Risk factors and Interaction analysis of Hypertension in People who were Overweight and obesity:Based on Machine Learning and Data Mining

Li Lu Wei (1055517208@qq.com)
Guilin Medical University Affiliated Hospital https://orcid.org/0000-0002-1439-6160
Jian Yu
Guilin Medical University Affiliated Hospital https://orcid.org/0000-0003-0787-6905

Research Article

Keywords: Overweight and obesity, Hypertension, Risk factors, Multiplicative interaction, Additive interaction

Posted Date: March 1st, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1268340/v1

Abstract

Objective To screen the independent risk factors of hypertension in People who were Overweight and obesity by Logistic regression and Decision tree model, and to analyze the two possible interactive risk factors by multiplying interaction scale and adding interaction scale.

Methods 5098 People who were Overweight and obesity were selected as the research object. Firstly, Logistic regression and Decision tree model were used to screen the independent risk factors and possible interactive risk factors of hypertension in People who were Overweight and obesity. Finally, the multiplicative scale analysis and additive scale analysis were used to analyze the two possible interactive risk factors from the perspective of statistics and biology.

Results Logistic regression showed that NAFLD, FPG, Age, TG, LDL-c, UA and Cr were positively correlated with overweight and obese hypertension, and GFR was negatively correlated with overweight and obese hypertension ($P<0.05$). The decision tree model suggests that Age, FPG and UA may interact. Multiplication scale analysis showed that FPG+UA, Age UA and Age+FPG had positive multiplication interaction ($P<0.05$, $B\neq0$, $OR>1$). Additive scale analysis shows that Age+UA single factor analysis and multi factor analysis have additive interaction, FPG+UA single factor analysis has additive interaction, multi factor analysis does not have additive interaction, and Age+FPG single factor analysis and multi factor analysis do not have additive interaction.

Conclusion The independent risk factors of hypertension in People who were Overweight and obesity include NAFLD, FPG, Age, TG, LDL-c, UA and Cr. Age+UA has statistical and biological synergistic interaction, which can provide a reference for the study of the etiological interaction of hypertension in People who were Overweight and obesity.

Study Importance

What is already known?

Overweight and obese people are the key high-risk groups suffering from hypertension, and the proportion of overweight and obese people is increasing year by year all over the world.

What does this study fing?

1. Age+UA has statistical and biological synergistic interaction.
2. The independent risk factors of hypertension in People who were Overweight and obesity include NAFLD, FPG, Age, TG, LDL-c, UA and Cr.
3. which can provide a reference for the study of the etiological interaction of hypertension in People who were Overweight and obesity.

How might these results change the focus of clinical practice?

1. According to the clinical and metabolic characteristics of overweight and obese people, the independent risk factors of hypertension in overweight and obese people were screened, so as to provide reference for etiological prevention.
2. Because age and uric acid have synergistic interaction on hypertension in overweight and obese people,it is very important to control the level of uric acid in people with age greater than 46 years old.
3. The physiological aspects of risk factor interaction can be discussed through statistics, which provides a reference for future etiological research.

Introduction

Hypertension is not only a common chronic disease worldwide, but also a common basic disease of cardiovascular and brain complications. According to the Chinese guidelines for the prevention and treatment of hypertension[1], the newly diagnosed population of hypertension in China shows an upward trend every year. The latest blue book survey shows that the prevalence of hypertension in China reached 31.89% in 2019, and the number has reached 358 million[2], 2020 edition of the international society of hypertension, also points out that despite the various measures taken, the incidence rate of hypertension and the adverse effects on cardiovascular morbidity and mortality continue to exist worldwide. Overweight and obesity are risk factors for hypertension[3]. With the gradual increase of body mass index, the risk of hypertension in People who were Overweight and obesity is 1.16 ~ 1.28 times that in normal weight people[4]. The cross-sectional study of 240000 people in China shows that[5], the risk of hypertension in people with overweight is 3-4 times higher than that in normal weight people, indicating that People who were Overweight and obesity are prone to hypertension. Previous studies have mostly studied hypertension from the perspective of the general population, while People who were Overweight and obesity have different metabolic characteristics from the general population, so they have different etiological discussions on the related risk factors, importance and interaction of hypertension. This study screened the independent risk factors of hypertension in People who were Overweight and obesity, and then explored the impact of risk factor interaction on hypertension from the perspective of statistics and biology, in order to provide reference for the prevention and treatment of hypertension from the perspective of etiology.

Methods

Research object

The subjects who underwent physical examination in the physical examination department of the Affiliated Hospital of Guilin Medical University from August to November 2019 were selected as the study population. The cross-sectional study was adopted. All of them had signed the informed consent. The study was approved by the ethics committee of Guilin Medical University (approval number: GLMU1A2019064). Inclusion criteria: BMI ≥ 24kg/m^2; Volunteer to join the researcher. Exclusion criteria:

age < 18 years; pregnant woman; People with major diseases such as malignant tumors; A total of 5098 patients with complete data were included in the study. The age of the subjects ranged from 18 to 85 years, with an average age of (44.92±11.75) years. There were 3609 males, accounting for 70.8%, with an average age of (43.83±11.72) years; 1489 women, accounting for 29.2%, with an average age of (47.54±11.41) years. There were 1277 People who were Overweight and obesity with hypertension, with an average age of (50.55±11.19) years. There were 909 males (71.1%) and 368 females (28.9%). There were 3821 People who were Overweight and obesity without hypertension, with an average age of (43.03±11.33) years, 2700 males (70.7%) and 1121 females (29.3%).

Data Collection

During the physical examination of the subjects, the trained professional physical examination doctors consulted their basic personal information, including Age, Nationality and Marital status; Past history, Hypertension, Nonalcoholic fatty liver disease (NAFLD), Malignant tumor, Severe liver and Kidney function injury, etc. Relevant medication history, Personal history and Family history.

Physical Measurement And Measurement Methods

Physical examination staff used the calibrated height and weight meter (Shenzhen, China) to measure the height and weight of the subjects. The height measurement was accurate to 0.1cm and the weight measurement was accurate to 0.1kg. Calculate body mass index (BMI), BMI = weight (kg) / height (m^2). The researcher rested quietly for 5~10 min, took a sitting position, and measured the blood pressure of the right upper arm in the sitting position, with the accuracy of 1mmHg (1mmHg = 0.133 kPa).

Laboratory Inspection And Measurement Methods

All subjects had a light diet the day before the examination, and elbow venous blood (5ml) was collected on an empty stomach in the morning of the examination. Biochemical indexes: fasting blood glucose (FPG), uric acid (UA), triglyceride (TG), total cholesterol (TC), low density lipoprotein cholesterol (LDL-c), high density lipoprotein cholesterol (HDL-c), creatinine (Cr),blood urea nitrogen(BUN), alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were detected by Roche Cobas C501 automatic biochemical analyzer. Glomerular filtration rate (GFR) was calculated. Use the simplified MDRD formula improved by the Chinese: GFR(mL/(min*1.73m^2)) =186×(Cr(mg/dl))^-1.154×(age)^-0.203×(0.742female). The diagnosis of NAFLD was confirmed by B-ultrasound examination of liver and gallbladder by a fixed ultrasound specialist.

Diagnostic Criteria

The diagnostic criteria of hypertension are defined according to the global hypertension practice guide of 2020 international society of hypertension[2]: systolic blood pressure ≥ 140mmHg and/or diastolic blood pressure ≥ 90mmHg, SBP ≥ 140mmHg and DBP < 90mmHg are simple systolic hypertension. The diagnostic criteria of dyslipidemia refer to the criteria of AACE/ACE dyslipidemia guidelines 2018[6]: TC ≥ 6.2mmol/l; TG≥2.3mmol/L;LDL-c≥4.1mmol/L□HDL-c < 1.0mmol/l, the occurrence of any of the above items is diagnosed as dyslipidemia. According to China Version 2 diabetes prevention guideline 2020 edition[7], the diagnostic standard of diabetes is FPG ≥7.0mmol/L. The diagnostic criteria of abnormal glucose tolerance were 6.1mmol/l ≤ FPG < 7.0mmol/l. The diabetes and glucose intolerance disorders were unified to abnormal blood glucose, so the diagnostic criteria for abnormal blood glucose were defined as FPG > 6.1mmol/L. According to the guidelines for the diagnosis and treatment of nonalcoholic fatty liver disease (2018 update)[8], the working definition of nonalcoholic fatty liver disease (NAFLD) is as follows: the imaging tips of patients such as color Doppler ultrasound and CT are similar to alcoholic liver disease, but there is no inducement of alcoholic liver disease such as excessive drinking history. According to the 2019 edition of the guidelines for primary diagnosis and treatment of obesity[9], the physical examination population with BMI ≥ 24kg/m^2 is defined as population who were Overweight and obesity. According to the Chinese guidelines for the diagnosis and treatment of hyperuricemia and gout, 2019 edition[10], hyperuricemia is defined as: uric acid > 420μmol/L(both male and female). Fasting blood BUN ≥ 7.1mmol/l was defined as high BUN, while the fasting blood Cr level: male ≥ 110μmol/L, female ≥ 93μmol/L was defined as hyperchromemia. ALT ≥ 40U/L in fasting blood was defined as high ALT, and AST ≥ 40U/L in fasting blood was defined as high AST.

Statistical Processing

All data shall be sorted by Excel 2007 software and analyzed by spss 26.0 software and Rx64 4.0.3 software. Firstly, the Logistic regression and Decision tree model of hypertension in People who were Overweight and obesity are established through SPSS software, from which the relevant independent influencing factors are screened and the relevant influencing factors that may have interaction are screened. The influencing factors that may have interaction are substituted into the product term of Logistic regression for single factor and multi factor multiplication and interaction test, Assuming the test level is 0.05, if the product term coefficient B of the Logistic regression model is ≠ 0 (or the confidence interval of the OR value does not include 1) and $P < 0.05$, it indicates that there is a multiplication interaction between the two factors. OR value > 1 indicates positive multiplication interaction, OR value < 1 indicates negative multiplication interaction. Finally, the R language is used to call ggthemes package for visual analysis of the additive interaction of relevant influencing factors, and the three indicators of RERI□AP and SI are used to evaluate whether the additive interaction of influencing factors is meaningful. If the two factors have no additive interaction, the confidence interval of RERI and AP should include 0 and the confidence interval of SI should include 1. On the contrary, it indicates additive interaction.

Result

Construct Logistic regression model

Before constructing the Logistic regression model, in order to make the data closer to clinical application, the influencing factors are transformed from continuous variables to classified variables by assignment. By querying the critical value of the latest medical guidelines of each specialty in each influencing factor, they are divided into two groups according to the critical value. The continuous variables with pathological significance are assigned as 1 above the critical value and 0 below the critical value. The Age boundary value refers to the average Age of People who were Overweight and obesity with and without hypertension, which is taken as 46 years old, and the Age ≥ 46 years old is assigned as 1, Age < 46 years old is assigned as 0, as shown in Table 1.

Table 1
main variables and assignment of influencing factors of overweight and obese hypertension

Variable	Assignment
Hypertension	N0=0, YES=1
MAFLD	N0=0, YES=1
UA(μmol/L)	<420=0;≥420=1
Age(years)	<46=0, ≥46=1
Gender	Female=0, Male=1
FPG(mmol/L)	<6.1=0;≥6.1=1
ALT(U/L)	<40=0;≥40=1
AST(U/L)	<40=0;≥40=1
TG(mmol/L)	<2.26=0;≥2.26=1
TC(mmol/L)	<6.22=0;≥6.22=1
LDL-c (mmol/L)	<4.14=0;≥4.14=1
HDL-c (mmol/L)	<1.04=0;≥1.04=1
BUN(mmol/L)	<7.1=0;≥7.1=1
GFR(mL/(min*1.73m^2))	<90=0;≥90=1
Cr(μmol/L)	Female: <93=0;≥93=1
	Male: <110=0;≥110=1
Table2 single factor and multi factor multiplicative interaction analysis of risk factors of overweight and obese hypertension	

The People who were Overweight and obesity with hypertension are assigned as 1, and the People who were Overweight and obesity without hypertension are assigned as 0. A univariate Logistic regression

model was constructed with hypertension as dependent variables, Gender, Age, NAFLD, UA, FPG, GFR, TG, TC, LDL-c, HDL-c, Cr, BUN, ALT and AST as independent variables. The results showed that NAFLD, FPG, Age, TG, TC, LDL-c, UA and Cr had a positive correlation with overweight and obese hypertension, and GFR had a negative correlation with overweight and obese hypertension ($P < 0.05$) .The significant factors in univariate Logistic analysis were used as independent variables for multivariate Logistic regression analysis. The results showed that NAFLD, FPG, Age, TG, LDL-c, UA and Cr were negatively correlated with overweight and obese hypertension, and GFR was positively correlated with overweight and obese hypertension ($P < 0.05$).

Building Decision Tree Model

Taking hypertension as dependent variable, NAFLD, FPG, Age, TG, LDL-c, UA, Cr and GFR screened by Logistic regression model as independent variables, and CRT method was used to establish decision tree model. In order to avoid too many confounding factors affecting the results, the decision tree was set to three layers and the tree was pruned to avoid over fitting. The results showed that Age, FPG, UA, TG and LDL-c were the risk factors of overweight and obese hypertension. At the same time, it is suggested that Age, FPG and UA may interact, as shown in Figure 1.

Multiplicative Interaction Analysis

The Logistic regression product term was used to analyze the multiplicative interaction of Age, FPG and UA screened by Decision tree model. Multivariate analysis included NAFLD, FPG, Age, TG, LDL-c, UA, Cr, GFR and other influencing factors screened by Logistic regression model as confounding factors. The results showed that FPG+UA, age+UA and age+FPG had positive multiplication interaction ($P < 0.05$, $B \neq 0$ and $OR > 1$). The results are shown in Table 2.

Table2 single factor and multi factor multiplicative interaction analysis of risk factors of overweight and obese hypertension

multiplicative interaction		Single factor analysis		*P* value	Multivariate analysis		*P* value
		B	*OR* value(95%CI)		*B*	*OR* value(95%CI)	
FPG	UA						
+	-	0.941	2.564(2.166-3.035)	0.000	0.533	1.704(1.422-2.042)	0.000
-	+	0.340	1.406(1.234-1.600)	0.000	0.266	1.305(1.129-1.509)	0.000
+	+	1.169	3.221(2.508-4.137)	0.000	0.729	2.073(1.591-2.702)	0.000
Age	UA						
+	-	1.160	3.190(2.783-3.655)	0.000	1.049	2.8562.468-3.304)	0.000
-	+	0.340	1.406(1.234-1.600)	0.000	0.266	1.305(1.129-1.509)	0.000
+	+	1.006	2.735(2.341-3.194)	0.000	0.732	2.080(1.759-2.459)	0.000
Age	FPG						
+	-	1.160	3.190(2.783-3.655)	0.000	1.049	2.856(2.468-3.304)	0.000
-	+	0.941	2.564(2.166-3.035)	0.000	0.533	1.704(1.422-2.042)	0.000
+	+	1.116	3.054(2.535-3.679)	0.000	0.958	2.606(2.150-3.158)	0.000

Additive Interaction Analysis

The R language is used to visually analyze the additive effect of single factor and multi factor for FPG+UA, Age+UA and Age+FPG. Multivariate analysis included NAFLD, FPG, Age, TG, LDL-c, UA, Cr, GFR and other influencing factors screened by Logistic regression model as confounding factors. The results show that Age+UA univariate and multivariate analysis have additive interaction (the confidence interval of RERI and AP does not include 0, and the confidence interval of SI does not include 1), FPG+UA univariate analysis has additive interaction, multivariate analysis does not have additive interaction, and Age+FPG univariate and multivariate analysis do not have additive interaction, as shown in Table 3, table 4, figure 2 and figure 3.

Table3 evaluation indexes of additive interaction of risk factors of overweight and obese hypertension

Additive interaction evaluation index	Single factor analysis	Multivariate analysis
FPG+UA		
RERI(95%CI)	1.188(0.134-2.242)	0.794(-0.036-1.625)
AP(95%CI)	0.307(0.096-0.519)	0.273(0.040-0.505)
SI(95%CI)	1.710(1.095-2.671)	1.714(0.991-2.961)
Age+UA		
RERI(95%CI)	1.458(0.646-2.269)	0.758(0.101-1.415)
AP(95%CI)	0.285(0.156-0.414)	0.199(0.046-0.352)
SI(95%CI)	1.548(1.217-1.969)	1.371(1.041-1.807)
Age+FPG		
RERI(95%CI)	1.200(-0.087-2.488)	0.917(-0.223-2.057)
AP(95%CI)	0.218(0.009-0.426)	0.189(-0.023-0.403)
SI(95%CI)	1.363(0.970-1.915)	1.315(0.930-1.859)

Table4 single factor and multi factor additive interaction analysis of risk factors of overweight and obese hypertension

additive interaction		Single factor analysis OR value(95%CI)	Multivariate analysis OR value(95%CI)
FPG	UA		
+	-	2.334(1.872-2.910)	1.996(1.590-2.507)
-	+	1.337(1.157-1.546)	1.115(0.957-1.300)
+	+	3.860(2.983-4.995)	2.907(2.218-3.808)
Age	UA		
+	-	3.187(2.662-3.815)	2.769(2.300-3.334)
-	+	1.470(1.180-1.831)	1.269(1.012-1.592)
+	+	5.115(4.181-6.258)	3.798(3.055-4.722)
Age	FPG		
+	-	2.983(2.572-3.460)	2.923(2.503-3.414)
-	+	2.318(1.596-3.365)	1.987(1.359-2.907)
+	+	5.502(4.469-6.773)	4.828(3.892-5.990)

Discussion

With the continuous improvement of people's living standards, the number of People who were Overweight and obesity worldwide is increasing. WHO's survey shows that obesity incidence rate has increased two times[11] worldwide over the past decades. The people who were Overweight and obesity have special clinical metabolic types, and can cause various diseases including hypertension, diabetes, lipid disorders, cardiovascular diseases and various types of malignant tumors. Overweight and obesity are themselves a risk factor for hypertension [6, 13]. Whether they are healthy metabolism or unhealthy metabolism, the risk of cardiovascular diseases including hypertension is very high[14, 15]. Because its population characteristics are different from the clinical and metabolic characteristics of the general population, we can explore the relevant influencing factors of hypertension in people who were Overweight and obesity, screen out the risk factors and their interactions, predict and intervene their interactions from the perspective of statistics and biology.It plays a certain role in reducing the prevalence of hypertension in people who were Overweight and obesity and reducing the public burden.

This study began with screening the relevant risk factors of hypertension in people who were Overweight and obesity. Referring to the relevant programming prepared by Xu Minrui etal[16], this study used binary variables for risk factor discussion and interaction analysis. Firstly, the Logistic regression model of hypertension in people who were Overweight and obesity was constructed, and the relevant independent influencing factors were screened by univariate and multivariate analysis. The results showed that

NAFLD, FPG, Age, TG, LDL-c, UA and Cr were positively correlated with overweight and obese hypertension, and GFR was negatively correlated with overweight and obese hypertension. Then the Decision tree correlation statistical analysis was carried out by CRT method, and it was concluded that the risk factors of hypertension in people who were Overweight and obesity include five factors such as Age, FPG, UA, TG and LDL-c, which are similar to previous studies [17, 18]. At the same time, the Decision tree model also showed that the prevalence of hypertension in people who were Overweight and obesity with Age ≥ 46 years old and FPG ≥ 6.1mmol/l was 47.1%,.At the same time, it is consistent with Age ≥ 46 years, FPG ≥ 6.1mmol/l and UA ≥ 420μmol/L. The prevalence of hypertension in people who were Overweight and obesity increased to 56.5%, suggesting that Age, FPG and UA may interact.

In multivariate statistical analysis, interaction means that the role of a factor varies with the level of other factors. When two factors exist at the same time, the role is not equal to the sum (additive interaction) or product (multiplicative interaction) of the two factors. The indicators for judging the existence and size of interaction are also very complex. As for the multiplicative interaction, the method of incorporating the product term of risk factors into the Logistic regression equation is often used for analysis. It is generally believed that the linear regression model is an additive model, and the product term reflects whether there is additive interaction between factors, while the Logistic regression or Cox regression model is a multiplication model, and the product term reflects whether there is multiplicative interaction between factors. The multiplicative interaction of this study was the univariate and multivariate analysis of relevant influencing factors through the product term of Logistic regression. The multivariate analysis included all influencing factors of hypertension in people who were Overweight and obesity screened by Logistic regression model as confounding factors. The results suggest that FPG+UA, Age+UA and Age+FPG have positive multiplication interaction in univariate and multivariate analysis ($P < 0.05$, $B \neq 0$ and OR>1). Since the multiplication interaction usually indicates statistical interaction, we believe that FPG+UA, Age+UA and Age+FPG have positive multiplication interaction, Compared with the independent existence of related factors, the combined existence will increase the prevalence by 2-3 times on the basis of their independent existence.

Even if the product term is not statistically significant, that is, there is no multiplication interaction between the two factors, it does not mean that the two factors have no additive interaction, nor does it mean that the two factors have no biological interaction on the occurrence of a disease. In this study, the pairwise combination of FPG, UA and Age has a positive multiplication interaction. It can be considered that there is a statistical interaction between the pairwise combination of the three risk factors, which has a significant impact on the prevalence of hypertension in people who were Overweight and obesity. However, from a biological point of view, it is necessary to conduct additive scale analysis to judge whether the combined existence of two risk factors has a greater impact on the prevalence of a disease than their independent existence.

Biological interaction refers to whether the two factors have joint effects on biological mechanisms, including synergy and antagonism. Rothman[19] proposed that the evaluation of biological interaction should be based on the additive scale. The additive interaction of risk factors is not a simple OR value

addition of risk factors. Its quantitative analysis is based on the statistical basis of Logistic regression, including complex programming operations such as establishing the covariance matrix of regression coefficients and constructing the OR value matrix. This study conducted quantitative and visual analysis of additive interaction of hypertension risk factors in people who were Overweight and obesity. The results showed that Age+UA had additive interaction in univariate and multivariate analysis (the confidence interval of RERI and AP did not include 0, and the confidence interval of SI did not include 1). Quantitative analysis showed that the prevalence of hypertension in people who were Overweight and obesity increased to 4-5 times. FPG+UA univariate analysis has additive interaction, multivariate analysis does not have additive interaction, and Age+FPG univariate and multivariate analysis do not have additive interaction. Therefore, this study concludes that even if the two risk factors have multiplicative interaction, that is, statistical interaction, they do not necessarily have additive interaction, that is, biological interaction.

In this study, the average age between people who were Overweight and obesity with hypertension and without hypertension is 46 years old. Taking the age of people who were Overweight and obesity = 46 years old as the critical value, they are divided into elderly people and young people. The results of Decision tree model showed that the prevalence of hypertension in people aged ≥ 46 years was 35.5%, which was twice as high as that in people aged < 46 years (14.7%). As an independent risk factor for hypertension in people who were Overweight and obesity, Age has been verified in many studies. Batte[20] Suggest that overweight, obesity and age > 40 are statistically significant predictors of hypertension. The study of Ahmed[21] Also shows that Age has a significant effect on hypertension. The 2020 guidelines of the international society of hypertension[2] also proposed that Age > 40 years old can predict hypertension. All showed that Age itself was an independent risk factor for hypertension in people who were Overweight and obesity. As an independent risk factor for the occurrence and development of hypertension in people who were Overweight and obesity, Age may be related to impaired vascular endothelial function, oxidative stress, nitric oxide deficiency and arterial remodeling[22, 23].

At the same time, this study also suggests that hyperglycemia is an important risk factor for hypertension, which has also been confirmed in many studies. Insulin resistance[24] and chronic low-grade inflammation that may be partially mediated by insulin resistance[25] are considered to be the pathogenesis of direct or indirect relationship between hyperglycemia and hypertension in people who were Overweight and obesity. High uric acid is another important risk factor for hypertension in people who were Overweight and obesity suggested in this study. High uric acid is an important independent risk factor for hypertension[26], although the correlation mechanism between them is not clear. At the same time, relevant studies show that[27], every 1% increase in serum uric acid level will increase the risk of hypertension by 13%. As an independent risk factor for new hypertension in people who were Overweight and obesity, High uric acid may be closely related to chronic renal injury[28].

Previous big data statistical studies on hypertension were basically carried out by constructing prediction models and exploring the impact of independent risk factors of hypertension on the disease, ignoring the

interaction between risk factors, which were mainly carried out in the general population, and there were few relevant studies in people who were Overweight and obesity. Recently, Ren Z[29] and others have discussed the prediction model and independent risk factors of hypertension in Central China. Chen y[30] and others analyzed the population in northern China and constructed the corresponding hypertension prediction model. They explored independent risk factors and were based on statistics. There were no relevant studies on the prevalence of hypertension in people who were Overweight and obesity, and the interaction between relevant risk factors and the related impact of merger on the prevalence. Therefore, this study conducted the multiplicative interaction and additive interaction of relevant risk factors. Both multiplicative interaction and additive interaction are significant for Age ≥ 46 years old combined with UA ≥ 420μmol/L has both statistical and biological interaction (synergy), suggesting that it has an important impact on the prevalence of hypertension in people who were Overweight and obesity. The prospective study of Kim W[31] also has that the relationship between uric acid and hypertension often depends on age and gender. Therefore, it is very important to control the level of uric acid in people with age greater than 46 years old.

Limitations

However, this study also has defects. For example, because it is a single center physical examination population sample, the sample diversity is insufficient, and a larger sample size and multi center joint research are needed. Secondly, lifestyle is not included in the statistical indicators, which needs further research in the future.

Conclusions

This study first constructed the Logistic regression model of hypertension in people who were Overweight and obesity, and concluded that NAFLD, FPG, Age, TG, LDL-c, UA and Cr had a positive correlation with overweight and obese hypertension, and GFR had negative a correlation with overweight and obese hypertension. Then, the interaction analysis of relevant influencing factors was carried out. The results showed that among the three groups of risk factors, only Age and UA had multiplicative interaction and additive interaction. It is considered that Age ≥ 46 years old is combined with UA ≥ 420μmol/L can not only promote the occurrence of hypertension in people who were Overweight and obesity from the perspective of statistics, but also biologically. The relevant mechanism needs to be further studied. Similarly, this study also provides a reference for relevant studies to screen disease influencing factors and explore interaction from the perspective of etiology.

Declarations

Disclosures: None.

Data sharing: No additional data available

Ackonowledments: We are very grateful to the medical staff and all participants who collected and summarized the data.

Competing interests: None declared.

Disclosures: None.

Funding: This work was supported by the funding from the Guilin scientific research and technology development plan project.

Contribution:LLW Collect and count data and write papers,YJ Guide thesis writing, review the thesis and put forward opinions.

Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Provenance and peer review: Not commissioned; externally peer reviewed.

References

1. Chinese guidelines for the prevention and treatment of hypertension. 2018 revision [J]. Prevention treatment of cardiovascular cerebrovascular diseases, 2019,19 (01): 1–44.
2. Unger T. Borghi C, Charchar F,et al. 2020 *International Society of Hypertension globalhypertension practice guidelines. J Hypertens. 2020 Jun;38(06):982-1004.*.
3. Wang Zengwu H, Guang W, Xin, et al. Overweight/obesity and aggregation analysis of cardiovascular risk factors in middle-aged people in China [J]. Chinese Journal of hypertension. 2014;22(10):1000.
4. Feng Baoyu C, Jichun, Li Y, et al. Follow up study on the relationship betweenoverweight and obesity and hypertension in Chinese adults [J]. Chinese Journal of epidemiology. 2016;37(05):606–11.
5. Chinese expert consensus on the management of obesity related hypertension. Chinese Journal of cardiovascular disease, 2016 (03): 212–219.
6. Jellinger PS. Handelsman Y, Rosenblit PD, et al. American association of clinical endocrinologists and american college of endocrinology guidelines for management of dyslipidemia and prevention of cardiovascular disease.*Endocr Pract*. 2017 *Apr;23*(*Suppl 2*):*1-87*.
7. Chinese Medical Association Diabetes Association. Guideline for prevention and treatment of type 2 diabetes in China (2020 Edition) [J]. Chinese Diabetes journal. 2021;13(04):315–409.
8. Fatty liver and alcoholic liver disease group of Hepatology branch of Chinese Medical Association, fatty liver disease expert committee of Chinese Medical Association, fan. Jiangao, et al. Guidelines for the prevention and treatment of nonalcoholic fatty liver disease (updated version in 2018) [J]. Journal of practical liver disease, 2018,21 (02): 30-39.
9. Chinese Medical Association, Journal of Chinese Medical Association. general medicine branch of Chinese Medical Association, etc. guidelines for primary diagnosis and treatmentof obesity (Practical

edition.2019) [J]. Chinese Journal of general practitioners. 2020;19(02):102–7.

10. Endocrinology branch of Chinese Medical Association. Chinese guidelines for the diagnosis and treatment of hyperuricemia and gout (2019) [J]. Chinese Journal of Endocrinology metabolism. 2020;36(01):1–13.
11. *World Health Organization*. Obesity *and overweight.* 2020 *April 1. [cited 17 December2020]. In: World Health Organization [Internet]. Available.from*: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.
12. Paczkowska-Abdulsalam M. Kretowski A. *Obesity, metabolic health and omics: Currentstatus and future directions*. *World J Diabetes. 2021 Apr 15;12(04*):*420-436*.
13. Bijani M. Parvizi S, Dehghan A, et al. *Investigating the prevalence of hypertension and its associated risk factors in a population-based study: Fasa PERSIAN COHORT data. BMC Cardiovasc Disord.* 2020 *Dec 1;20(01):503.*.
14. Yeh TL. Hsu HY, Tsai MC, et al. *Association between metabolically healthy obesity / overweight and cardiovascular disease risk: A representative cohort study in Taiwan. PLoS One.* 2021 *Feb 1;16(02):e0246378.*.
15. Drozdz D. Alvarez-Pitti J, Wójcik M, et al. *Obesity and Cardiometabolic Risk Factors: From Childhood to Adulthood. Nutrients.* 2021 *Nov 22;13(11):4176.*.
16. Xu Minrui Q, Deren Z Yihong, et al. .Interaction analysis of logistic regression model using R software [J]. China health statistics, 2017,34 (04): 670–5.
17. *van* Oort S, Beulens JWJ. *van* Ballegooijen AJ, et al. Association of Cardiovascular Risk Factors and Lifestyle Behaviors With Hypertension: A Mendelian Randomization Study. Hypertension. 2020 *Dec;*76(06):1971–9.
18. Xiong XL. Ma YM, Zhou WH, et al. *[Prevalence and associated risk factors of pre-hypertension and hypertension in young and middle-aged population in Nanjing]. Zhonghua Nei Ke Za Zhi.* 2021 *Apr 1;60(04):338-344.*.
19. Rothman KJ. Epidemiology: An introduction. New York: Oxford University Press; 2002. pp. 168–80.
20. Batte A. Gyagenda JO, Otwombe K, et al. *Prevalence and predictors of hypertension among adults in Mbarara City, Western Uganda. Chronic Illn.* 2021 *Nov 17:17423953211058408. d*.
21. Ahammed B. Maniruzzaman M, Talukder A, et al.Prevalence and Risk Factors of Hypertension Among Young Adults in Albania. High Blood Press Cardiovasc Prev. 2021 *Jan,*28(01):35–48.
22. Lee JH. Kim KI, Cho MC. Current status and therapeutic considerations of hypertension in the elderly. Korean J Intern Med. 2019 *Jul,*34(04):687–95.
23. Xu X. Wang B, Ren C, et al Age-related impairment of vascular structure and functions. Aging Dis 2017;8:590–610.
24. Freeman AM. Pennings N. Insulin Resistance. 2021 *Jul 10. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan–. PMID: 29939616.*.

25. Mancusi C. Izzo R, *di* Gioia G, et al. .Insulin Resistance the Hinge Between Hypertension and Type 2 Diabetes. High Blood Press Cardiovasc Prev. 2020 *Dec;*27(06):515–26.
26. Qian T. Sun H, Xu Q, et al. Hyperuricemia is independently associated with hypertension in men under 60 years in a general Chinese population. J Hum Hypertens. 2021 *Nov;*35(11):1020–8.
27. Borghi C. Domienik-Karłowicz J, Tykarski A, et al. Expert consensus for the diagnosis and treatment of patient with hyperuricemia and high cardiovascular risk: 2021 update. Cardiol J. 2021;28(1):1–14.
28. Kawazoe M. Funakoshi S, Ishida S, et al. *Effect of chronic kidney disease on the association between hyperuricemia and new-onset hypertension in the general Japanese population: ISSA-CKD study. J Clin Hypertens (Greenwich)*. 2021 *Nov 21*.
29. Ren Z. Rao B, Xie S, et al. *A novel predicted model for hypertension based on a large cross-sectional study. Sci Rep. 2020 Jun 30;10(01*):*10615*.
30. Chen Y, et al *Incident hypertension and its prediction model in a prospective northern urban Han Chinese cohort study. Journal of human hypertension*.
31. Kim W. Go TH, Kang DO, et al.*Age and sex dependent association of uric acid and incident hypertension. Nutr Metab Cardiovasc Dis. 2021 Apr 9;31(04*):*1200-1208*.

Figures

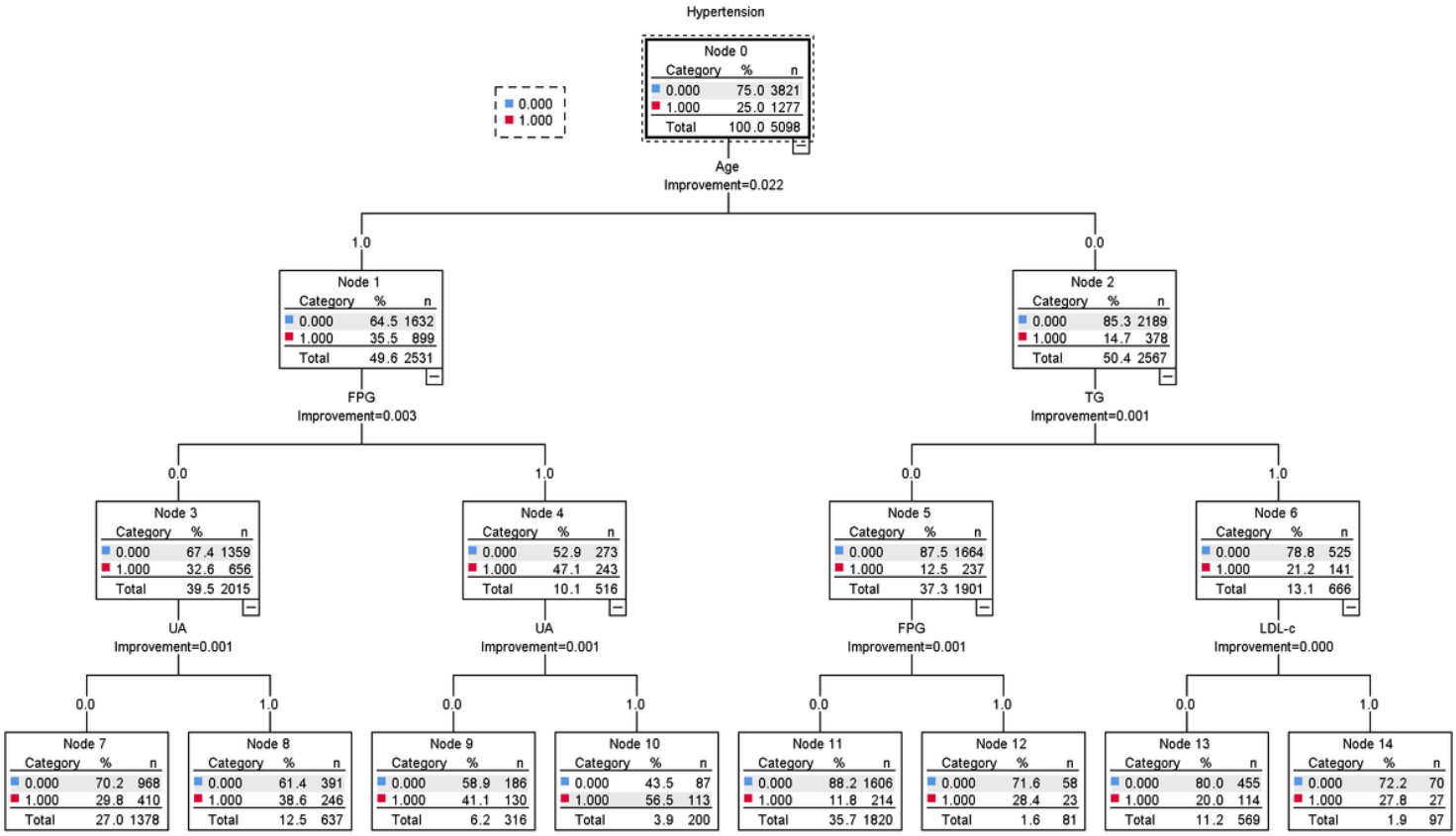

Figure 1

decision tree model of influencing factors of overweight and obese hypertension

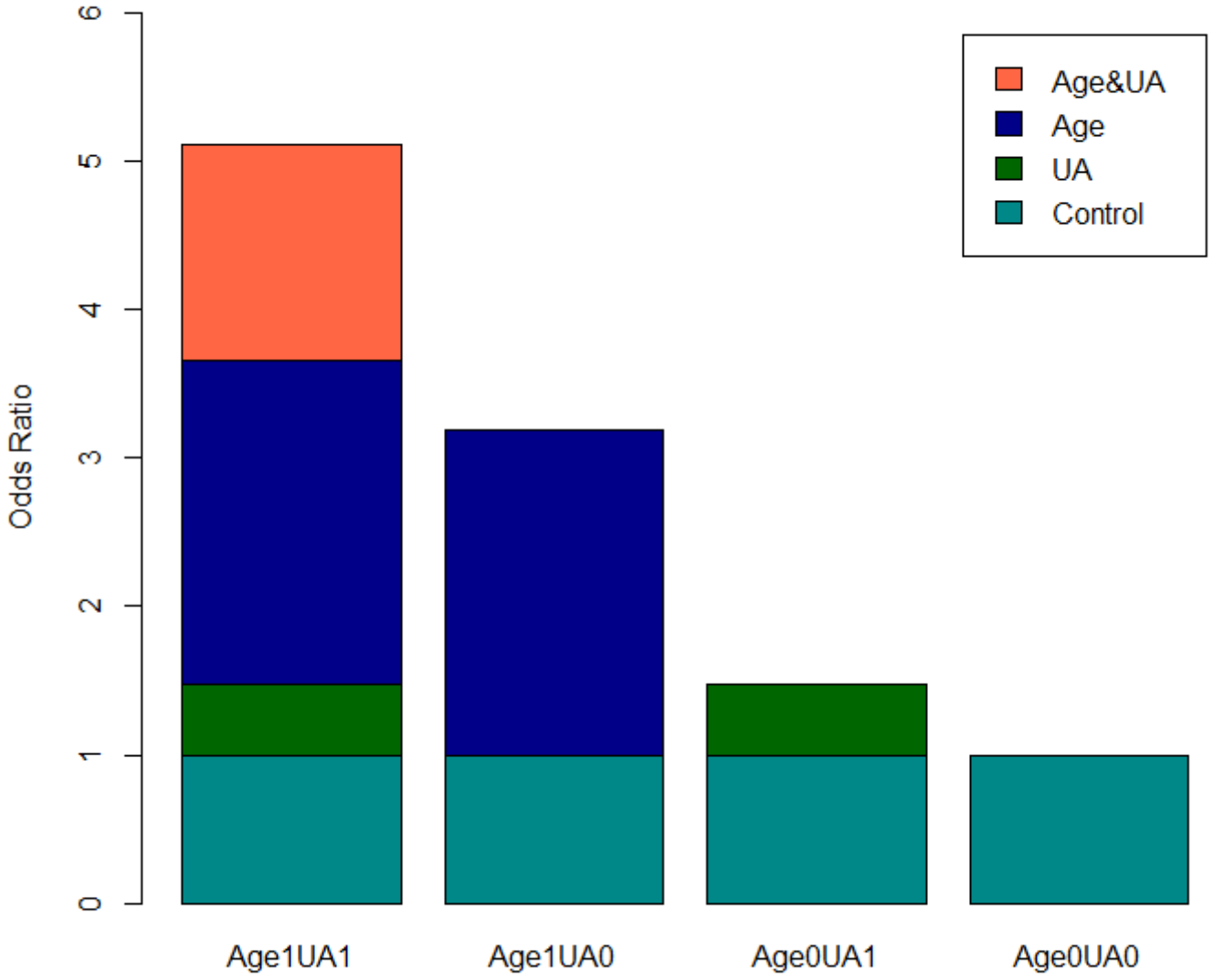

Figure 2

visual analysis of single factor additive interaction of overweight and obese hypertension risk factors

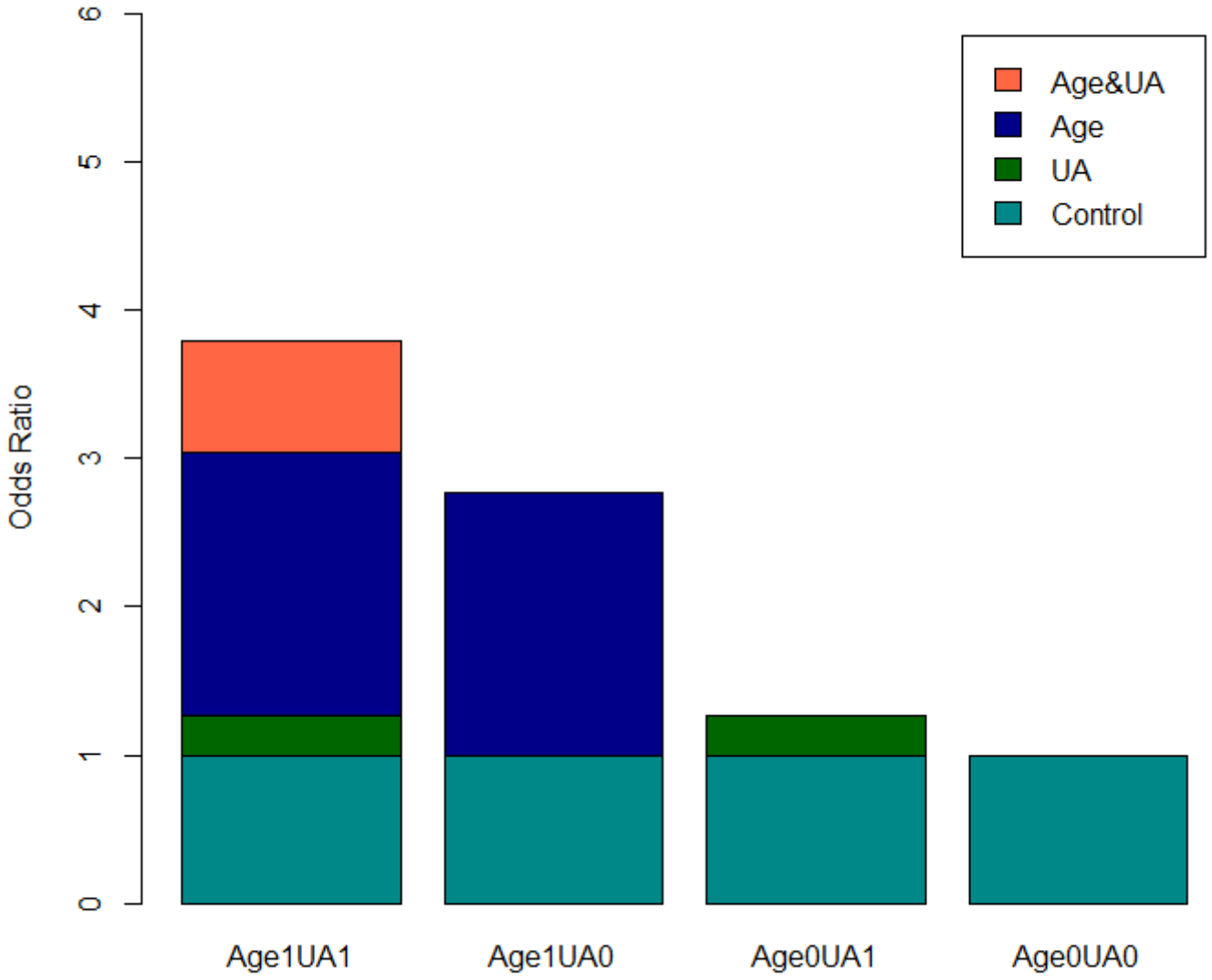

Figure 3

visual analysis of multivariate additive interaction of risk factors for overweight and obese hypertension