Blood lipid status

The average cholesterol levels of 22 males and 19 females with diabetes were 5.17±0.98mmol (200±38mg/dL) and 5.67±0.83mmol/L (219±32mg/dL), and the average triglyceride levels were 2.19±1.30mmol/L (194±115mg/dL) and 2.48±1.64mmol/L (220±145mg/dL). The results show that most of the tested patients have increased blood lipids, the detection rate of hypercholesterolemia is 46.2%, and the detection rate of hypertriglyceridemia is 84.6%. Therefore, it is important and necessary for patients to reduce fat intake. Sex.

Occurrence of comorbidities

Most diabetic patients suffer from various comorbidities, mainly infectious diseases, eye diseases, and cardiovascular and cerebrovascular diseases. This is related to changes in the functional state of various organs caused by high blood sugar status and triggers various comorbidities.[5] The results suggest that people with diabetes should control the glycemic index to prevent and reduce complications. (Table 2)

The nutritional status of the subjects

It can be seen from Table 3 and Table 4 that diabetic patients pay more attention to controlling total energy intake under the guidance of doctors. Still, according to the newly released domestic dietary nutrient reference intake assessment, the patients' vitamin A, B1, and B2 are mildly insufficient.[6] There are insufficient calcium and zinc in inorganic salts, and there are also insufficient iron, copper and selenium in female patients. Besides, there are nutritional problems such as high fat intake and low fiber intake.

Table 1. Body fat, body mass index and obesity detection rate of diabetic patients.

Gender	Number of cases	Body fat (%)	Body Mass Index (BMI)	Obesity rate (%)
Male	22	30.79±7.03	25.01±3.49	50.00
Female	19	34.41±8.85	25.79±3.48	52.63

Table 2. Incidence rates of various comorbidities in 44 diabetic patients tested.

Comorbidity name	Incidence rate (%)
Cardiovascular and cerebrovascular disease	30.4
Kidney disease	8.7
Eye disease	47.8
Neuropathy	39.1
Skin lesions	17.4
Infectious disease	52.2

Table 3. Diabetics' intake of energy, three significant nutrients and fiber.

Gender	Number of cases	Protein		Fat	
		Intake (g)	Heat energy ratio (%)	Intake (g)	Heat energy ratio (%)
Male	22	89±29	18	65±33	29
Female	19	70±21	16	70±33	35
Gender	**Number of cases**	**Carbohydrate**		**Cellulose (g)**	**Total calories (Kcal)**
		Intake (g)	**Heat energy ratio (%)**		
Male	22	260±86	52	11±7	1985±591
Female	19	216±52	49	12±6	1771±432

Table 4. The intake of vitamins and inorganic salts in the tested diabetic patients.

Project	Male	Female
Vitamin A (μg)	449±344	483±306
Carotene (μg)	1348±2007	1746±1595
Retinol equivalent (mg)	675±676	774±564
Vitamin B1 (mg)	1.08±0.35	1.00±0.33
Vitamin B2 (mg)	1.15±0.35	1.08±0.17
Vitamin PP (mg)	19.37±8.32	17.01±9.45
Vitamin C (mg)	101±114	94±62
Vitamin E (mg)	21±12	21±11
Potassium (mg)	2157±1092	1930±611
Sodium (mg)	2272±1618	1556±1388
Calcium (mg)	695±341	563±224
Magnesium (mg)	350±131	323±112
Iron (mg)	19.6±8.8	17.9±7.2
Manganese (mg)	4.61±1.60	4.01±1.43
Zinc (mg)	11.61±3.58	9.92±2.48
Copper (mg)	2.10±0.89	1.60±0.71
Selenium (μg)	60.75±32.44	45.22±24.44

Subjects' blood glucose, glycosylated hemoglobin and insulin levels

The fasting blood glucose level of diabetic patients is higher than the average level (>7mmol/L, equivalent to 126mg/dl), and the average value of glycosylated hemoglobin is also higher than the normal range (2.9-4.6%).

The effect of walking on blood sugar and glycosylated hemoglobin levels in diabetic patients

According to statistical analysis, the activity level of diabetic patients is 11959±2751, and the energy consumption is 379±127Kcal. The blood glucose level of 18 diabetic patients did not change significantly before and after walking exercise, and the performance of glycosylated hemoglobin decreased. Still, it did not reach a significant level, P>0.05.

Blood glucose prediction results

Experiments have found that if the model parameters are arbitrarily selected for prediction, the prediction accuracy will be very low. For example, if the step size is 1 step, the average relative error can reach 0.1808. Therefore, the paper wrote an optimization algorithm to optimize the parameters.[7] Experiment 1 uses 171 continuous data as samples, with three inputs and one output for each group of samples, and the prediction step is 1.

DISCUSSION

NIDDM is a common type of diabetes, accounting for more than 90% of the incidence of diabetes. Obesity, hyperlipidemia, and diabetes are closely related and often coexist. Our research results show that the incidence of obesity in the diabetic population is higher, with an average of 50%. This investigation shows that the popularization of diabetes prevention and treatment knowledge and diabetes patients with higher education levels can take the initiative to control diet and appropriate exercise, and the blood sugar level can be maintained at a relatively stable level.[8]

Studies have confirmed that exercise can increase muscle glycogen synthesis and increase the phosphorylation of glucose transport in muscle cells stimulated by insulin.[9] Exercise can directly improve the abnormal lipid metabolism associated with abdominal obesity syndrome and adjust the composition of plasma lipoproteins. Exercise can improve fiber Protein activity. Exercise enhances insulin activity.[10] Exercise increases the glucose transporter GLUT4 and plasma membrane GLUT4, which mediates glucose transport in skeletal muscle and adipose tissue. Recent studies in our laboratory have also observed that exercise can increase insulin receptor and leptin receptor Body function and expression, improve sugar, fat and energy metabolism, and increase insulin sensitivity and reduce insulin resistance.

CONCLUSION

As a low-intensity exercise, walking is easy to master and easy to integrate with daily life. It is a practical and ideal adjuvant treatment for diabetes, and it has been proven to be beneficial to cardiovascular health. In this study, observing diabetic patients, the daily energy consumption reached 300-400Kcal with more than 10,000 steps. The daily energy consumption of diabetic patients over 70 years old reached 240Kcal for six weeks, and no side effects were seen. Mild diabetic patients have a good effect on controlling blood sugar levels and reducing A1C, but the effect is not apparent for severe diabetic patients.

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REFERENCES

1. Moser O, Eckstein ML, West DJ, Goswami N, Sourij H, Hofmann P. Type 1 Diabetes and Physical Exercise: Moving (forward) as an Adjuvant Therapy. Curr Pharm Des. 2020;26(9):946-57.
2. Yang D, Yang Y, Li Y, Han R. Physical Exercise as Therapy for Type 2 Diabetes Mellitus: From Mechanism to Orientation. Ann Nutr Metab. 2019;74(4):313-21.
3. Du MC, Ouyang YQ, Nie XF, Huang Y, Redding SR. Effects of physical exercise during pregnancy on maternal and infant outcomes in overweight and obese pregnant women: A meta-analysis. Birth. 2019;46(2):211-21.
4. Turner G, Quigg S, Davoren P, Basile R, McAuley SA, Coombes JS. Resources to Guide Exercise Specialists Managing Adults with Diabetes. Sports Med Open. 2019;5(1):20.
5. Morales JS, Valenzuela PL, Pareja-Galeano H, Rincón-Castanedo C, Rubin DA, Lucia A. Physical exercise and Prader-Willi syndrome: A systematic review. Clin Endocrinol (Oxf). 2019;90(5):649-61.
6. Aljawarneh YM, Wardell DW, Wood GL, Rozmus CL. A Systematic review of physical activity and exercise on physiological and biochemical outcomes in children and adolescents with type 1 diabetes. J Nurs Scholarsh. 2019;51(3):337-45.
7. Pedersen BK. Physical activity and muscle-brain crosstalk. Nat Rev Endocrinol. 2019;15(7):383-92.
8. Reddy R, Wittenberg A, Castle JR, El Youssef J, Winters-Stone K, Gillingham M, et al. Effect of aerobic and resistance exercise on glycemic control in adults with type 1 diabetes. Can J Diabetes. 2019;43(6):406-414.e1.
9. Murphy MH, Lahart I, Carlin A, Murtagh E. The effects of continuous compared to accumulated exercise on health: a meta-analytic review. Sports Med. 2019;49(10):1585-607.
10. Artsanthia J, Sari NPWP. The Effects of Meditation-Healing Exercise in Elderly Who are Living with Non-Communicable Disease in Bangkok and Surabaya. Journal of the Royal Thai Army Nurses (JRTAN). 2019;19(1):74-83.