European Review for Medical and Pharmacological Sciences 2019; 23: 4391-4397

A study of the correlation of waist circumference with metabolic risks among non-obese populations

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Abstract. – OBJECTIVE: To investigate the correlation of waist circumference with metabolic risks among non-obese populations.

PATIENTS AND METHODS: A retrospective analysis was conducted for the clinical information of 13,145 non-obese subjects who received physical examinations in the hospital from January 2015 to January 2018. Among them, 1,971 subjects were definitely diagnosed with diabetes mellitus, hypertension, and metabolic syndrome and set as the metabolic disorder group, with the remaining 11,174 cases as the control group. All metabolism-related indicators were compared between the patients in the two groups, the analysis was performed for the prevalence of diabetes, hypertension, and metabolic syndrome in patients with different waist circumferences as well as males and females with different waist circumferences. Finally, the optimal cut-off points of waist circumference were determined.

RESULTS: According to the comparison, there were no statistically significant differences in subjects with low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and total cholesterol between the metabolic disorder group and the control group ($p>0.05$). The subjects in the metabolic disorder group had higher waist circumference, waist-to-hip ratio, triglyceride, fasting insulin, fasting blood glucose, and insulin resistance index than those in the control group, displaying statistically significant differences ($p<0.05$). When waist circumference was more than 70 cm, as it increased, the prevalence rates of diabetes, hypertension, and metabolic syndrome gradually elevated. When waist circumference was 60-90 cm, hypertension took the leading place in metabolic disorders, so did the metabolic syndrome and diabetes, with a waist circumference of more than 90 cm. There were no remarkable differences in the prevalence rates of diabetes, hypertension, and metabolic syndrome among male and female patients with different waist circumferences ($p>0.05$). The patients with the waist circumference of over 90 cm exhibited gradually declined prevalence rates of diabetes, hypertension, and metabolic syndrome, while those in the patients with a waist circumference of 60-90 cm were gradually increased. The optimal cut-off points of waist circumference were calculated according to the prevalence rates of diabetes, hypertension, and metabolic syndrome among patients, and the calculation results were 78 cm, 79 cm, and 77 cm for male patients and 73 cm, 78 cm, and 73 cm for female patients. Based on the weight combined with the optimal cut-off points of waist circumference, the optimal waist circumference cut-off points for males and females were 78 cm and 74 cm, respectively.

CONCLUSIONS: There is a correlation between the waist circumference and metabolic risks among non-obese populations, but the screening for metabolic diseases should be conducted among males with a waist circumference of over 78 cm and females with a waist circumference of over 74 cm. The treatment measures are supposed to be taken promptly to improve the prognosis.

Key Words:
Non-obese populations, Hypertension, Diabetes mellitus, Metabolic syndrome, Waist circumference, Correlation.

Introduction

The metabolic risk factors, such as hypertension, diabetes mellitus, and blood lipid abnormalities are correlated with cardiovascular diseases and can increase their incidence rates and mortality rates[1-3]. In recent years, as Chinese life has constantly been improved and the lifestyles have gradually changed, the incidence rates of hypertension, diabetes, and blood lipid

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abnormalities are rapidly rising in China[4-6]. Some studies[7] have pointed out that such factors as insulin resistance and obesity are closely related to the increase in metabolic risks, and clinically, the simple and practical indicators, including waist circumference, body mass index (BMI), waist-to-height ratio, and waist-to-hip ratio have been widely applied in the evaluation and prediction of metabolic risks. The obese population has always been regarded as the focus of clinical researches on metabolic risks, and as the metabolic obesity among the non-obese population have been put forward. However, some studies[8] have established that even non-obese populations with normal BMI also manifest a higher prevalence rate of metabolic disorders. There is a certain correlation between the content of abdominal visceral fat and hypertension, indeed, the degree of abdominal fat accumulation can be reflected via waist circumference[9]. For this reason, the correlation between waist circumference and metabolic risks among non-obese population was explored in this study, hoping to provide a reference for the later clinical treatments. The analysis and report are as follows.

Patients and Methods

Patients

A retrospective analysis of the clinical information was performed for 13,145 non-obese subjects who received physical examinations in the hospital from January 2015 to January 2018. The subjects consisted of 5,483 males and 7,662 females, aged 18-84 years old and (51.29±5.39) years old on average. The inclusion criteria were: 1) Patients with normal BMI, namely 18.5 kg/m^2≤ BMI<24 kg/m^2; 2) those aged no less than 18 years old; 3) those clinically diagnosed with hypertension, diabetes or metabolic syndrome; 4) those with complete clinical information. The exclusion criteria were: 1) Patients with the history of hypertension, diabetes or metabolic syndrome; 2) those who continuously smoked or drank within 1 month before the study; 3) those who took in relatively large amounts of high-fat foods and sodium salts; 4) those with incomplete clinical information.

Methods

The clinical information of 13,145 non-obese subjects receiving physical examinations in the hospital from January 2015 to January 2018 was retrospectively analyzed, and they included waist circumference, waist-to-hip ratio, triglyceride, fasting insulin, fasting blood glucose, insulin resistance index, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and total cholesterol. The analysis of the prevalence of diabetes, hypertension, and metabolic syndrome was conducted among patients with different waist circumferences, as well as males and females with different waist circumferences. Moreover, the optimal cut-off points of waist circumference were determined.

Statistical Analysis

SPSS 20.0 software package (IBM Corp., Armonk, NY, USA) was utilized for statistical analysis. The *t*-test was performed for the measurement data, and the diagnosis cut-off points were combined on the basis of the weight of the prevalence rate. $p<0.05$ suggested that differences were statistically significant.

Results

Comparisons of All Metabolism-Related Indicators

Based on the comparisons of LDL-C, HDL-C, and total cholesterol of subjects between the metabolic disorder group and the control group, the differences were not statistically significant ($p>0.05$). The waist circumference, waist-to-hip ratio, triglyceride, fasting insulin, fasting blood glucose, and insulin resistance index of the subjects in the metabolic disorder group were higher than those in the control group, with statistically significant differences ($p<0.05$) (Table I).

Prevalence of Diabetes, Hypertension, and Metabolic Syndrome Among Patients with Different Waist Circumferences

Once waist circumference was more than 70 cm, and with the increase in the waist circumference, the prevalence rates of diabetes, hypertension, and metabolic syndrome were gradually raised. In addition, when waist circumference was 60-90 cm, hypertension was the most prevalent among metabolic disorders, so were metabolic syndrome and diabetes, with a waist circumference of more than 90 cm (Table II).

Table I. Comparisons of all metabolism-related indicators.

Group	Waist circumference	Waist-to-hip Ratio	Triglyceride (mmol/L)	LDL-C (mmol/L)	HDL-C (mmol/L)	Total cholesterol (mmol/L)	Fasting insulin (mU/L)	Fasting blood glucose (mmol/L)	Insulin resistance index
Metabolic disorder group (n=1971)	92.53±6.17	0.90±0.05	1.47±0.37	2.97±0.70	1.40±0.14	5.19±0.71	9.81±3.54	5.56±0.57	0.76±0.45
Control group (n=11174)	83.67±6.74	0.85±0.06	1.41±0.42	2.85±0.71	1.39±0.13	5.22±0.63	9.14±3.18	5.10±0.64	0.56±0.40
t	2.495	2.767	2.125	1.669	1.945	1.617	1.983	2.559	2.412
p	0.023	0.008	0.041	0.095	0.057	0.180	0.048	0.014	0.030

Table II. Prevalence of diabetes, hypertension and metabolic syndrome among patients with different waist circumferences.

Waist circumference (cm)	Hypertension (n=1086)	Diabetes (n=434)	Metabolic syndrome (n=451)	Total
Less than 60 (n=120)	5 (4.16)	2 (1.66)	1 (0.83)	8 (6.65)
60-70 (n=3099)	112 (3.61)	39 (1.25)	20 (0.64)	171 (5.50)
71-80 (n=6490)	521 (8.02)	190 (2.92)	142 (2.18)	853 (13.12)
81-90 (n=3002)	381 (12.69)	178 (5.92)	196 (6.52)	755 (25.13)
91-100 (n=385)	61 (15.84)	10 (2.59)	78 (20.25)	149 (38.68)
More than 100 (n=49)	6 (12.24)	15 (30.61)	14 (28.57)	35 (71.42)

Prevalence of Diabetes, Hypertension, and Metabolic Syndrome Among Males and Females With Different Waist Circumferences

Male and female patients with different waist circumferences showed no remarkable differences in the prevalence rates of diabetes, hypertension and metabolic syndrome ($p>0.05$), but when the waist circumference was over 90 cm, the prevalence rates of diabetes, hypertension and metabolic syndrome gradually declined among patients, while those with a waist circumference of 60-90 cm showed gradually increased prevalence rates of diabetes, hypertension and metabolic syndrome (Table III).

Cut-Off Points of Waist Circumference

Based on the prevalence rates of diabetes, hypertension, and metabolic syndrome among patients, the optimal cut-off points of waist circumference were calculated, and the calculation results were 78 cm, 79 cm, and 77 cm for male patients and 73 cm, 78 cm, and 73 cm for female patients. On the basis of the weight combined with the optimal cut-off points of waist circumference, the optimal waist circumference points for males and females were 78 cm and 74 cm, respectively (Table IV).

Discussion

The metabolic risk refers to the probability that the metabolic disorders, such as hypertension, diabetes, and metabolic syndrome will occur, and may be associated with insulin resistance[10,11]. The affected patients usually manifest visceral fat deposition that serves as an important risk factor for various cardio-cerebral vascular diseases and has effects on the structures and functions of major organs. Besides, the severe visceral fat deposition can cause organ failure and substantially increase the incidence rates and mortality rates of cardiovascular diseases, seriously influencing the patients[12]. The majority of Chinese residents suffer from abdominal obesity, and fat is accumulated in abdomen, shoulders, face, and back, thereby leading to abdominal distention, fat shoulders and back, rounded face, fat proximal extremities, and slim distal extremities. Besides, as the quality of life of the Chinese population is improving, the obesity rate is elevated annually. Obesity is taken as the focus of clinical studies on various diseases, but there has been a dearth of studies on different diseases among the non-obese population with normal BMI, and most non-obese patients tend to receive diagnosis and treatment only after severe metabolic diseases and related complications occur[13]. One of the earliest important factors affecting and determining physical health is body composition, and the body fat rate is the proportion which the fat content in human body accounts for in body weight. The risks of metabolic disorders and cardiovascular diseases are closely related to the stature and body composition, and indeed, the metabolic risks vary among different fat areas. Clinically, the visceral fat index is often employed to mark the distribution of fat and dysfunctions, and waist circumference is a significant indicator for reflecting visceral fat[14,15]. Therefore, in the present study, it was considered whether the metabolic risk of the non-obese population was raised with the increase in waist circumference, and this correlation was explored.

The results of this study revealed that the subjects in the metabolic disorder group had higher waist circumference, waist-to-hip ratio, triglyceride, fasting insulin, fasting blood glucose, and insulin resistance index than those in the control group, with statistically significant differences ($p<0.05$). This suggests that the waist circumference, waist-to-hip ratio, triglyceride, fasting insulin, fasting blood glucose, and insulin resistance index of the non-obese population can be detected in clinical practice to raise the diagnostic rate of metabolism-related diseases; and waist circumference is correlated with metabolism-related diseases. It was found through the study that when waist circumference was more than 70 cm, the prevalence rates of diabetes, hypertension, and metabolic syndrome were gradually elevated as it increased. When waist circumference was 60-90 cm, hypertension took the leading place in metabolic disorders, so did metabolic syndrome and diabetes when waist circumference was more than 90 cm. There were no remarkable differences in the prevalence rates of diabetes, hypertension, and metabolic syndrome among male and female patients with different waist circumferences ($p>0.05$). However, the patients with the waist circumference of over 90 cm exhibited gradually declined prevalence rates of diabetes, hypertension, and metabolic syndrome, while those in the patients with a waist circumference of 60-90 cm were gradually increased. The larger waist circumference, the more accumulated fat in the bodies of the subjects.

Table III. Prevalence of diabetes, hypertension and metabolic syndrome among males and females with different waist circumferences.

Waist circumference (cm)	Hypertension (n=1086)		Diabetes (n=434)		Metabolic syndrome (n=451)	
	Male (n=463)	Female (n=623)	Male (n=178)	Female (n=256)	Male (n=181)	Female (n=270)
Less than 60 (n=120)	3 (0.65)	2 (0.32)	1 (0.56)	1 (0.39)	0 (0.00)	1 (0.37)
60-70 (n=3099)	65 (14.03)	47 (7.54)	19 (10.68)	20 (7.82)	11 (6.07)	9 (3.33)
71-80 (n=6490)	240 (51.84)	281 (45.11)	65 (36.52)	125 (48.83)	53 (29.29)	89 (32.97)
81-90 (n=3002)	133 (28.73)	248 (39.81)	87 (48.88)	91 (35.55)	79 (43.65)	117 (43.34)
91-100 (n=385)	19 (4.10)	42 (6.74)	5 (2.80)	5 (1.95)	35 (19.34)	43 (15.92)
More than 100 (n=49)	3 (0.65)	3 (0.48)	1 (0.56)	14 (5.46)	3 (1.65)	11 (4.07)

Table IV. Cut-off points of waist circumference.

Disease	No.	Waist circumference (cm)	Specificity (%)	Sensitivity (%)	Youden index	AUC	95% CI	*p*
Female								
Diabetes Mellitus	623	73	49.16	76.54	0.256	0.674	0.666-0.682	0.001
Hypertension	256	73	51.34	73.35	0.246	0.669	0.661-0.677	0.001
Metabolic syndrome	270	78	76.54	66.91	0.434	0.801	0.795-0.809	0.001
Male								
Diabetes	463	78	50.42	74.88	0.253	0.659	0.649-0.670	0.001
Hypertension	178	77	45.93	69.53	0.154	0.605	0.594-0.616	0.001
Metabolic syndrome	181	79	56.29	79.59	0.358	0.748	0.739-0.758	0.001

According to the International Diabetes Federation, the obesity in Asians is defined when the waist circumferences of males and females are no less than 90 cm and 80 cm, respectively. Hence, the above result suggests that hypertension is a prevalent metabolism-related disease in patients with the waist circumference of less than 90 cm, while obese patients are susceptible to metabolic syndrome and diabetes[16,17]. The possible cause is that the patients with more than 90 cm waist circumference have more fat accumulated in their body, and they are much likely to exhibit fatty liver, resulting in hypertension, hyperlipidemia, and hyperglycemia. Additionally, the accumulation of fat can put pressure on all organs, giving rise to heart discomfort and asthma[18]. Based on the weight combined with the optimal cut-off points of waist circumference, the optimal cut-off points for males and females were 78 cm and 74 cm, respectively, indicating that enhanced monitoring for non-obese males with a waist circumference of no less than 78 cm and females no less than 74 cm is necessary to ensure the early discovery and early treatment of metabolism-related diseases.

Conclusions

We demonstrated that the waist circumference of non-obese populations is correlated with metabolic risks, but the males with the waist circumference of more than 78 cm and the females with the waist circumference of more than 74 cm should receive the screening for metabolic diseases, and timely treatments to improve the prognosis.

Conflict of Interests

The Authors declare that they have no conflict of interests.

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