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How much excess body weight, blood sugar, or age can double the risk of hypertension?

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ABSTRACT

Background: Despite the well-known impact of advanced age, excess body weight, and raised blood glucose on blood pressure, the level of exposure to these risk factors that is necessary to double the risk hypertension is not widely investigated, but was explored in this study.
Study design: Cross-sectional study.
Methods: This study reports the results of a screening program conducted on a large population of adults to assess the prevalence of diabetes and hypertension and their associated risk factors. The participants were people aged 30 years or older referring to 16 health centers in Tehran. A standard questionnaire was used to collect data on blood pressure, body mass index (BMI), waist-hip ratio (WHR), fasting blood sugar (FBS), smoking status, and demographic characteristics (age and gender) based on WHO STEPS manual.
Results: Of the 7611 people who participated in the screening program, 696 (9.1%) had raised blood pressure. The level of exposure to risk factors for high blood pressure that is necessary to replicate the OR of 2.0 indicated that an OR of 2.0 corresponds to an increase in age of about 9.4 years, an increase in BMI of about 10.3 kg/m^2, an increase in waist-to-hip ratio of about 0.5, and an increase in fasting blood sugar (FBS) of about 85.8 mg/dl.
Conclusions: This study indicated how much increase in age, BMI, waist-hip ratio, and FBS can double the risk of hypertension. These results may be helpful for public health policy and prioritizing effective prevention programs to reduce the burden of high blood pressure.

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Introduction

Primary hypertension (also called essential hypertension or idiopathic hypertension) is the most common form of hypertension, accounting for 95% of all cases of hypertension.[1] Primary hypertension is still a major predominant risk factor for cardiovascular disease, despite considerable advances in the understanding of its etiology and the availability of effective therapeutic measures.[2–4]

In almost all countries worldwide, blood pressure increases with age and the risk of hypertension in advanced ages is remarkable.[5] Hypertension results from a complex interaction between genetic, metabolic and behavioural factors such as body weight,[6,7] blood sugar,[8] salt intake,[9,10] physical activity,[11] alcohol intake,[12] and many other factors.

Despite the impact of age, excess body weight, and raised blood glucose on blood pressure is well-known, however, it is not widely investigated how much level of exposure to any one of these risk factors may replicate the odds ratio of 2.0. Knowing how much increase/decrease in the level of exposure to a risk factor can double/halve the incidence rate of an outcome of interest is of great importance in public health policy and allows to prioritize and plan more effective prevention programs. For instance, the risk of cardiovascular disease doubles for each incremental increase of 20/10 mmHg of blood pressure, or participation in 150 min of moderate physical activity each week (or equivalent) can reduce the risk of ischemic heart disease by about 30% and the risk of diabetes by 27%.[13] However, there is no sufficient evidence to show how much increase in the level of exposure to each of the well-known risk factors of raised blood pressure can double the risk of hypertension and vice versa. In this cross-sectional study, we used data of a screening program conducted on a large population of adults in order to estimate the level of exposure to common risk factors necessary to double the risk of blood pressure.

Methods

This study was conducted in Tehran in 2014. The Research Council of Hamadan University of Medical Sciences approved the study. This study reports the results of a screening program conducted in Tehran to assess the prevalence of diabetes and hypertension and their associated risk factors. The participants were people aged 30 years or older referring to 16 health centers, affiliated with Shahid Beheshti University of Medical Sciences, in Tehran and its suburbs.

A standard questionnaire was used to collect data on blood pressure, body mass index, waist-hip ratio, fasting blood sugar, smoking status, and demographic characteristics (age and gender).

Height and weight were measured in light clothing not wearing shoes. Body mass index (BMI), the weight in kilograms divided by the square of the height in meters (kg/m^2), was used as an index to classify overweight and obesity in adults based on the World Health Organization recommendation as follows: a BMI less than 18.5 kg/m^2 is underweight, a BMI equal to or greater than 18.5 kg/m^2 is normal weight, a BMI equal to or greater than 25 kg/m^2 is overweight, and a BMI equal to or greater than 30 kg/m^2 is obese.[14]

The waist-hip ratio was used as an index of abdominal obesity. The waist circumference was measured at the end of a normal expiration with the arms relaxed at the sides at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant tape. The hip circumference was measured at its widest portion of the buttocks, with the tape parallel to the floor.[15]

Blood pressure was measured using standardized mercury Sphygmomanometers after five minutes resting in the sitting position twice with 10–15 min interval, but was not repeated on the next day. A mean blood pressure at or above 140/90 mmHg was defined as hypertension.[15] The people on medication for high blood pressure were considered hypertensive regardless of their blood pressure level.

Fasting blood sugar (FBS) was measured by taking a venous blood sample after 12 h overnight fasting. FBS was categorized according to the American Diabetes Association as follows: an FBS less than 110 mg/dl is normal fasting glucose, an FBS between 110 and 125 mg/dl is impaired fasting glucose, and an FBS equal to or more than 126 mg/dl is diabetes.[16] The people on medication for high blood glucose were considered diabetes, regardless of their FBS level.

Logistic regression analysis was performed to investigate the association between major risk factors and blood pressure. To control for the confounding effect of the variables, an adjusted analysis was performed and reported. The 2 by 2 interactions between age and BMI, age and FBS, and BMI and FBS were checked. All statistical analyses were performed at a 95% significance level using the statistical software Stata version 11 (StataCorp, College Station, TX, USA).

Results

Of the 7611 people who participated in the screening program, 696 (9.1%) had raised blood pressure. The mean (SD) age of the participants was 46.92 (12.88) years with a range of 30–93 years. The characteristics of the study population are given in Table 1. Based on multiple logistic regression analysis [odds ratio (95% confidence interval)], raised blood pressure was significantly associated with every 10-year increase in age 2.06 (1.87, 2.27), obesity 1.64 (1.16, 2.33), impaired blood glucose 1.58 (1.11, 2.25), and diabetes 2.97 (2.25, 3.93). Raised blood pressure was non-significantly associated with female gender 1.20 (0.93, 1.54), overweight 1.24 (0.88, 1.76), abdominal obesity 1.08 (0.81, 1.46), and smoking 1.42 (0.85, 2.36).

The level of exposure to four well-known risk factors for high blood pressure that is necessary to replicate the OR of 2.0 is given in Table 2. According to the results, an OR of 2.0 corresponds to an increase in age of about 9.4 years, an increase in BMI of about 10.3 kg/m^2, an increase in waist-hip ratio of about 0.5, and an increase in fasting blood sugar of about 85.8 mg/dl.

Table 1 – Characteristic of the study population and odds ratio estimates of high blood pressure using multiple logistic regression adjusted for all variables in the table.

Variables	Normotensive $n = 6915$[a]	Hypertensive $n = 696$[a]	Odds ratio (95% CI)	P-value
Gender				
Male	3387	270	1.00	
Female	3528	426	1.20 (0.93, 1.54)	0.160
Age group (yr)				
30–39	2608	50	1.00	
40–49	2173	120	2.84 (1.73, 4.65)	0.001
50–59	1190	176	6.03 (3.72, 9.79)	0.001
60–69	507	168	14.17 (8.66, 23.20)	0.001
≥70	405	178	19.19 (11.52, 31.97)	0.001
Every 10-year increase in age	6883	692	2.06 (1.87, 2.27)	0.001
Body mass index (kg/m^2)				
Normal weight (18.5–24.9)	2638	146	1.00	
Underweight (<18.5)	42	3	2.30 (0.44, 11.97)	0.323
Overweight (25.0–29.9)	2566	257	1.24 (0.88, 1.76)	0.213
Obese 1 (≥30.0)	1623	276	1.64 (1.16, 2.33)	0.005
Waist-to-hip ratio				
Normal	1616	123	1.00	
Abdominal obesity[b]	4982	524	1.08 (0.81, 1.46)	0.587
Fasting blood sugar (mg/dl)				
Normal (<100)	2428	232	1.00	
Impaired fasting glucose (100–125)	256	55	1.58 (1.11, 2.25)	0.011
Diabetes (≥126)	255	150	2.97 (2.25, 3.93)	0.001
Smoking status				
Non-smoker	5589	617	1.00	
Smoker	608	47	1.42 (0.85, 2.36)	0.178

[a] The sum of subgroups may be less than total because of missing data.
[b] Waist-to-hip ratio >0.90 in men and >0.85 in women.

Table 2 – Odds ratio estimates of high blood pressure based on logarithmic scale using multiple logistic regression adjusted for gender, smoking, and all variables in the table.

Variables[a]	Coef.	Std. Err.	z	P-value	95% CI		Exposure level[b]
Age (yr)	0.07350	0.00481	15.270	0.001	0.06406	0.08294	9.4
Body mass index (kg/m^2)	0.06706	0.01285	5.220	0.001	0.04188	0.09224	10.3
Waist to hip ratio	1.35092	0.80079	1.690	0.092	−0.21860	2.92043	0.5
Fasting blood sugar (mg/dl)	0.00807	0.00137	5.880	0.001	0.00539	0.01076	85.8
Constant	−8.45811	0.52544	−16.100	0.001	−9.48795	−7.42826	–

[a] There was no significant 2 by 2 interaction between age and BMI ($P = 0.829$), age and FBS ($P = 0.866$), and BMI and FBS ($P = 0.940$) (not shown in the table).
[b] The level of exposure of risk factor necessary to replicate the odds ratio of 2.0.

Discussion

Raised blood pressure, elevated fasting plasma glucose, and abdominal obesity along with high serum triglycerides and low high-density cholesterol are components of metabolic syndrome. The exact mechanisms of the complex pathways of this syndrome has been only partially elucidated. The most important contributing factors that have been suggested playing a role in the etiology of the metabolic syndrome are ageing, genetics, unhealthy diet, inactivity, and harmful use of alcohol.[17–20]

We indicated that every 9–10 years increase in age can double the risk of hypertension. Age is a major predisposing factor for most common degenerative diseases. Aging exerts a substantial effect on the cardiovascular system and, in particular, the arterial stiffness.[21] Age is among the six major risk factors that compose the WHO/ISH risk prediction chart used to estimate 10-year risk of a fatal or nonfatal major cardiovascular event including myocardial infarction or stroke.[22]

According to our results, the risk of hypertension doubles for every 10 unit increase in BMI or every 0.5 unit increase in waist-hip ratio. Considerable progress has been made in clarifying the pathophysiology of the obesity-related hypertension. It is a multifactorial disorder in which several potential pathogenic mechanisms probably play a role, including hyperinsulinemia, stimulation of the sympathetic nervous system, and activation of the renin-angiotensin system which results in renal tubular reabsorption, sodium retention, volume overload, and hence hypertension.[23–25]

Based on our findings, the risk of hypertension doubles if FBS increases about 85.8 mg/dl. Diabetes

and hypertension, so often occur together. There is considerable overlap between the two diseases in etiology. Diabetes and hypertension have several common metabolic pathways, including obesity, inflammation, oxidative stress, and insulin resistance.[26] Furthermore, the metabolic abnormalities due to diabetes mellitus induce vascular dysfunction that predisposes the patients to atherosclerosis.[27] In other words, having diabetes puts the patients at increased risk for hypertension, ischemic heart disease, and stroke because diabetes damages arteries and makes them targets for atherosclerosis.[28,29]

The replicated odds ratio of 2.0 which was reported for each variable was adjusted for other variables in the model as well as gender and smoking. That means we assessed the pure effect of each variable on blood pressure independent of other variables in the model because we used multiple logistic regression model and controlled for all other variables. In other words, we measured the effect of each variable on blood pressure while the other variables are considered fixed, but in real world, these variables may change over time. Therefore, if the level of these risk factors increases, the risk of blood pressure would increase much more because of the synergistic effect of these variables. Furthermore, increase in BMI will be associated with increased risk of central obesity and diabetes. Therefore, an increase in BMI will increase the risk of hypertension through several pathways, although we measured the effect of this factor on blood pressure as an independent variable.

We acknowledge the limitations and potential biases of this cross-sectional study as follows. An important limitation of this study was incomplete data on FBS because FBS was not examined for all participants. Furthermore, the people on medication for high blood pressure/glucose were considered hypertensive/diabetic, regardless of their blood pressure/glucose level. Indeed, patients with hypertension/diabetes had a normal blood pressure/glucose because of using medication. This may underestimate the association between blood glucose and blood pressure. Despite its limitation, we believe the results of study are of great importance for public health policy and prioritizing prevention programs.

Conclusion

This study indicated how much increase in age, body mass index, waist-hip ratio, and fasting blood sugar can double the risk of hypertension. These results may be of importance in public health policy and in prioritizing and planning effective prevention programs to reduce the burden of high blood pressure.

Author statements

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The data used in this study was the results of a screening program conducted in Tehran to assess the prevalence of diabetes and hypertension and their associated risk factors. We thank the staffs and managers of the Shahid Beheshti University of Medical Sciences for their collaboration with this study.

Ethical approval

The Research Council of Hamadan University of Medical Sciences approved the study.

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Competing interests

The authors declare that they have no conflicts of interest in this work.

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