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Changes of serum trace elements in patients with type 2 diabetes mellitus

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Abstract: **To investigate the changes of serum trace elements in patients with type 2 diabetes mellitus (T2DM), and to provide evidence for the prevention, control and treatment of type 2 diabetes mellitus. A cross-sectional study was conducted in 50 patients with diabetes mellitus and 50 healthy controls. The contents of trace elements in serum were determined by inductively coupled plasma mass spectrometry (ICP-MS). T test was used to analyze the difference of serum trace element levels between type 2 diabetic patients and healthy controls. Compared with the healthy control group, the body weight and BMI of the diabetic group were increased significantly ($P<0.05$), serum B and V levels were significantly lower in diabetic patients ($P<0.05$), and serum Co and Mo contents were not statistically significant ($P>0.05$).**

Keywords: Serum trace elements; Type 2 diabetes mellitus; inductively coupled plasma mass spectrometry

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1. Introduction

Type 2 diabetes mellitus is a common endocrine disease or a chronic metabolic disorder. The endocrine changes are mainly the absolute or relative deficiency of insulin secretion. The metabolic disorder is mainly caused by disorder of glucose metabolism, and the clinical features are hyperglycemia and high urine sugar. In recent years, with the improvement of people's living standards, lifestyle changes and the acceleration of population aging, the incidence of diabetes mellitus in the world is increasing year by year[1]. In 2017, the International Diabetes Alliance reported that there are about 425 million people with diabetes worldwide, an increase of 10 million over 2015[2]. There are expected to be nearly 700 million people with diabetes, with the fastest growth in low-income countries by 2045[3].

Trace elements are the basic components of organisms, which participate in a variety of human biochemical reactions. Trace elements are the components of many enzymes, or auxiliary factors used by enzymes, and play an irreplaceable role in the human body[4]. Trace elements are involved in the functional structure of tissues, cells and sub-cells, including immune regulation of cellular mechanisms, nerve conduction, muscle contraction, mitochondrial activity and enzyme response [5]. For example, chromium, manganese, iron, cobalt, zinc, selenium, copper and molybdenum are trace elements involved in human biochemical reaction; arsenic, cadmium, mercury, thallium and lead are toxic trace elements to human body when excessive; chromium, manganese, iron, cobalt, zinc, selenium, copper and molybdenum are trace elements involved in human biochemical reaction. Vanadium, nickel, tin, antimony, tungsten and barium are potential essential trace elements for human body. Studies have shown that the metabolism of trace elements has changed in type 2 diabetes mellitus patients, these elements may play a specific role in the pathogenesis and development of type 2 diabetes mellitus[6]. At present, it is generally accepted that the changes of trace elements may be due to the long-term uncontrolled hyperglycemia, or some trace elements may be involved in the regulation of glucose homeostasis[7].

In this study, electric microwave digestion method was used for pretreatment and inductively coupled plasma mass spectrometry (ICP-MS) was used for element detection. Among them, microwave digestion has the advantages of good reproducibility, high accuracy, energy saving, safety and so on[8]. ICP-MS has the advantages of simple and rapid operation, small sampling, very low detection limit, simultaneous determination of many elements and so on.

The purpose of this study is to analyze the difference of trace elements in serum between type 2 diabetes mellitus and healthy control group, and to provide reference for the intervention of trace elements in patients with long-term diabetes mellitus.

2. Materials and Methods

2.1. Research object

Fifty type 2 diabetes mellitus patients and fifty healthy controls were selected into this study. The mean age was (51.32 ±11.52) years, with 75 males (mean age 52.46 ±11.32years) and 25 females (mean age 50.25±12.36 years). The diagnostic criteria of diabetes mellitus refer to the criteria recommended by the World Health Organization in 1999, that is, diabetic symptoms, fasting blood glucose ≥ 7.0 mmol/L, or 2 h blood glucose after glucose load or random blood glucose ≥ 11.1 mmol/L.

2.2. Reagents

Nitric acid (organic purity); Ultra-pure water (resistivity 18.2 Ω. Cm); 10ug/mL multi-element standard solution: B, V, Co, Mo; 1ug/L turning solution: Ge, Co, Li, Mg, TI, Y; 100mg/L internal standard solution: Bi, Ge, In, Sc.

2.3. Sample Preparation

Fasting venous blood samples were collected from patients with type 2 diabetes mellitus and healthy controls. The collected blood was centrifuged by 3000r/min, and then the upper serum was divided into 1.5mL centrifugal tube. The serum samples were stored at − 80 °C until they were required for determination of the trace elements.

2.4. Determination of trace elements

500μL serum was added to 5mL 65% nitric acid solution and put into micro-wave deconstruction. The digested solution was transferred to polypropylene test tube and the volume was fixed to 15mL. At the same time, the blank experiment was carried out, the external standard correction standard curve method was used to quantify, and the internal standard was used to correct the matrix interference and drift.

2.5. Statistical Analysis

Data were analyzed using SPSS17.0 software. The measurement data that conformed to the normal distribution were expressed by x ± s. χ^2 test was used to compare the qualitative data between groups. The t-test was used for comparison between groups. The difference was statistically significant at P<0.05.

3. Results

3.1. Comparison of characteristics between healthy controls and diabetic patients

A total of 100 people were collected during the study period, including 50 diabetic patients and 50 healthy controls, aged between 20 and 69 years, 75 males and 25 females. Compared with the healthy control group, the body weight and BMI of the diabetic group were increased significantly. The difference was statistically significant (P<0.05). There was no significant difference in age, sex and height between the two groups (P>0.05) (Table 1).

3.2. Comparison of serum trace elements between healthy controls and diabetic patients

Compared with healthy controls, serum B and V levels were significantly lower in diabetic patients (P<0.05), and serum Co and Mo contents were not statistically significant (P>0.05) (Table 2).

Table 1. Characteristics of study subjects (x±s)

	Control group	DM group	t/χ2	*P*
N	50	50		
Age, y	50.69±10.99	51.23±12.35	0.91	0.36
Sex			2.05	0.15
Male（n,%）	37(74)	38(76)		
Female (n, %)	13(26)	12(24)		
Height, cm	167.53±8.30	169.33±7.67	1.35	0.18
Body weight, kg	62.51±7.78	70.77±9.77	4.32	＜0.01
BMI, kg/m^2	22.22±1.74	24.54±2.97	4.60	＜0.01

Table 2. Comparison of serum trace elements between study subjects(x±s)

	Control group	DM group	t	*P*
B	58.69±25.54	50.02±24.12	-2.35	0.01
Co	0.25±0.38	0.25±0.35	-0.02	0.68
Mo	2.25±1.23	2.20±1.19	-0.746	0.362
V	9.21±2.30	8.32±2.24	2.731	0.01

4. Discussion

Diabetes mellitus is a metabolic disorder caused by a variety of etiology. The complications of diabetes mellitus can involve multiple organs[9] .The occurrence of diabetes is also caused by the participation and interaction of a variety of risk factors. In this study, the basic characteristics of the diabetic group and the control group were compared. The body weight and BMI in the diabetic group were also significantly higher than those in the control group, suggesting that diabetic patients tended to be obese. Studies have shown that the prevalence of obesity in patients with type 2 diabetes is about 80% ~ 95%[10]. The health risks associated with obesity are mainly caused by abdominal fat deposition, which is an independent cardiovascular risk factor[11].There was no significant difference in age, sex and height between the two groups.

The study found that serum B and V levels in diabetic patients were significantly lower than healthy controls ($P < 0.05$), serum Co and Mo levels were not statistically significant ($P > 0.05$).Boron is an important nutrient of human and animals. Boron has an important impact on the function of human brain, the regulation of immune system, the structure and function of bone and the metabolism of energy substrate[12]. It can increase the expression and secretion of related enzymes and hormones in the body. These enzymes can maintain the integrity of cell membrane, prevent lipid peroxidation and remove free radicals. Boron can not only promote carbohydrate metabolism, but also has anti-inflammatory, analgesic and promote the development of immune organs and so on[13]. In addition, studies have shown that boron compounds for human cancer (including lung cancer, prostate cancer, cervical cancer, breast cancer, etc.) have effective prevention and treatment. High doses of boron can cause boron poisoning. The toxic effects of boron are mainly neurotoxicity, developmental toxicity and reproductive toxicity, and participate in and affect the metabolic and respiratory process of the human body[14].

Cobalt is mainly used in the form of vitamin B12 and B12 coenzyme, and its main functions in human body include: stimulating hematopoiesis and inhibiting many important respiratory enzymes in fine cells. It also promotes iron metabolism, increases hemoglobin and red blood cell count, participates in the synthesis of vitamin B12 and coenzyme B12, participates in the synthesis of proteins and other substances, and participates in the synthesis of vitamin B12 and coenzyme B12. It is an auxiliary factor of some enzymes and affects the activity of enzymes, which can catalyze hydrolysis, oxidation, polymerization, decarboxylation and so on. It may have anti-tumor effect and some detoxification effects[15].

In this study, it was found that the contents of vanadium were lower in diabetic patients. Study found that the vanadium content in diabetic patients was lower than that in the control group, which was consistent with the results of this experiment[16]. Vanadium can affect all aspects of glucose metabolism, including glucose transport, glycolysis, glucose oxidation and glycogen synthesis. Vanadium has insulin-like effect and can increase the sensitivity of tissues to insulin. Oral sodium vanadate can reduce blood glucose.

Molybdenum is an excessive metal, which can form a variety of valence states. Molybdenum is considered to have insulin-like effect, which can promote glucose metabolism and alleviate the condition of type 2 diabetes mellitus; some scholars have shown that molybdenum can cause toxicity in experimental animals at high molybdenum level[17]. So the real effect of molybdenum may depend on its dose.

5. Conclusion

This study is helpful to understand the pathogenesis of diabetes related to trace element deficiency or excess, and can provide data support for further elucidating the pathogenesis and development process of diabetes related to trace elements. It also provides a theoretical basis for the use of trace elements to prevent and control diabetes mellitus.

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