Comparison of High-Risk Lifestyles and Obesity in Predicting Risk of Incident Hypertension: A Cohort Study

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Research article

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Abstract

Background

The aim of this study was to compare the impact of obesity and lifestyle factors, including sedentary behavior, high fat diet and low fiber diet on incident essential hypertension (EH) in a population-based Chinese cohort.

Methods

We analyzed data from a population-based prospective cohort of 2778 participants aged 35–74 years from Jiangsu China who were free of hypertension, diabetes and cardiovascular disease (CVD) at enrollment and were followed for hypertension events.

Results

Cox proportional hazards regression model was used to calculate the hazard ratio (HR) of hypertension and corresponding 95% confidence interval (CI). A total of 2778 participants were studied, including 660 cases. In non-obese subjects, SBP and DBP levels were lower in subjects without high risk lifestyles, compared to subjects with high risk lifestyles. However, in obese subjects, SBP and DBP levels were not different between subjects with and without high-risk lifestyles. In non-obese subjects, all high risk lifestyles were associated with higher EH risk, however, all high risk lifestyles were not associated with EH in obese subjects.

Conclusions

Obesity was a more important risk factor of EH than high-risk lifestyles. Life style modification may achieve few effects on EH risk if no weight was lost. Life style modification only achieved few effects on EH risk factors in obese subjects, suggesting that a focus on reducing obesity through a broad range of actions is likely to be more effective in preventing EH than an approach that solely focuses on inactivity and unhealthy diet style.

1. Introduction

Essential hypertension (EH) was a risk factor for many inverse outcomes, and contributes to more excess premature deaths than any other preventable factor [1]. Many modifiable high-risk lifestyles for hypertension have been identified, including obesity [2, 3], physical inactivity [4–6], and unhealthy diet behavior [7, 8]. Evidence suggested that lifestyle modification and weight loss may decrease blood pressure in adults [9–11], the steady decrease in its prevalence has been accompanied by an increase in modification of high risk life style, such as increase physical activity levels, reduction for intake of energy-dense food and increase for consumption of high-fiber food. However, there are still many subjects who have no high risk life style but were obese yet, or subjects who have high risk life style but were not obese. So it is very necessary to compare the importance of high risk life style and obesity on EH risk, so as to

evaluate the EH risk of these persons. However, the relative importance of obesity and physical activity as predictors of EH risk remains controversial, and it is still uncertain whether lifestyle modification has a significant reduction effect on the risk of EH in subjects, who were obese still. Therefore, the main purpose for this study was to compare the impact of obesity and high risk lifestyle factors (including sedentary behavior, high fat diet and low fiber diet) on incident hypertension in a population-based Chinese cohort.

2. Methods

2.1 Study cohort

The Prevention of MS and Multi-metabolic Disorders in Jiangsu Province of China Study (PMMJS) is a prospective cohort study aimed to estimate the prevalence of MS and the incidence of cardiovascular disease (CVD) and type 2 diabetes mellitus in Jiangsu province of China. The detailed design of this study has been described in our previous studies [12, 13]. Briefly, the cohort was established between 2000 and 2004 in Jiangsu, China. Overall, 6400 participants aged 35–74 years were randomly selected based on a multi-stage sampling method. In the first survey, 5888 participants (92%) returned a completed questionnaire with information on diet, education, occupation, lifestyle factors, physical activity levels and medical history. The protocol was approved by the ethical committee of Soochow University. All research methods in this study were carried out by the approved guidelines.

In the second survey between 2006 and 2008, 4582 participants who have been followed for at least five years in this cohort were reached by actual re-contact. A total of 4083 participants completed the follow-up survey, with a follow-up rate of 89.1%. The characteristics of non-participants, such as age, sex, and metabolic variables, were similar to those who participated in the follow-up survey.

For this analysis, we excluded participants with hypertension ($n=820$), diabetes ($n=289$), CVD ($n=36$), and missing data ($n=133$) at baseline. We also excluded participants with BMI $<18.5 \text{ kg/m}^2$ ($n=27$), leaving 2778 eligible participants (1097 males and 1681 females) for final analysis. Each participant signed an informed consent form at the interview.

2.2 Exposure assessment

Overweight and obesity were defined as body mass index (BMI) $\geq 25 \text{ kg/m}^2$ and BMI $\geq 30 \text{ kg/m}^2$ respectively [14]. Sedentary behavior was evaluated according to definition raised by Pate [15]. The subjects also reported their diet intake information. High fat and low fiber diet style was defined according to “Chinese Dietary Reference Intakes (DRIs)” [16] by Chinese Nutrition Society. Fat intake more than recommended nutrient intake (RNI) was considered as high fat diet-style. Fiber intake less than RNI were considered as low fiber diet style.

2.3 End point ascertainment

For this study, hypertension was defined as systolic blood pressures (SBP) ≥ 140 mmHg and/or diastolic blood pressures (DBP) ≥ 90 mmHg and/or the use of antihypertensive medication, as reported in the questionnaires [17].

2.4 Covariate measurement

Covariate measurements for all studied factors have been shown in our previous study [13]. Data on demographic characteristics, lifestyle risk factors, personal medical history and family history of hypertension for all participants were obtained using a standard questionnaire administered by trained staff. Three sitting blood pressure (BP) measurements were taken at 30-second intervals by trained observers using a standard mercury sphygmomanometer after the subjects had been resting for 5 min according to a standard protocol. The first and fifth Korotkoff sounds were recorded as the SBP and DBP, respectively. The mean of the three BP measurements was used in the analysis. Body weight and height were measured using standard methods, and the BMI was calculated as the weight in kilograms divided by the square of the height in meters.

Blood samples were collected in the morning after at least 8 hours of fasting. All plasma and serum samples were frozen at -80°C until laboratory testing was performed. Plasma glucose was measured using an oxidase enzymatic method. The concentrations of high density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were assessed enzymatically using an automatic biochemistry analyzer (Hitachi Inc, Tokyo, Japan) and commercial reagents. All analyses were performed by the same lab.

2.5 Statistical analysis

Means with standard deviations (SD) were calculated for baseline normal distributed continuous variables, and medians with inter-quartile range for baseline non-normal distributed continuous variables, percentages were calculated for categorical variables. Baseline characteristics were grouped and compared according to obese status using chi-square test for categorical variables and t test for continuous variables. Cox proportional hazards regression model was used to calculate the hazard ratio (HR) of hypertension and corresponding 95% confidence interval (CI). All statistical analyses were performed using the SPSS statistical software system for Windows version 16.0 (SPSS Inc. Chicago, USA).

3. Results

A total of 2778 participants (1097 males and 1681 females) were studied, this number included 660 (23.8%) subjects (254 males and 406 females) who developed hypertension by the follow-up investigation and 578 obese subjects. Compared to non-obese subjects, total cholesterol (TC), fast plasma glucose (FPG), TG, SBP, DBP, low density lipoprotein cholesterol (LDL-C) were higher and HDL-C was lower in obese subjects. The baseline characteristics of the 2778 study participants separated by BMI status are shown in Table 1.

Table 1
Baseline characteristics of 2778 study participants by BMI.

Variables	Non obese (n = 2200)	Obese (n = 578)	P-values
Males (%)	41.6	31.3	< 0.001
Age (year)	49.03 ± 9.66	48.6 ± 9.24	0.343
TC (mmol/l)	4.47 ± 0.94	4.70 ± 0.91	< 0.001
HDL-C (mmol/l)	1.29 ± 0.35	1.16 ± 0.2	< 0.001
LDL-C (mmol/l)	2.51 ± 0.76	2.69 ± 0.78	0.003
FPG (mmol/l)	5.23 ± 1.05	5.46 ± 1.43	< 0.001
TG (mmol/l)	1.20 (0.92–1.65)	1.60 (1.22–2.29)	< 0.001
SBP (mmHg)	116.58 ± 11.04	120.76 ± 10.53	< 0.001
DBP (mmHg)	75.22 ± 7.75	78.82 ± 6.95	< 0.001
Smoking (%)	22.7	19.7	0.263
Alcohol consumption (%)	21.1	20.9	0.456
Family history of hypertension (%)	25.1	25.8	0.735
Sedentary behavior (%)	17.3	19.0	0.381
High-fat diet (%)	36.7	38.9	0.330
Low-fiber diet (%)	9.0	10.0	0.465
BMI, body mass index; TC, total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein; LDL, low density lipoprotein; FPG, fast plasma glucose; TG, triglyceride.			

After adjustment for age, sex, TC, TG, FPG, HDL-C, LDL-C, family history of hypertension, HRs of hypertension were 1.53 (1.24–1.93) and 2.70 (1.47–4.97) for overweight and obese subjects, compared with non-obese subjects. HR of hypertension was 0.62 (0.48–0.79) for subjects without sedentary behavior, compared with subjects with sedentary behavior. HR of hypertension was 0.52 (0.44–0.65) for subjects without high-fat diet, compared with subjects with high-fat diet. HR of hypertension was 0.57(0.43–0.76) for subjects without low-fiber diet, compared with subjects with low-fiber diet (Table 2). In non-obese subjects, SBP and DBP levels were lower for subjects without high risk lifestyles, compared to subjects with high risk lifestyles. However, in obese subjects, SBP and DBP levels were not different between subjects with and without high risk lifestyles. (Table 3)

Table 2
Association between BMI, sedentary behavior, high-fat diet, low-fiber diet and EH risk

Variables	Number of EH cases (N)	Cumulative incidence (%)	HR(95%CI)	aHR (95%CI) ^a
BMI				
Normal	472	21.5	1.00	Ref
Overweight	168	31.6	1.67 (1.35–2.06) *	1.53 (1.24–1.93) *
Obese	20	43.5	2.81 (1.55–5.07) *	2.70 (1.47–4.97) *
Sedentary behavior				
Yes	134	34.7	1.00	Ref
No	400	22.3	0.54 (0.43–0.68) *	0.62 (0.48–0.79) *
High -fat diet				
Yes	320	31.0	1.00	Ref
No	240	19.5	0.53 (0.45–0.64) *	0.52 (0.44–0.65) *
Low -fiber diet				
Yes	85	33.1	1.00	Ref
No	575	22.8	0.60 (0.45–0.79) *	0.57 (0.43–0.76) *
^a Adjusted for age, sex, TC, TG, FPG, HDL-C, LDL-C, family history of hypertension. * P < 0.05				

Table 3
Association between high risk lifestyle and EH risk in obese and non-obese subjects

High-risk lifestyles	SBP (Mean $\pm$ SD)			DBP (Mean $\pm$ SD)		
	Normal BMI	Overweight	Obese	Normal BMI	Overweight	Obese
Sedentary behavior						
No	124.3 $\pm$ 16.8	131.0 $\pm$ 17.3	129.9 $\pm$ 16.5	76.6 $\pm$ 10.1	80.7 $\pm$ 11.0	85.1 $\pm$ 11.6
Yes	132.6 $\pm$ 21.4	134.4 $\pm$ 18.7	138.8 $\pm$ 15.8	81.2 $\pm$ 10.0	84.0 $\pm$ 10.6	86.1 $\pm$ 9.1
P-values	< 0.001	0.121	0.109	< 0.001	0.016	0.782
High-fat diet						
No	124.0 $\pm$ 16.2	129.0 $\pm$ 15.8	134.1 $\pm$ 17.4	76.4 $\pm$ 9.7	80.0 $\pm$ 10.1	84.6 $\pm$ 10.5
Yes	130.6 $\pm$ 19.0	134.1 $\pm$ 18.7	135.7 $\pm$ 16.7	80.4 $\pm$ 10.0	83.5 $\pm$ 10.9	84.9 $\pm$ 10.9
P-values	< 0.001	0.001	0.396	< 0.001	< 0.001	0.922
Low-fiber diet						
No	125.4 $\pm$ 17.2	130.4 $\pm$ 16.8	131.9 $\pm$ 17.2	77.6 $\pm$ 9.9	81.3 $\pm$ 10.4	84.7 $\pm$ 10.6
Yes	130.0 $\pm$ 19.6	135.8 $\pm$ 19.7	132.5 $\pm$ 17.7	80.5 $\pm$ 10.3	82.0 $\pm$ 11.4	84.8 $\pm$ 11.2
P-values	< 0.001	0.031	0.940	0.006	0.660	0.988

After adjustment for age, sex, TC, TG, FPG, HDL-C, LDL-C, family history of hypertension, EH risk was lower for non-obese subjects without high risk lifestyle, compared with non-obese subjects with high risk lifestyle. In obese subjects, however, all high risk lifestyles were not associated with EH risk (Table 4). Both in subjects with and without high risk lifestyles, there are higher EH risk in overweight or obese subjects, compared to non-obese subjects, except overweight subjects with low-fiber diet. (Table 5)

Table 4
Association between high risk lifestyle and EH risk in obese and non-obese subjects

High-risk lifestyles	Normal BMI		Overweight		Obese	
	Cumulative incidence (%)	HR (95%CI) ^a	Cumulative incidence (%)	HR (95%CI) ^a	Cumulative incidence (%)	HR (95%CI) ^a
Sedentary behavior						
Yes	33.3	Ref	38.5	Ref	42.9	Ref
No	19.0	0.54 (0.41–0.72)*	33.1	0.83 (0.49–1.41)	48.1	2.23 (0.39–12.88)
High-fat diet						
Yes	28.5	Ref	39.0	Ref	50.0	Ref
No	17.5	0.52 (0.42–0.65)*	26.7	0.53 (0.36–0.79)*	37.5	0.56 (0.10–3.08)
Low-fiber diet						
Yes	31.7	Ref	38.5	Ref	45.0	Ref
No	20.5	0.53 (0.38–0.74)*	30.6	0.66 (0.36–1.23)	33.3	2.14 (0.17–27.40)
^a Adjusted for age, sex, TC, TG, FPG, HDL-C, LDL-C, family history of hypertension; * P < 0.05						

Table 5
Association between BMI and EH risk in subjects with and without high risk lifestyle

High-risk lifestyles	Normal BMI		Overweight		Obese	
	Cumulative incidence (%)	HR (95%CI) ^a	Cumulative incidence (%)	HR (95%CI) ^a	Cumulative incidence (%)	HR (95%CI) ^a
Sedentary behavior						
Yes	33.3	Ref	38.5	1.56 (1.05–2.24) *	42.9	2.19 (1.24–9.69) *
No	19.0	Ref	33.1	1.95 (1.48–2.56) *	48.1	3.66 (1.67–8.04) *
High-fat diet						
Yes	28.5	Ref	39.0	1.59 (1.14–2.24) *	50.0	2.44 (1.02–5.81) *
No	17.5	Ref	26.7	1.68 (1.25–2.27) *	37.5	2.68 (1.12–6.45) *
Low-fiber diet						
Yes	31.7	Ref	38.5	1.22 (0.75–3.07)	45.0	2.03 (1.24–5.75) *
No	20.5	Ref	30.6	1.65 (1.31–2.08) *	33.3	2.99 (1.56–5.73) *
^a Adjusted for age, sex, TC, TG, FPG, HDL-C, LDL-C, family history of hypertension; * P < 0.05						

4. Discussion

Obesity and lack of exercise are both important risk factors of hypertension. Changing these unhealthy risk factors plays an important role in the prevention of hypertension [18]. However, there are many subjects who have no sedentary behavior but were obese yet, or subjects who have sedentary behavior but were not obese. So it is very necessary to compare the importance of sedentary behavior and obesity on EH risk, and to clarify whether lifestyle modification has a significant reduction effect on the risk of EH in subjects, who were obese still. In this study, there are lower EH risk for non-obese subjects. However, the association between decreased high-risk lifestyle and lower EH risk just existed in non-obese subjects. Conversely, lower BMI level was associated with lower EH risk, regardless of lifestyles. It means that

obesity was a more important risk factor for EH than high-risk lifestyles, maybe diet behavior modification could reduce EH risk by decreased BMI level, but modifying high-risk lifestyle is not associated with reduction for EH if no weight is lost, because the association between decreased high-risk lifestyle and lower EH risk just existed in non-obese subjects.

Physical inactivity or lack of exercise is an important factor that causes the global disease burden to increase year by year, and is significantly related to many other diseases except hypertension [19]. Some cohort studies [20] confirmed that physical inactivity rather than obesity is a causal factor for EH. The benefits of regular physical exercise on human health and life span exceed the effects of any medicine or medical measures [21, 22]. It means that it may be more effective to prevent chronic diseases by reducing body weight in various ways than only focusing on physical activities but not paying attention to heavy weight reduction [23]. Previous attention has focused on the limited success rate of traditional methods of preventing or managing weight at the individual or population level in reducing body mass index. If the weight is not reduced, the efforts to increase physical activity have limited effect on preventing hypertension.

Non- healthy lifestyles, such as an increased intake of high fat foods and decreased intake of fiber intake, is the major contributor to the higher BMI levels and some common diseases, including hypertension. Patel et al [24] indicated that a negative relation between SBP and dietary fiber (fruits and vegetables) based on data gathered from CHASRS. Howard et al. [25] proposed that dietary interventions such as reducing total fat intake and increasing vegetable, fruit and cereal intakes did not significantly reduce the risk of CVD in the population. In this study, obesity should be focused on more than diet behavior modification in the prevention of EH. Diet behavior modification could reduce EH risk by decreased BMI level, but could not reduce EH risk significantly, if no weight was lost.

Limitations of this study should be considered. Firstly, we cannot obtain the detailed measurement of high-fat diet, low fiber diet and time of physical inactivity in our database. In addition, the proportion of male subjects is higher than that of female subjects. However sex was adjusted in the analysis as a confounder factor. There are relatively few obese subjects in our population.

Conclusions

The results from this Chinese prospective cohort study indicated that obesity was a more important risk factor of EH than sedentary behavior, unhealthy diet style. Life style modification only achieved few effects on EH risk factors in obese subjects, suggesting that a focus on reducing obesity through a broad range of actions is likely to be more effective in preventing EH than an approach that solely focuses on inactivity and unhealthy diet style.

Abbreviations

EH

Essential hypertension; CVD:cardiovascular disease; BMI:body mass index;

SBP

systolic blood pressures; DBP:diastolic blood pressures; HDL-C:high density lipoprotein cholesterol; HR:hazard ratio; TC:total cholesterol; SBP:systolic blood pressure; DBP:diastolic blood pressure; HDL:high density lipoprotein; LDL:low density lipoprotein; FPG:fast plasma glucose; TG:triglyceride.

Ethics approval and consent to participate

this study has been approved by ethics committee of the Soochow University.

Consent for publication

Not applicable

Availability of data and material

Not applicable

Competing interests

The authors declare that they have no competing interests

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Declarations

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Authors' contributions: ZRG analyzed and interpreted the patient data regarding the hematological disease and the transplant. DY and WSL performed the histological examination of the kidney, and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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