Study on the Relationship Between Insulin Resistance and Hypertension by Using CHNS Database

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Abstract: To assess the relationship between insulin resistance and hypertension, our team selects 1731 people without clinical high blood pressure by reference to CHNS's large-scale survey in 2009 as a baseline, calculating the insulin resistance index and continuing to observe their hypertension incidence. The results showed that the incidence of hypertension was significantly higher in the insulin-resistant group than in the non-insulin-resistant group.

Keywords: CHNS database, insulin resistance, hypertension

1. Introduction

Hypertension is one of the causes of many cardiovascular and cerebrovascular diseases. At present, China confronts grim situation in the prevention and control of hypertension in China. According to the Guidelines for Prevention and Treatment of Hypertension in China (2018 Revised Edition), the prevalence of hypertension in China is about 27.9% (2012-2015), with the control rate about 16.8%[1]. According to the Hypertension Guidelines of the United States in 2017, the prevalence of hypertension in China was 46.4%, twice the prescribed standard, while the control rate is only 3%[2].

Therefore, exploration on the factors that can easily lead to high blood pressure is necessary, there are many researchers believe that there is a close relationship between insulin resistance and high blood pressure, but there lacks a systematic investigation and epidemiological studies as the basis, so the CHNS database provided by the survey data and statistical methods are adopted in this paper to explore the relationship of insulin resistance and high blood pressure, in order to provide statistical and epidemiological basis for exploration of the relationship between insulin resistance and hypertension.

2. Objects and methods

2.1 Overview of the overall research methods and research objects

To investigate the relationship between insulin resistance and hypertension, the research team adopted data from the Chinese People's Health and Nutrition Survey (CHNS) database for statistical analysis. Based on a large-scale population survey conducted by CHNS in 2009, residents who were not diagnosed with hypertension at that time were selected as the research subjects, and their insulin resistance indicators were calculated according to the survey indicators provided by CHNS, such as fasting blood glucose concentration and fasting insulin level. In the next few investigations, we will continue to pay attention to the incidence of hypertension among people with insulin resistance and those without insulin resistance for analysis with statistical tools, and conclude the relationship between insulin resistance and hypertension after the interference factors were removed.

2.2 CHNS

The China Health and Nutrition Survey (CHNS) is an ongoing international cooperative project between the Population Center of the University of North Carolina at Chapel Hill and the Institute of Nutrition and Health of the Chinese Center for Disease Control and Prevention. This survey was conducted by a team of international researchers whose research backgrounds included nutrition, public health, economics, sociology, Chinese studies and demography. The follow-up rate during the survey was very high, so the data in this database was highly reliable and scientific and suitable for this study[3].

2.3 Judgement criteria for hypertension

According to the Guidelines for Prevention and Treatment of Hypertension in China (Revised Edition in 2018), hypertension in China is currently defined as: systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg measured in the office three times on different days without the use of antihypertensive drugs[1]. Therefore, this is used as the criterion for the judgment of hypertension in this study. Considering that some interviewees take antihypertensive

drugs after being diagnosed with hypertension in the past, all interviewees in this study who were medically diagnosed with hypertension before the survey in 2009 were classified as hypertensive regardless of their blood pressure at the time of the survey.

2.4 Introduction and calculation of insulin resistance and related indicators

The regulation of insulin on blood glucose is mainly reflected in promoting glucose uptake by muscle and inhibiting gluconeogenesis. Insulin resistance or decreased insulin sensitivity occurs when the insulin produced by the body fails to effectively promote glucose uptake and inhibit glucose output. At this time, if the islet function is insufficient to produce enough insulin to lower blood glucose, blood glucose can gradually increase and eventually cause diabetes. If the pancreatic islet compensates by secreting a large amount of insulin to regulate blood glucose, it may cause hyperinsulinemia[4].

At present, there are two methods to measure insulin resistance: direct index and indirect index. Among them, the direct detection indexes mostly adopted the high insulin-glucose clamp technique (HEC) designed by Andres and improved by DeFronzo[5]. However, due to the high cost of testing, demanding requirements for testing personnel in proficiency and other limitations, as well as the fact that CHNS database failed provide relevant data, direct testing indicators were not adopted in this paper.

In this study, fasting blood glucose and fasting insulin data provided by CHNS were used to calculate homeostasis insulin resistance index (HOMA-IR) and quantitative insulin sensitivity index (QUICKI), indirect indicators of insulin resistance, so as to measure the level of insulin resistance of the subjects.

HOMA-IR, as an indirect indicator of insulin resistance, can be made only by measurement of fasting blood glucose level (FPG) and fasting insulin level (FINS) to determine the level of insulin resistance, and its calculation formula is[6]: HOMA-IR=FPG*FINS/22.5 (FPG unit mmol/L, FINS unit μU/ml) According to the formula, the higher the HOMA-IR value, the more serious the insulin resistance. For the interpretation of HOMA-IR numerical results, there is no unified standard in the medical field. Researchers found that there were statistical differences among races at homA-IR pointcuts[7], which has been fully considered and avoided in this study.

Since HOMA-IR is still controversial in the medical field in terms of standards, QUICKI was also adopted for calculation in this study, and the calculation formula is as follows: QUICKI=1/ (log FPG + log FINS) (FPG unit mg/dl, FINS unit μU/mL) According to the formula, the lower the QUICKI value, the more serious the insulin resistance. Meta-analysis has demonstrated that QUICKI index has a better accuracy in predicting the progression of insulin resistance to diabetes than other indexes, and its application scope is basically the same as HOMA-IR. The two indexes are complementary to reduce errors[8].

2.5 Research objects and data collection

In this study, a large-scale survey conducted by CHNS in 2009 was taken as the research baseline. After removing the population originally diagnosed with hypertension, a total of 1731 people distributed in 15 provinces, municipalities and autonomous regions of China were investigated, including 751 males and 980 females. 129 were younger than 30 years old, 686 between 30 and 50 years old and 916 were older than 50 years old.

Available survey indicators cover fasting blood glucose, fasting insulin and blood pressure values, among which the collection method of fasting blood glucose and fasting insulin indicators is community physical examination survey, and the collection method of blood pressure values is achieved in form of questionnaire survey.

2.6 Specific methods of statistical analysis

Statistical analysis was performed with adoption of SAS9.2, based on a large-scale survey conducted by CHNS in 2009. After removing all the people originally suffering from hypertension, 1731 respondents were divided into two groups according to whether HOMA-IR value was greater than 2.8, namely, insulin resistance group (HOMA-IR≥2.8) and normal group (HOMA-IR < 2.8), and the incidence of hypertension in the two groups in 2011 and 2015 was continuously observed. Finally, the data were processed by survival analysis to find the correlation between hypertension and insulin resistance.

In addition, in light of the controversy on HOMA-IR in the medical field in terms of standards, in this study, all the subjects were re-grouped according to whether or not the QUICKI value was greater than 0.339 (the group with QUICKI≤0.339 was the insulin resistance group, QUICKI > 0.339 was the non-insulin resistant group), which verified the relationship between insulin resistance and hypertension from another perspective.

In order to avoid the influence of gender, age, hemoglobin, serum magnesium level and other interfering factors, Cox proportional risk regression model was adopted in this study to avoid the factors that may affect the research results.

3. Results

3.1 Survival analysis

The survival analysis results of hypertension in the two groups in 2011 and 2015 were shown in Figure 1 and Figure 2 respectively.
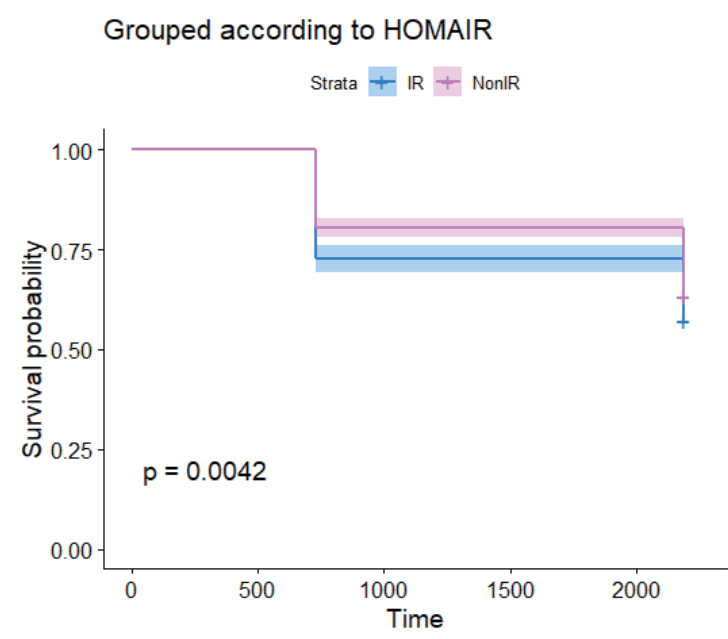

Figure 1. HOMAIR values and hypertension

As can be seen from Figure 1, the survival rate (i.e., the non-hypertensive rate) of the insulin-resistant group representing HOMAIR≥2.8 (blue) was significantly lower than that of the non-insulin-resistant group representing HOMAIR < 2.8 (red), and P=0.0042 < 0.05, indicating statistical significance.
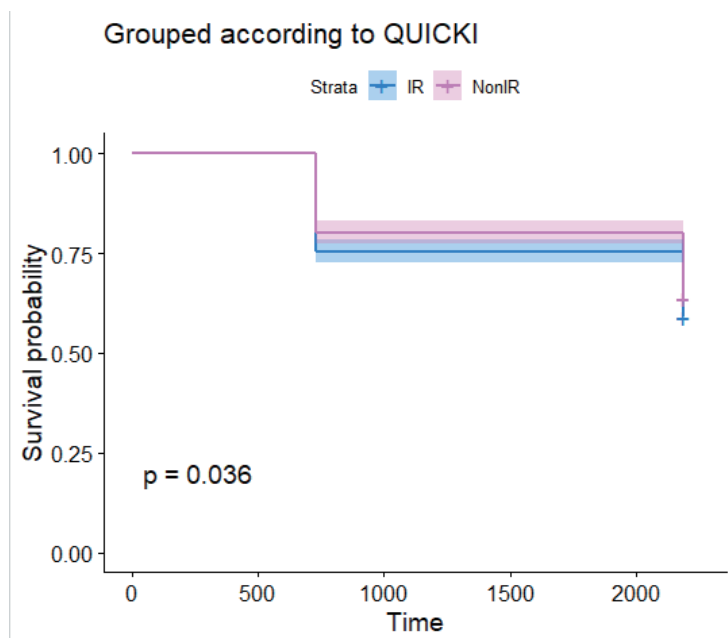

Figure 2. QUICKI values and hypertension

It can be seen from Figure 2 that the survival rate (i.e., non-hypertension rate) of the insulin resistant group representing QUICKI≤0.339 (blue) was significantly lower than that of the non-insulin resistant group representing QUICKI > 0.339 (red), and P=0.036 < 0.05 indicated statistical significance.As HOMAIR and QUICKI both reflect that the prevalence of

hypertension in the insulin-resistant group is higher than that in the non-insulin-resistant group, it can be preliminarily judged that insulin resistance is one of the inducing factors of hypertension

3.2 Cox proportional risk regression model

To eliminate interference factors, and to further validate taht insulin resistance may cause high blood pressure, the Cox proportional hazards regression model was adopted by the research team for analysis on insulin resistance, age, gender, serum magnesium and hemoglobin index. It is concluded that insulin resistance, age, hemoglobin have an effect on the incidence of hypertension (Table 1).

Table 1. Cox proportional risk regression model

Variable	Standard error	Likelihood ratiox2	P value	HR value	95% (prescribed minimum)	95% Upper limit
Age	0.00296	135.0437	<0.0001	1.035	1.029	1.041
HGB	0.00184	8.6208	0.0033	1.005	1.002	1.009
Group1 (QUICKI)	0.07785	4.9094	0.0267	1.188	1.020	1.384
Group2 (HOMA-IR)	0.07609	10.2819	0.0013	0.784	0.675	0.910

It can be seen from Table 1 that age, hemoglobin, and insulin resistance are statistically significant, and the risk of hypertension is 1.035 times of the previous age. For each unit with increase in HGB, the risk of hypertension was 1.005 times higher. According to HOMAIR values, the risk of hypertension in insulin resistant people was 1.276 times than that in non-insulin resistant people. The QUICKI value calculated that the risk of hypertension in the insulin resistant population was 1.188 times higher than that in the non-insulin resistant population.

4. Discussion

Based on the results of this study, there is an obvious relationship between insulin resistance and hypertension, and the risk of hypertension in people with insulin resistance is significantly higher than that in people without insulin resistance.

Based on relevant studies, it is currently believed that the mechanism may be related to the regulation of the nervous system. High insulin concentration can promote the activity of the sympathetic nervous system and make it excited, thus promoting the release of catecholamines, and ultimately leading to the tension and contraction of blood vessels in the body and the increase of blood pressure.

At the same time, for patients with insulin resistance, the activation of α adrenoergic receptors in the body leads to vasoconstriction and increased blood pressure.[9] In addition, some scholars believe that the mechanism of insulin resistance in hypertension is also related to insulin's proliferation of vascular smooth muscle cells[10], water and sodium retention[11] increased synthesis and secretion of endothelin 12 However, the specific systematic elaboration of the mechanism of insulin resistance to cause hypertension remains to be further studied.

In this study, epidemiology and statistics were used to explore the knowledge related to insulin resistance and hypertension, and the conclusion was drawn that insulin resistance is prone to hypertension, which provides a certain basis for clinical judgment of the etiology of hypertension and the search for the association of diseases. However, there are still limitations in this study. First, there are few years with statistics and CHNS only provides the baseline data of 2009 and the survey data of 2011 and 2015, which lead to insufficiency of data. Second, this study can only prove that insulin resistance is prone to hypertension,without interpretation on whether hypertension is prone to insulin resistance.

The study on the relationship between insulin resistance and hypertension plays a positive role in clinical diagnosis and treatment. It is my sincere hope that this study can make a contribution to this.

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