Original Article

Salt intake, obesity, and pre-hypertension among Iranian adults: A cross-sectional study

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ABSTRACT

Objective: Overweight and obese subjects are prone to have a high salt intake. This study was aimed to investigate the relationship between salt intakev and prehypertension among overweight and obese subjects.

Methodology: This was across-sectional study performed in the setting of a community-based intervention: the Isfahan Healthy Heart Program (IHHP). In total, 806 subjects with normal blood pressure or prehypertension entered the study. Salt intake, BMI, and blood pressure were measured using standard methods.

Results: The salt intake was 9.19±5.34, 11.62±6.87, and 11.64±6.68 gm/d in normal-weight, overweight and obese subjects with normal blood pressure, respectively (p=0.0001). The values for normal-weight, overweight and obese prehypertensive subjects were12.04±8.03, 12.41±6.45, and 12.52±7.63 gm/d, respectively (p=0.236). The unadjusted odds ratio for prehypertension among obese subjects was 4.78 (95% CI2.38–9.60). The odds ratio was 4.73 (95%CI 2.19–10.19), 4.65 (95%CI 2.15–10.05), and 3.37 (95%CI 1.45–7.85) after adjustment for socio demographic characteristics, lifestyle factors, and salt intake, respectively. An increase of one gram per day in the daily salt intake increased the probability of having prehypertension by 5% after adjusting for age, education, BMI, and lifestyle factors.

Conclusion: The findings of this study support a role for high salt intake in the high blood pressure of overweight and obese subjects.

KEYWORDS: Salt intake, Obesity, Blood pressure.

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INTRODUCTION

High salt intake is being known to have harmful effects such as high blood pressure, stroke, renal disease, renal stones, osteoporosis, and probably stomach cancer.[1] It is one of the most powerful risk factors for left ventricular hypertrophy relative to other factors such as high diastolic blood pressure and body mass index (BMI).[2] High salt intake is also associated with an increased risk of stroke and cardiovascular disease (CVD).[3] A Cochran ere view in 2004 showed a reduction in systolic and diastolic blood pressure following the reduction in salt intake.[4] Studies such as the NHANES (National Health and Nutrition Examination Survey) and TOHP (Trials of Hypertension Prevention) have shown a 20–30% reduction in adverse

cardiovascular Events that is equivalent to a 2–3% reduction in adverse cardiovascular events over a 10–20-year period.[5,6]

Hypertension is the most important risk factor for CVD, which is the leading cause of mortality, and its prevalence has been increasing worldwide.[7] A high salt intake, obesity, and unfavorable dietary habits have been considered as underlying factors that affect the blood pressure.[8] A previous study showed a significant increase in the prevalence of hypertension in Iran from17.4%to 19.6% during the period from 2001 to 2007.[9] Another recent study showed that hypertension has the highest hazard ratio for CVD events in Iran.[10] Obesity is associated with increased blood pressure and premature death.[11] According to a national survey in Iran, the prevalence of overweight and obesity has been increasing in Iran.[12]

Hypertension is more prevalent among overweight and obese subjects than those of normal weight. It is estimated that 60 to 70%ofreportedcases of hypertension are related to obesity.[13] Several hormonal, physiologic, and hemodynamic mechanisms have been associated with obesity and high blood pressure.[13-16] In addition, demographic and lifestyle factors including the amount of salt intake appear to play a role in the association between obesity and hypertension. However, few studies have addressed the role of salt intake in elevated blood pressure in overweight and obese people. Our hypo thesis is that overweight and obese subjects have a higher salt intake because of increased food intake, which then adversely affects their blood pressure.

This study was conducted to investigate the association of salt intake and prehypertension among overweight and obese subjects in a population-based sample of Iranians.

METHODOLOGY

The study was performed on a subsample of the Isfahan Healthy Heart Program (IHHP) in Isfahan in 2007. The IHHP was a community trial performed between 2001 and 2007 in Isfahan, Najafabad, and A rank to address the increasing epidemic of non-communicable disease (NCD) and to promo tea healthy lifestyle.[17,18] A randomized systematic method was used to collect 806 subjects, and written informed consent was obtained from all participants. The study was approved by the Isfahan Cardiovascular Research Center Ethical Committee. The Isfahan Cardiovascular Research Center is a WHO-collaborating center in the Eastern Mediterranean Region. For our study, subjects with any of the following conditions were excluded: hypertension, diabetes, diabetes in sipidus, fasting or having a special diet at the time of the study, the use of diuretic medication, renal disease, being in the menstrual period at the time of the study, bleeding disorders, incapable of collecting a 24-hour urine sample according to the protocol.

At-home interviews were performed by trained health professionals. Socio demographic characteristics were recorded during interviews using standard questionnaires. To measure salt the intake, a24-hoururinesamplewasobtained from all participants based on the INTERSALT (INTERnational study of SALT and blood pressure) protocol.[19]

For accurately collecting the urine sample oral and written instructions were offered to the participants by the interviewers. After the participants voided the spot urine, the 24-hour urine collection was started. Appointments were arranged with all participants on the collection date of the urine sample, and the urine was delivered to the nearest health center the following day. The blood pressure and anthropometric indices were measured and blood specimens were collected at the health center to measure Na, K, BUN, and creatinine. To improve the participants` cooperation, the interviewers collected the urine sample at home if the participants could not deliver it to the Health Center. The blood pressure was measured twice in the sitting position. The first measurement was performed on both hands. The second measurement was performed on the hand with the higher blood pressure, and the mean of two measurements was calculated. The height was measured with the subjects barefoot in the standing position, and it was recorded to the nearest 0.5cm using a secured metal ruler. The weight was measured using calibrated scales with the subjects in light clothing. Urinary sodium was determined by flame photometry. Urinary creatinine was measured as a determinant by the Jaffe method (Technical SMA 12-60).[20] The laboratory where the blood and urine measurements were performed is nationally and internationally standardized.

Prehypertension was defined as systolic blood pressure 120–139 mmHg or diastolic blood pressure 80–89 mmHg according to the JNC-7 (Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure) definition.[21] The body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters. Smoking was defined as smoking at least one cigarette per day at the time of the study. Participants having at least 30 minutes of

Table-I: Basic characteristics of the study population.

Normal blood pressure	*Prehypertension*	*P*	
Age (years)(mean±SD)	35.92±11.97	44.73±12.55	<0.001
Sex (%)			
Women	57.8	45.9	0.05
Education (years)(%)			
0–5	23.3	47.9	<0.001
6–12	54.6	32.9	
>12	22.1	19.2	
BMI (kg/m2)(mean±SD)	25.09±4.28	27.95±3.83	<0.001
SBP (mmHg)(mean±SD)	101.01±8.68	124.76±6.479	<0.001
DBP (mmHg)(mean±SD)	67.27±7.10	82.09±4.98	<0.001
Salt intake (gram/day)(mean±SD)	10.38±6.19	12.76±7.11	0.003
Physical activity*(%)			
Inactive	64.7	69.9	0.38
Smoking**(%)			
Yes	9.6	9.7	0.97
Diet** (%)			
Consuming unhealthy diet	79.9	84.9	0.30

* Physically inactive: Subjects having <30 minutes of leisure time physical activity <5 days/week.
** Smoker: Subjects smoking at least 1 cigarette/day at the time of the study.
*** Unhealthy diet: A dietary score classified as unhealthy.

leisure-time physical activity on at least 5 days per week was regarded as active; other participants were considered to be physically inactive. A dietary score was calculated to classify the diet as healthy and unhealthy.[22]

Statistical Analysis: The mean±SD was calculated for the socio demographic as well as BMI, blood pressure and salt intake data, and the lifestyle habits were presented as percentages (%). An ANOVA was used to compare salt intake, BMI, and systolic and diastolic blood pressure in normal-weight, overweight, and obese subjects. The association of blood pressure with quartiles of salt intake was calculated. Logistic regression models were used to calculate the odds ratios of prehypertension in normal-weight, overweight, and obese subjects in five models. The first model was the crude model. The second model was adjusted for socio demographic characteristics. Model 3 was adjusted according to socio demographic characteristics as well as lifestyle habits including smoking, physical activity and diet. Model 4 was adjusted according only to socio demographic characteristics and salt intake. Model 5 was further adjusted for salt intake.

RESULTS

Of the 842 subjects that entered the study, 23 subjects were excluded because of incorrect collection of 24-hour urine samples based on creatinine values; therefore, 806 subjects were included in the final analysis. The age, BMI, and lifestyle characteristics of the study population are shown in Table-I. The salt intake was 10.38±6.19 gr/d and 12.76±7.11 gr/d in subjects with normal blood pressure and prehypertension, respectively (p=0.003). The mean systolic and diastolic blood pressure was 101.01±8.68 mmHg and 67.27±7.10 mmHg in subjects with normal blood pressure and 124.76±6.47 mmHg and 82.09±4.98 mmHg in subjects with prehypertension, respectively (p<0.001). The lifestyle habits including physical

Table-II: Salt intake, BMI, and blood pressure among normal, overweight, and obese Iranian adults based on normal blood pressure and prehypertension status.

	Normal blood pressure			*Pre-HTN*		
	Mean	*SD*	*P*	*Mean*	*SD*	*P*
Salt intake						
Normal	9.19	5.34	.0001	12.04	8.03	.231
Overweight	11.62	6.87		12.41	6.45	
Obese	11.64	6.68		15.52	7.63	
BMI(mean±SD)[1]						
Normal[2]	21.73	2.25	<.0001	23.58	0.93	<.0001
Overweight	27.17	1.41		27.34	1.43	
Obese	32.78	2.47		32.94	2.59	
Systolic blood pressure						
Normal	98.45	8.06	<.0001	125.00	6.61	.679
Overweight	103.14	8.77		124.92	7.29	
Obese	105.43	8.049		124.08	5.66	
Diastolic blood pressure						
Normal	65.48	6.88	<.0001	79.41	6.70	.019
Overweight	68.57	7.19		82.06	3.77	
Obese	70.64	5.93		83.95	4.51	

[1] Data are expressed as the mean±SD, and p-values were obtained from the t-test.
[2] The data are expressed as percentages, and p-values were obtained from the chi-squared or exact chi-squared test.

activity, smoking, and diet were not significantly different between subjects with normal blood pressure and those with prehypertension.

The BMI was 25.09±4.28 and 27.95±3.83 in participants with normal blood pressure and those with prehypertension, respectively (p<.000). The salt intake was 9.19±5.34, 11.62±6.87, and 11.64±6.68 in normal-weight, overweight and obese subjects with normal blood pressure, respectively (p=0.0001). The corresponding figures for normal, overweight, and obese prehypertensive subjects were 12.04±8.03, 12.41±6.45, and 12.52±7.63, respectively (p=0.231). The blood pressure was not significantly associated with the quartiles of salt intake in crude models or after adjustment for socio demographic factors, lifestyle, and BMI. (Table-III)

The unadjusted odds ratio for prehypertension relative to normal blood pressure among obese subjects was 4.78 (95% CI 2.38–9.60). After adjustment for socio demographic characteristics, the odds ratio was 4.73 (95% CI 2.19–10.19). A further adjustment for socio demographic factors and lifestyle habits changed the odds ratio for prehypertension. After salt intake was included in the model, the odds ratio decreased from 4.78 (95% CI 2.38–9.60) to 3.37 (95% CI 1.45–7.85). (Table-IV) An increase of one gram per day in the daily salt intake increased the probability of having prehypertension by 5% after adjusting for age, education, BMI, and lifestyle factors.

Table-III: Adjusted odds ratios (95% CI) for prehypertension among quartiles of salt intake.

Quartile of salt intake[a]	*Normal blood pressure*	*Prehypertension*
Model 1		
< Quartile 1	ref	ref
Quartile 1_ Quartile 2	ref	0.92(0.41–2.07)
Quartile 2_ Quartile 3	ref	1.68 (0.82–3.46)
>Quartile 3	ref	1.87 (0.92–3.82)
Model 2		
< Quartile 1	ref	ref
Quartile 1_ Quartile 2	ref	0.91(0.39–2.12)
Quartile 2_ Quartile 3	ref	1.58 (0.73–3.40)
>Quartile 3	ref	1.89 (0.89–3.99)
Model 3		
< Quartile 1	ref	ref
Quartile 1_ Quartile 2	ref	0.94 (0.40–2.18)
Quartile 2_ Quartile 3	ref	1.63 (0.75–3.52)
>Quartile 3	ref	1.96 (0.93–4.15)
Model 4		
< Quartile 1	ref	ref
Quartile 1_ Quartile 2	ref	0.92(0.39 , 2.15)
Quartile 2_ Quartile 3	ref	1.61(0.74 , 3.49)
>Quartile 3	ref	1.86(0.87,3.96)

[a] indicates : quartile 1 of salt intake =5.85; quartile 2 =9.08; quartile 3 = 14.35.
The data are expressed as odds ratios (95% confidence interval) from logistic regression.
Model 1: unadjusted.
Model 2: adjusted by sex, age, education, occupation.
Model 3: adjusted by sex, age, education, occupation, physical activity, diet.
Model 4: adjusted by sex, age, education, occupation, physical activity, diet, smoking.

DISCUSSION

According to the results of the present study, the salt intake was higher among overweight and obese individuals. We also found that the association between blood pressure and obesity was affected by socio demographic and lifestyle factors and mediated by a higher salt intake among overweight and obese subjects.

The salt intake was higher among overweight and obese subjects compared with normal-weight individuals. Although the daily salt intake level recommended by the World Health Organization is less than 6 g/d[23], the salt intake ranges from 9 to 12 g/d in many countries.[24] This is similar to our findings and the findings of a previous study in

Table-IV: Adjusted odds ratios (95%CI) for prehypertension among overweight & obese individuals.

	Prehypertension
Model 1	
Normal weight	1
Overweight	2.65(1.45-4.84)
Obese	4.78(2.38-9.61)
Model 2	
Normal weight	1
Overweight	2.33(1.23-4.39)
Obese	4.73(2.19-10.19)
Model 3	
Normal weight	1
Overweight	2.42(1.28-4.58)
Obese	4.65(2.15-10.05)
Model 4	
Normal weight	1
Overweight	2.19(1.13-4.23)
Obese	3.46(1.49-8.02)
Model 5	
Normal weight	1
Overweight	2.25(1.17-4.36)
Obese	3.37(1.45-7.85)

The data are expressed as odds ratios (95% confidence interval) from the logistic regression.
*Model 1: Crude model.
Model 2: Adjusted according to sociodemographic characteristics.
Model 3: Adjusted according to sociodemographic characteristics, smoking, physical activity, and diet.
Model 4: Adjusted according to sociodemographic characteristics, and salt intake.
Model 5: Adjusted according to sociodemographic characteristics, smoking, physical activity, Diet, and salt intake.

2001 found a salt intake of 9.9 ± 2.9 g/d among the general Iranian population.[20] It appears that the salt intake has increased among the Iranian population and is higher among individuals with overweight and obesity.

A population-based study in India showed an association between salt intake and blood pressure that remained significant even after adjustment for socio demographic characteristics, total energy intake, and dietary fat.[25] In our study, the association between weight and blood pressure was significant, as expected. Moreover, socio demographic factors, lifestyle factors, and salt intake modified the odds ratio as confounding factors. This finding supports our hypothesis that some of the association between obesity and high blood pressure is mediated by increased salt intake in obese individuals.

A previous study from INTERSALT showed a significant association between salt intake and blood pressure such that systolic and diastolic blood pressure increases of 6.00 and 2.52 mmHg were observed per 100 mmol salt intake, respectively. The association decreased to 3.14 and 0.14 mmHg for systolic and diastolic blood pressure, respectively, after adjustment for BMI.[26] These studies did not consider the effect of lifestyle factors such as smoking, physical activity, and diet and they were performed on the general population regardless of weight. The association of these lifestyle habits with blood pressure and weight is well established.[27]

However, few studies have considered the confounding role of these factors on the relationship between weight and blood pressure. A study on children aged 4–18 years showed an association between salt intake and soft drink consumption, thereby proposing a link between obesity and salt intake such that higher salt intake leads to a higher consumption of fluids that is mainly covered by soft drinks, which may lead to overweight and obesity. The authors proposed that a reduction of the salt intake could reduce childhood obesity by reducing the consumption of sugar-sweetened soft drinks.[28] However, the attribution of the adverse effect of higher salt intake to merely higher soft drink consumption requires further justification.[29] Our study did not investigate the relationship between obesity and salt intake in this way; rather, we used statistical models to show the role of increased salt intake in high blood pressure among overweight and obese subjects.

The underlying mechanisms that affect blood pressure in obesity have been the subject of many studies. The effects of the sympathetic nervous system; higher set points for diuresis and natriuresis; sodium retention; increased plasmarenin, aldosterone, angiotensinogen, and angiotensin II; insulin resistance; inflammation; leptin and other neuropeptides have been suggested as underlying factors.[13,30-37]

We documented a higher salt intake among overweight and obese subjects, although the difference was not significant in subjects with prehypertension. This finding, in addition to the lower odds ratios for the association of blood pressure and weight after adjustment for the effect of salt intake, supports a role for salt intake as a factor that results in higher blood pressure among overweight and obese subjects relative to normal-weight subjects.

Hypertension was one of the exclusion criteria for our study, and our sample only included subjects with normal blood pressure and prehypertension. However, our hypothesis was supported. If we had hypertensive subjects in ours ample, we may not have been able to test our hypothesis as clearly.

Further studies are needed to clarify the underlying mechanism for increased blood pressure in overweight and obese subjects in light of the increased salt intake among these subjects. Weight reduction and a special attention to salt restriction in overweight and obese subjects may help to control the blood pressure, especially when efforts for weight reduction are not optimally practiced by patients.

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