Original Article

Association of obesity and pulse pressure with hypertension in an Iranian urban population

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Abstract

Objective: Nowadays, obesity is an important health problem and pulse pressure (PP) is a good predictor of cardiovascular events. The aim of study was to determine the association of obesity and PP with hypertension (HTN) in individuals aged 30 years or older in the urban population of Jahrom, Iran. **Materials and Methods:** In this study, we used a multistage stratified sampling method to select participants among the urban population aged 30 years or older. Height, weight, and blood pressure were obtained by a trained physician. Obesity was defined according to the World Health Organization classification. Angina was assessed with reliable and validate Rose questionnaire. Data were record by SPSS-16. Categorical and continues variables analyzed by Chi-squared, independent *t*-test, and one-way ANOVA test. Binary logistic regression analysis method was used for the association of PP and obesity with HTN and Rose angina that adjusted for age, gender, education class, marital status, smoking, total cholesterol, triglyceride, low-density lipoprotein, and high-density lipoprotein. A $P < 0.05$ was considered as statistical significance. **Results:** The prevalence of obesity was 18.1% that was greater in women (24.8% vs. 9.9%, $P < 0.001$). The prevalence of Rose angina and HTN in obese individuals were more than in normal weight individuals (24.8% vs. 16.4%, $P = 0.027$) and (42.0% vs. 31.1%, $P < 0.001$), respectively. Furthermore, patients in higher PP groups were older, were more possible to had HTN and had greater diastolic blood pressure (DBP), systolic blood pressure (SBP), and mean arterial pressure (MAP) in compared to individuals in the lower PP group. The individuals with HTN had greater DBP, SBP, MAP, PP, and body mass index (BMI) than individuals without HTN. However, individuals who had Rose angina, only had higher PP and BMI in compared to ones without Rose angina. The obese individuals had 1.97 (1.22–3.17, $P = 0.005$) fold for HTN risk than individuals with normal weight. In addition, PP weakly increased the risk of HTN about 1.09 fold (1.07–1.10, $P < 0.001$). However, Rose angina was associated only to overweight status (odds ratio = 1.51, confidence interval 95%: 1.03–2.20), $P = 0.035$) than individuals in normal weight group. **Conclusion:** Obesity and PP were higher in hypertensive individuals and overweight in individuals with Rose angina. It is time to pay more attention to abnormal BMI.

Keywords: Hypertension, mean arterial pressure, obesity, pulse pressure, rose angina

Introduction

Obesity is considered as dangerous health problems, because of its association with morbidity, disability, and mortality.[1] The prevalence of overweight and obesity is increasing in developed and developing countries.[2] The World Health Organization (WHO) estimated that in 2005 about 1.6 billion and at least 400 million adults (aged > 15 years) were overweight and obese, respectively.[3] In studies conducted in general population in Iran, the prevalence of obesity was 10.8–38.0%.[4]

Overweight and obesity associated with high risk for health problems including; type two diabetes mellitus, prediabetes, hypertension (HTN), metabolic syndrome, and hyperlipidemia.[5] Investigators found that blood pressure rose as body mass index (BMI) increased.[6,7]

Higher pulse pressure (PP) increases cardiovascular (CV) and cerebrovascular accidents and is an indicator of large artery

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Received: 28-04-2020 **Revised:** 11-06-2020
Accepted: 21-07-2020 **Published:** 30-09-2020

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_723_20

How to cite this article: Shojaei M, Jahromi AS, Karamatollah R. Association of obesity and pulse pressure with hypertension in an Iranian urban population. J Family Med Prim Care 2020;9:4705-11.

stiffness.[8] Investigators documented that morbidity and mortality following CV insults, including myocardial infarction (MI) was independently associated with PP.[9,10] In addition, Weiss *et al.* found that PP was associated with all-cause mortality (hazard ratio = 1.69, 95% confidence interval [CI] = 1.19 − 2.38, $P = 0.003$) in elderly patients admitted to an acute geriatric ward.[11] Bangalore *et al.* found that PP, as well as systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), are independent and strong predictors of adverse outcomes. However, SBP, DBP, and MAP are relatively stronger predictors of CV events than PP. Higher PP had potent stress on arteries that caused higher fracture rate in elastic constituents. Intima of vasculatures becomes vulnerable to threat, thus the risk of atherosclerosis and thrombosis greater than before. In addition, increased PP caused more stress on the heart, which be able to result in cardiac disease.[12] The prevalence of HTN and Rose angina, respectively, was 35.4% and 21.1% among individuals aged 30 years or over, in Jahrom, a south city in Fars province, Iran.[13,14]

Thus, in the present study, we determined the association of obesity and PP with HTN and Rose angina.

Methods

This investigation was based on a cross-sectional survey that adopted a cluster stratified systematic random sampling in urban area of Jahrom, a south city in Iran. Participants aged 30 years or older were selected from all urban health centers (10 centers) according to sex, age, and proportion of population in each health center. All called individuals interviewed face-to-face at internal clinic of Peymanie hospital and completed a demographic and a detailed medical questionnaire by trained interviewers. Pregnant and lactating women, people with chronic disease and mental disorders, and persons who were unable to walk, were not included in the study.

Eight hundred and ninety-one individuals participated in study. The procedures followed were in accordance with Ethical Committee on human experimentation of Jahrom University of Medical Sciences (ethics code: JUMS.REC.1378.51.7). Of all participants were obtained a written informed consent.

Height was measured, to the nearest 0.5 cm, without shoes. The weight was measured to the nearest 100 g (Seca700, Germany), with light cloths and without shoes. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. The definition proposed by the WHO for three groups of BMI was used in this study. Individuals with BMI of less than 25 kg/m^2 were classified as normal weight, those with BMI of 25 to <30 kg/m^2 were classified as overweight and those with BMI ≥30 kg/m^2 were classified as obesity.[15] We also stratified the subjects by smoking status. Then, smoker was defined as subjects who used smoking material at least 1 day/week.

Blood pressure was measured after at least 5 min' rest, using a mercuric sphygmomanometer (Richter, Germany) by trained physician. The subject's right arm was placed at the heart level. Two measurements were taken with 5 min' interval. SBP and DBP were defined as the average of the two SBP and DBP readings. HTN was defined as an average SBP ≥140 mmHg, an average DBP ≥90 mmHg, according to JNC7.[16] PP was calculated as subtracting DBP from SBP, and the individuals were categorized into three PP groups, by one-third; PP1: PP <40 mmHg, $n = 315$ (35.4%); PP2: PP 40–50 mmHg, $n = 298$ (33.4%); and PP3: PP >50 mmHg, $n = 278$ (31.2%). MAP was calculated as (2DBP + SBP)/3.

Angina was assessed by validate and reliable of Persian version of Rose questionnaire. Definite angina was defined according to standard criteria as chest pain or discomforts which: 1-was brought on by exertion, 2-was situated in the central or left anterior chest, 3-forced the subject to slow down or stop, 4-was relieved if the subject did so, and 5-was relieved within 10 min. Possible angina was defined as chest pain brought on by exertion, but not fulfilling all of the four additional criteria for definite angina.[17] Totally, we use sum of definite and possible angina as Rose angina.

Continuous variables were presented as mean values and standard deviation (SD). Categorical variables were presented as frequencies. Associations between categorical variables were tested by the use of contingency tables and the Chi squared test. Comparisons between continuous variables between groups were performed by analysis of independent *t*-test or one-way ANOVA test. Binary logistic regression test was used for determining of PP and BMI groups with HTN and angina. The other entered variables in model were age, gender, education, marital status, smoking, total cholesterol, triglyceride, high-density lipoprotein, and low-density lipoprotein. The result is presented as odds ratios (ORs) with 95% CI. The statistical analysis was performed using SPSS software, version 16 (SPSS Inc., Chicago, IL, USA). Values of $P < 0.05$ were considered to indicate statistical significance.

Results

In total, of 891 participants, 45.3% were men and 89.5% were married. The most of participants (28.9%) belong to aged 40–49 years and then to 30–39 years (25.7%), 50–59 years (23.4%) and 60 years or older (22%), respectively. One hundred and forty (15.7%) of participants had academic level of, 39.8% ≥9 years of, and 25.6% primary of education. Also, 18.9% of individuals were illiterate.

As shown in Table 1, the prevalence of obesity was 18.1% among participants that was higher in female (24.8% vs. 9.9%, $P < 0.001$) and in subjects with primary education ($P = 0.023$). Contrariwise, participants aged ≥60 years had lower prevalence of obesity ($P = 0.021$), and marital status had not effect on obesity percentage. Obese individuals had greater prevalence of HTN ($P = 0.045$) and Rose angina ($P = 0.027$) than individuals with normal weight. Also, individuals in the obese group had

Table 1: The prevalence of obesity according to age group, sex, education, and marital status

Variables	Normal weight, BMI <25	Overweight, BMI 25- <30	Obesity, BMI ≥30	*P*
Prevalence, *n* (%)	347 (38.9)	383 (43.0)	161 (18.1)	-
Age, year, mean (SD)	51.4 (14.6)	49.6 (13.1)	47.8 (11.2)	0.013
Age group (year), *n* (%)	89 (38.9)	96 (41.9)	44 (19.2)	
30-39				0.021
40-49	83 (32.1)	122 (47.4)	53 (20.5)	
50-59	82 (39.2)	85 (40.7)	42 (20.1)	
≥60	93 (47.7)	80 (41.0)	22 (11.3)	
Gender, *n* (%)				
Male	197 (48.8)	167 (41.3)	40 (9.9)	<0.001
Female	150 (30.8)	216 (44.4)	121 (24.8)	
Education, *n* (%)				
Illiterate	69 (40.9)	79 (46.7)	21 (12.4)	0.023
Primary	87 (38.3)	87 (38.4)	53 (23.3)	
Secondary to diploma	131 (36.9)	158 (44.5)	66 (18.6)	
Academic	60 (42.9)	59 (42.1)	21 (15.0)	
Marital status, *n* (%)				
Married	301 (39.0)	345 (43.3)	141 (17.7)	0.762
Others	36 (38.3)	38 (40.4)	20 (21.3)	
SBP (mmHg), mean (SD)	124.4 (20.1)	128.7 (19.4)	129.6 (18.5)	0.003
DBP (mmHg), mean (SD)	77.7 (12.4)	81.2 (10.4)	83.3 (10.1)	<0.001
MAP (mmHg), mean (SD)	93.3 (13.7)	97.0 (11.9)	98.7 (11.8)	<0.001
Pulse pressure (mmHg), mean (SD)	46.6 (15.1)	47.5 (15.9)	46.3 (13.8)	0.599
Blood pressure status, *n* (%)				
Normal blood pressure	142 (40.9)	97 (25.3)	39 (24.2)	<0.001
Prehypertension	96 (27.7)	148 (38.6)	53 (32.9)	
Previous hypertension	42 (12.1)	50 (13.1)	32 (19.9)	
Newly diagnosed hypertension	67 (19.3)	88 (23.0)	37 (23.0)	
Hypertension, *n* (%)				
Yes	109 (31.4)	138 (36.0)	69 (42.9)	0.045
No	238 (69.6)	245 (64.0)	92 (57.1)	
Angina, *n* (%)				
Yes	57 (16.4)	90 (23.5)	40 (24.8)	0.027
No	290 (83.6)	293 (76.5)	121 (75.2)	

DBP: Diastolic blood pressure, BMI: Body mass index, MAP: Mean arterial pressure, SBP: Systolic blood pressure, SD: Standard deviation

higher blood pressure components of DBP, SBP, and MAP than those in the normal weight group.

Individuals in higher PP groups were older, were more possible to had HTN and had greater DBP, SBP, and MAP in compared to individuals in the lower PP group. Although there are higher proportions of individuals who reported Rose angina in the high PP group, statistically was not significant [Table 2].

The individuals with HTN had greater DBP, SBP, MAP, PP, and BMI than individuals without HTN [Table 3]. However, individuals who had Rose angina, only had higher PP and BMI in compared to ones without Rose angina.

In binary logistic regression analysis, the obese individuals had 1.97 (1.22–3.17, $P = 0.005$) fold for HTN risk than individuals with normal weight. In addition, PP weakly increased the risk of HTN about 1.09-fold (1.07–1.10, $P < 0.001$). However, Rose angina was associated only to overweight status (OR = 1.51, CI 95%: 1.03–2.20), $P = 0.035$) than individuals in normal weight group [Table 4].

Discussion

In the present study, the prevalence of obesity was 18.1% that was more frequent in female. Also, obese individuals had greater proportion of HTN and Rose angina. We found that individuals with higher PP were older and hypertensive and had higher DBP, SBP, and MAP in compared to individuals in lower PP group. In the other hand, PP and obesity were associated to HTN and overweight to Rose angina.

The prevalence of obesity in our study was consistent to the result of found in Jamaica 19.7%,[18] but was more than China 2%,[3] Japan 2.9%,[19] Ghana 10.4%,[20] and Switzerland 14.3%.[21]

Our study showed the higher prevalence of obesity in women than in men, similar to results of Ghana[20] and Switzerland.[21] Adversely, the same prevalence of obesity among men and women was suggested by Lee *et al.*,[19] but was more in men than in women by Borges *et al.* in Brazil,[22] and Wu in Taiwan.[23]

Table 2: Baseline characteristics according to pulse pressure groups

Variables	Pulse pressure			*P*
	<40 (mmHg)	40-50 (mmHg)	>50 (mmHg)	
Age (year), mean (SD)	42.6 (9.1)	48.2 (11.4)	60.2 (13.3)	<0.001
Gender, *n* (%)				
Male	143 (35.4)	133 (32.9)	128 (31.7)	0.943
Female	172 (35.3)	165 (33.9)	150 (30.8)	
BMI (kg/m^2)	26.3 (4.5)	26.8 (4.5)	26.0 (4.2)	0.084
Smoking status, *n* (%)				
Others	264 (34.1)	264 (34.1)	247 (31.9)	0.114
Current smoker	51 (44.0)	34 (29.3)	31 (26.7)	
DBP (mmHg), mean (SD)	78.7 (10.1)	80.5 (10.5)	81.7 (13.3)	0.005
SBP (mmHg), mean (SD)	112.3 (11.1)	124.6 (10.8)	146.8 (18.0)	<0.001
MAP (mmHg), mean (SD)	89.9 (10.2)	95.2 (10.5)	103.4 (13.7)	<0.001
Blood pressure status, *n* (%)				
Normal blood pressure	172 (54.6)	94 (31.5)	12 (4.3)	<0.001
Prehypertension	94 (29.8)	132 (44.3)	71 (25.5)	
Previous HTN	9 (2.9)	25 (8.4)	90 (32.4)	
Newly diagnosed HTN	40 (12.7)	47 (15.8)	105 (37.8)	
HTN, *n* (%)				
Yes	50 (15.9)	71 (23.8)	195 (70.1)	<0.001
No	265 (84.1)	227 (76.2)	83 (29.9)	
Rose angina, *n* (%)	55 (17.5)	61 (20.5)	71 (25.5)	
Yes				0.053
No	260 (82.5)	237 (79.5)	207 (74.5)	

DBP: Diastolic blood pressure, MAP: Mean arterial pressure, SD: Standard deviation, SBP: Systolic blood pressure, HTN: Hypertension, BMI: Body Mass Index

Table 3: Blood pressure components and body mass index according to hypertension and Rose angina

Variable, mean (SD)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	PP (mmHg)	BMI (kg/m^2)
Blood pressure status					
Normal blood pressure	108.3 (7.9)	70.4 (6.5)	83.0 (6.1)	37.9 (7.4)	25.3 (4.4)
Prehypertension	124.3 (6.9)	80.2 (6.3)	94.9 (4.5)	44.1 (9.8)	26.8 (4.2)
Previous hypertension	147.6 (19.8)	86.4 (12.4)	106.8 (13.0)	61.2 (16.8)	27.0 (4.8)
Newly diagnosed hypertension	145.8 (15.0)	90.5 (10.4)	108.9 (8.6)	55.3 (18.2)	26.8 (4.3)
P	<0.001	<0.001	<0.001	<0.001	<0.001
HTN					
Yes	146.6 (16.9)	89.0 (11.3)	108.2 (10.4)	57.6 (17.9)	26.9 (4.5)
No	116.5 (10.9)	75.4 (8.0)	89.1 (8.0)	41.1 (9.3)	26.1 (4.4)
P	<0.001	<0.001	<0.001	<0.001	0.012
Rose angina					
Yes	129.0 (21.1)	79.4 (11.7)	96.0 (13.5)	49.5 (16.0)	27.3 (4.7)
No	126.7 (19.2)	80.4 (11.3)	95.9 (12.6)	46.3 (14.9)	26.1 (4.3)
P	0.152	0.297	0.908	0.009	0.002

DBP: Diastolic blood pressure, BMI: Body mass index, MAP: Mean arterial pressure, PP: Pulse pressure, SBP: Systolic blood pressure, HTN: Hypertension

The differences in lifestyles, physical activity, and sex hormones, additionally, other genetic or behavioral factors and also, the age of participants and the defining of obesity may explain the observed differences in the prevalence of obesity. The major contributors for obesity are low physical activity and high consumption of fat. Other factors are urbanization, advancing age, high socioeconomic level, dietary habits, and life styles.[21]

Obese and overweight individuals were more hypertensive than individuals with normal weight. Similar to our finding, results of a study in Peru confirmed the higher prevalence of HTN in obese than in normal weight individuals.[24] Furthermore, Nurdiantami *et al.*[25] found that the prevalence of HTN was positively related with increasing BMI. Also, Kawamoto *et al.* found that increasing BMI category were positively associated to HTN.[26] In study carried out in Nigeria, hypertensive individuals were more obese than ones without HTN.[27] In an analysis of the overall sample, each increasing in BMI unit was associated with a 10% increase the odds ratio of HTN (OR = 1.1, 95% CI: 1.1–1.2, $P < 0.0001$).[28]

Our finding suggested the greater frequency of Rose angina in obese individuals. This finding was suggested by Robinson *et al.* that showed the higher prevalence of obesity in patients with atherosclerosis than without one.[29] A prospective study showed a positive association of BMI with risk of coronary

Table 4: Binary logistic regression method of the association between hypertension and Rose angina with body mass index groups and pulse pressure

	HTN			Rose angina		
	OR	CI 95%	*P*	OR	CI 95%	*P*
BMI group						
Normal	Reference	-	-	Reference	-	-
Overweight	1.25	0.85-1.83	0.265	1.51	1.03-2.20	0.035
Obesity	1.97	1.22-3.17	0.005	1.48	0.92-2.38	0.107
PP	1.09	1.07-1.10	<0.001	1.01	0.99-1.02	0.620

Entered variables included: age, gender, education, marital status, and smoking, BMI groups, total cholesterol, LDL, HDL, triglyceride, and PP for hypertension and Rose angina. LDL: Low-density lipoprotein, HDL: High-density lipoprotein, CI: Confidence interval, OR: Odds ratio, BMI: Body mass index, PP: Pulse pressure

artery disease which each 2 kg/m^2 raise in usual BMI, increased 12% (95% CI 6%–19%, $P = 0.0001$) of ischemic heart disease mortality.[30] However, by Frohlich and Dobiasova[31] suggested the opposite finding.

This study also assessed the relationship between blood pressure indexes (SBP, DBP, MAP, and PP), HTN, and angina. Our results confirmed the greater level of blood pressure indexes in HTN and PP in Rose angina which these were higher in subjects with hypertensive and Rose angina individuals. SBP, DBP, and MAP have confirmed that were relatively stronger predictors of CV events than PP in elderly patients with coronary artery disease and HTN.[32] In another study in women with coronary disease, increased levels of PP were associated with coronary disease progression following 3.2 years of follow-up.[33]

With binary logistic regression model, HTN was associated to obesity and PP and Rose angina to overweight. It found that the relation between PP and coronary heart disease is nonlinear in patients with type 2 diabetes and HTN. So that, patients with PP < 45 mmHg and PP more than 55 mmHg had increased risk of future event of coronary heart disease, compared with those with PP between 45 and 55 mmHg.[34] In agreed to our results, certain studies have shown that PP is a stronger predictor of CV events than SBP and/or DBP,[35] while other studies have shown that SBP and/or DBP is a more potent predictor of CV events than PP.[36] A study by Ghanbarian *et al.* showed that SBP, DBP, and PP were not significant difference in subjects with myocardial ischemic finding on electrocardiogram than individuals without myocardial ischemic.[37] Also, in Framingham Heart Study, confirmed the association of PP with coronary heart disease in middle-aged and elderly patients.[35]

This is study about the association of obesity and PP with HTN and Rose angina in the Iranian urban population.

This study showed that the prevalence of HTN in society is high and higher BMI is one of the major risk factors in patients. Therefore, paying attention to measuring blood pressure in clients (especially people with high BMI) to health-care centers is very important to identify hypertensive patients.

As for the limitations of current study, this is a cross-sectional study in general population, without control on affecting other factors on relation of HTN, BMI, and angina. In our study, the diagnosis of CV disease was done by Rose questionnaire but in other studies was done by angiography.

Conclusion

We found that obesity and PP had a positive effect on HTN but overweight on the angina. Thus, attention to abnormal BMI is essential.

Acknowledgment

The authors would like to thank the Research Deputy of Jahrom University of Medical Sciences. We also appreciate all those who participated in this research project or otherwise helped us conduct this study. This study was funded by the Jahrom University of Medical Sciences.

Financial support and sponsorship

This research work has been financed by Jahrom University of Medical Sciences, Jahrom, Iran.

Conflicts of interest

There are no conflicts of interest.

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