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Pickle Consumption is Associated with Body Mass Index and Blood Pressure among Iranian Female College Students: a Cross-Sectional Study

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ABSTRACT

Pickle is consumed in high amount among Iranians. Pickle consumption may be related to body mass index (BMI) and blood pressure (BP) but limited evidence exist in this regard. The aim of current study was to determine the association between pickle consumption and risk of overweight, central obesity and BP among Isfahanian female youths. A cross-sectional study was conducted on 289 female students aged 18–27 years randomly selected from students of Isfahan University of Medical Sciences, Isfahan, Iran. Diet was assessed by a validated and reliable food-frequency questionnaire. Mean pickle consumption was 15.1 ± 2.2 g/day. Individuals in the highest tertile of pickle consumption had a significantly higher BMI, systolic and diastolic BP (p = 0.001, 0.03, and 0.03, respectively), whereas we did not observe significant association for waist circumference (p = 0.21). Total energy intake (p = 0.02) and consumption of carbohydrate (p = 0.01), protein (p = 0.03), and fat (p = 0.05) in the upper tertile was higher than lower tertiles. There was a significant association between pickle consumption and obesity and BP among Iranian female youths. Further prospective studies are needed to confirm this association.

Keywords: Pickle; Obesity; Body mass index; Blood pressure

INTRODUCTION

Obesity is growing public health problem in the world, both in developed and developing countries [1-4]. The obesity rate has increased in adult urban population of Iran in the past few decades [3]. Epidemiological studies in Iran revealed that overweight, obesity, and central adiposity is higher among women than men [3]. Epidemiologic studies indicate that obesity is predisposing factors for type 2 diabetes [1,3-8], cardiovascular disease (CVD) [1,3-8], and hypertension (HTN) [3,4,7,8]. There is positive correlation between increased abdominal fat and the increased risk of morbidity [9]. Increase in waist circumference (WC), a simple anthropometric measure of central body fat [3], is stronger predictor of obesity-related disease [10] such as: dyslipidemia, diabetes, insulin resistance, coronary

heart disease (CHD) risk factors and CHD events [11]. Hypertension (HTN) is now increased in developing countries [12,13]. Risk factors of HTN are excessive salt intake, higher body mass index (BMI) values, decreased level of physical activity and increased WC [12,14]. HTN is a leading risk factor for stroke, CVD, and end-stage renal disease [13-16]. The adverse effects of obesity and HTN on health start at the young ages [17]. HTN is increased in youths but limited information exists about the risk factors of HTN among this population [18]. Approximately, 11.5% of individuals aged > 15 years suffered from HTN in Iran [16]. It is estimated that the prevalence of HTN will be increased by 24% in developed and 80% in developing countries in 2025 [13].

Physical inactivity and diet have a potential effect on increasing prevalence of obesity [3,5,18-20]. Among dietary factors, fruit and vegetable intake may play an important role in preventing or managing weight and blood pressure (BP) [21]. Low energy dense diets rich in fiber may also play a favorable role in weight control [22] and BP [21]. Several studies showed an inverse association between vegetable intake and BP [21]. Vegetables are high in water and rich in dietary fiber, subsequently low energy density, so vegetable consumption might be associated with lower weight and BP [23]. Most previous studies have focused on raw or cooked vegetable consumption, but it is not evaluated whether vegetables in the form of pickle have a health benefits as raw or cooked vegetables or not.

Pickled vegetables are a form of traditional vegetable processing consumed commonly with meals in Iran. For pickling vegetables, raw vegetables including carrot, onion, pepper, cabbage, cauliflower, garlic, tomato, and cucumber are soaked in a brine and vinegar for several months. So, the acidity and color of the vegetables change. Pickled vegetables are low calorie foods. Sodium intake has main role in the prevalence of HTN [24,25]. Although they contain vinegar which may have beneficial effects on cardiometabolic risks [26], pickle is appetizing and salty foods, so they may increase energy intake by increasing appetite and result in increasing food intake.

Previous studies showed that most human obesity occurred in the presence of highly palatable foods [25,27,28]. Pickle is consumed commonly in Iran with main meals and a major component of the traditional Iranian dietary habit. According to our knowledge few studies have assessed the relationship between pickle consumption, obesity and BP. It is hypothesized that pickle consumption may have role in hypertension and obesity. However, pickle is vegetable and may have beneficial effects of vegetable consumption. Therefore, the purpose of the present study is to determine the association between pickle consumption, obesity and BP among female students.

MATERIALS AND METHODS

For this cross-sectional study, participants were randomly selected by multistage cluster random sampling method among female students of Isfahan University of Medical Sciences, Isfahan, Iran. Regarding to this sampling method, we selected some schools in random, from all of the Isfahan University of Medical Sciences. Some students of these schools were chosen by random sampling. So, not only dormitory students, but also students living with their family were included in the present study. Healthy subjects with no medical history were included in the present study. Also, they were not overweight/obese and hypertensive. Our analysis was limited to 344 students aged 18 to 27 years. The response rate was estimated

89%. We excluded the following participants: 1) those who reported energy intake < 800 kcal/day or > 4,200 kcal/day; and 2) those who disagree with participating in this study. We also excluded individuals who used medication that had significant effect on weight and were on diet. Thus, there were 289 students available for statistical analysis. Written informed consent was obtained from all participants. The study protocol and written informed consent used for this study were approved by the Ethic Committee of the School of Health, Isfahan University of Medical Sciences, Isfahan, Iran (code: 287255).

Assessment of dietary intakes

A semi quantitative trained dietitian-administered food frequency questionnaire (FFQ) contained 168-food items were used to assess the habitual dietary intake during the previous year. The validity and reliability of this FFQ have been assessed in compared with dietary recall and the results showed good validity and reliability [28,29]. Portion sizes of consumed foods were converted to grams then coded and converted to a daily intake. Data were analyzed using Nutritionist IV software (version 7.0; N-Squared Computing, Salem, OR, USA) that designed for Iranian foods to determine the amount of nutrients.

Anthropometric measurements

Following anthropometric variables were measured for all individuals: weight, height, BMI, WC, and hip circumference. Body weight was measured with lightweight clothing and without shoes by digital scales. Height was measured while the participants were standing in a normal position [3]. BMI was calculated dividing weight in kilograms by the square of height in meters (kg/m^2). BMI was used to assess students' weight status. The normal BMI range was considered as 18.5–24.9 kg/m^2. Underweight, overweight and obesity were defined as BMI < 18.5, $25 \leq BMI < 30$, and $BMI \leq 30$ kg/m^2, respectively. Indicator of abdominal adiposity [3] was measured as the mid-point between the iliac crest and the below the end of the lower rib [3]. Hip circumference was measured at the maximum level of gluteal muscles over light clothing [3].

Assessment of BP

In order to evaluate BP after an initial resting for 15 minutes while the patients were in seated position and arms were at the same level of heart, a professional clinic staff measured BP twice with at least 30 second interval. The average of 2 measurements was used. Systolic and diastolic BPs were respectively defined as the onset of first phase of Korotkoff sound and the disappearance of sound (the fifth phase of Korotkoff sound) [18]. Normal BP was defined as a systolic blood pressure (SBP) less than 120 mmHg and diastolic blood pressure (DBP) less than 80 mmHg [15]. SBP of 120–139 mmHg or a DBP of 80–90 mmHg was considered as prehypertension (pre-HTN) [15].

Assessment of other variables

Information on age and socioeconomic status (weak, moderate, and strong) and were collected by questionnaires. We used a 24-hour physical activity record for assessing physical activity. As we described in our previous study [30], the mean of physical activity of subjects were calculated by following formula:

$$\text{Mean of physical activity} = \Sigma\left(\frac{\text{Time of activity} \times \text{metabolic equivalent [MET]}}{24}\right)$$

MET values were extracted from a previous study [31].

As the most physical activity questionnaires are too long and time consuming, our previous experience shows that using these physical activity questionnaires was not suitable for our study population. Therefore, we used a 24-hour physical activity record for assessing physical activity [32].

Statistical analysis

We used Nutritionist IV to analyze dietary intakes. SPSS software (version 12) was used to conduct the statistical analysis. Normal distribution was evaluated by Kolmogorov-Smirnov test, histogram graph and p-p plot graph.

Pickle consumption was reported in tertiles. Cut points for pickle tertiles were: 1st, < 12.0; 2nd, 12.0–18.0; and 3rd, > 18.0 g/day. χ^2 test was used for evaluating the prevalence of overweight and obesity as well as central adiposity across tertiles of pickle consumption. $p \leq 0.05$ was considered as statistically significant.

To compare the variations of continuous variables across tertiles of pickle consumption we used analysis of covariance (ANCOVA) which was adjusted for energy intake in a separated model. Then estimated marginal means were gathered as energy adjusted means. Partial correlation was used to assess the relation between pickle consumption and energy intake as well as BMI, waist circumference, and BP. Linear regression was run to determine the contribution of pick consumption to obesity and BP. Result of linear regression was reported in crude and an adjusted model in which energy intake was considered as covariate. We also used logistic regression to see the association between the pickle consumption and the risk of obesity as well as hypertension.

RESULTS

Mean pickle consumption was 15.1 ± 2.2 g/day. General characteristics and dietary intake of the study population are presented in **Table 1**. There were no significant differences in age, physical activity, and socioeconomic status between tertiles of pickle consumption. Individuals in the first tertile of pickle consumption had lower total energy intake compared to third tertile (2,123 ± 73 kcal in the first tertile compared with 2,374 ± 58 kcal in third tertile; p = 0.02). As compared with those in the lowest tertile, students in the highest tertile of pickle consumption had higher intake of carbohydrate (304 ± 97 g in the first tertile compared with 341 ± 103 g in third tertile; p = 0.01), protein (55.6 ± 30.2 g in the first tertile compared with 66.2 ± 34 g in third tertile; p = 0.03), fat (68.7 ± 41.1 g in the first tertile compared with 79.7 ± 38.5 g in third tertile; p = 0.05), and iron (12.5 ± 4.1 mg in the first tertile compared with 14.7 ± 6.0 mg in third tertile; p = 0.005). Other nutrients intake has no significant difference across tertiles of pickle intake.

Mean of anthropometric variables and BP by tertile of pickle consumption is displayed in **Table 2**. Subjects in the first tertile of pickle intake had lower BMI (20.3 kg/m^2 in the first tertile compared with 23.2 kg/m^2 in third tertile; p = 0.001), DBP (71 mmHg in the first tertile compared with 74 mmHg in third tertile; p = 0.03) and SBP (100 mmHg in the first tertile compared with 104 mmHg in third tertile; p = 0.03). WC, hip circumference, and waist to hip ratio were not different across tertiles of pickle consumption. Similar findings were observed after adjusting for total energy intake.

Table 1. General characteristics and dietary intake of female students across the tertiles of pickle consumption among Iranian female college students

Variables	Tertiles of pickle consumption			p*
	1st (< 12 g/day) (n = 96)	2nd (12–18 g/day) (n = 96)	3rd (> 18 g/day) (n = 97)	
All (%)	41.4	26.0	32.6	
Mean age (yr)	20.8 ± 1.6	20.6 ± 1.4	20.9 ± 1.7	0.49
Physical activity (MET, h/wk)	13.1 ± 9.9	13.3 ± 9.9	13.2 ± 9.8	0.43
Socioeconomic status (%)				0.18
Weak	22	21	23	
Moderate	60	59	61	
Strong	18	20	16	
Dietary intake				
Total energy intake (kcal/day)	2,123.54 ± 73.21	2,305.42 ± 65.47	2,374.75 ± 58.45	0.02[†]
Carbohydrate (g/day)	304.51 ± 97.75[‡]	335.21 ± 111.65	341.54 ± 103.68	0.01[†]
Protein (g/day)	55.62 ± 30.26	62.16 ± 31.85	66.26 ± 34.45	0.03[§]
Fat (g/day)	68.71 ± 41.17	72.14 ± 36.43	79.74 ± 38.55	0.05[§]
Cholesterol (mg/day)	205.45 ± 95.12	189.45 ± 88.56	193.45 ± 84.78	0.28
Iron (mg/day)	12.52 ± 4.14	13.60 ± 5.81	14.75 ± 6.02	0.005[§]
Zinc (mg/day)	9.64 ± 3.64	8.82 ± 3.43	9.11 ± 3.31	0.18
Vitamin A (μg/day)	1,010.54 ± 1,063.32	8,493.87 ± 521.45	9,919.87 ± 1,178.38	0.38
Vitamin C (mg/day)	158.54 ± 101.65	162.75 ± 113.42	169.77 ± 119.61	0.64
Folate (μg/day)	318.41 ± 160.46	307.64 ± 109.75	314.82 ± 166.73	0.75
Food groups				
Fruits (g/day)	339.64 ± 201.61	345.43 ± 228.24	372.50 ± 234.24	0.34
Vegetables (g/day)	171.28 ± 92.39	178.81 ± 98.82	198.88 ± 105.29	0.19
Meat & Fish (g/day)	121.19 ± 56.17	133.22 ± 67.82	141.61 ± 71.63	0.05[§]
Grain (g/day)	501.51 ± 181.53	536.31 ± 188.46	553.57 ± 196.51	0.04[†]
Dairy (g/day)	271.55 ± 111.54	291.97 ± 119.79	293.45 ± 114.44	0.23

Values are mean ± standard deviation, otherwise it is indicated.
MET, metabolic equivalent.
*p-vales are resulted from multivariate analysis of variance in quantitative variables & from χ^2 tests regarding the quantitative variables; [†]1st and 2nd tertiles as well as 1st and 3rd tertiles are significantly different; [‡]Adjusted for energy intake; [§]1st tertile is significantly different from 2nd tertile, 2nd tertile is significantly different from 3rd tertile, and 1st and 3rd tertiles are significantly different.

Table 2. Anthropometric variables and blood pressure by tertile of pickle consumption among Iranian female youths

Variables	Tertiles of pickle consumption			p*
	1st (< 12 g/day) (n = 96)	2nd (12–18 g/day) (n = 96)	3rd (> 18 g/day) (n = 97)	
BMI (kg/m²)				
Crude model	20.39 ± 2.14	21.34 ± 2.31	23.2 ± 3.10	0.001[†]
Model 1[‡]	20.37 ± 2.01	21.37 ± 2.20	23.30 ± 3.10	0.008[†]
WC (cm)				
Crude model	70.35 ± 8.40	70.38 ± 8.24	71.7 ± 8.38	0.22
Model 1[‡]	70.08 ± 8.33	70.91 ± 8.31	71.66 ± 8.32	0.27
SBP (mmHg)				
Crude model	100.0 ± 12.0	102.0 ± 13.0	104.0 ± 9.0	0.03[†]
Model 1[‡]	100.0 ± 12.0	1030. ± 13.0	103.0 ± 9.0	0.04[§]
DBP (mmHg)				
Crude model	71.0 ± 8.0	73 ± 9.0	74.0 ± 10.0	0.03[§]
Model 1[‡]	71.0 ± 9.0	73 ± 9.0	74.0 ± 10.0	0.03[§]
Hip circumference				
Crude model	80.07 ± 8.03	81.11 ± 8.21	81.73 ± 8.29	0.12
Model 1[‡]	80.00 ± 8.10	81.05 ± 8.19	81.52 ± 8.17	0.10
Waist to hip ratio				
Crude model	0.87 ± 6.78	0.86 ± 6.65	0.87 ± 6.54	0.29
Model 1[‡]	0.87 ± 6.34	0.87 ± 6.45	0.88 ± 6.23	0.23

BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*p-values are resulted from multivariate analysis of variance; [†]1st tertile is significantly different from 2nd tertile, 2nd tertile is significantly different from 3rd tertile, and 1st and 3rd tertiles are significantly different; [‡]Model 1: adjusted for energy intake; [§]1st and 2nd tertiles as well as 1st and 3rd tertiles are significantly different.

Correlation coefficients between pickle consumption, BMI, WC, BP, and energy intake are shown in **Table 3**. There was a direct significant association between pickle consumption, energy intake (r = 0.35, p = 0.01), BMI (r = 0.35, p = 0.01), WC (r = 0.36, p = 0.01), DBP (r = 0.31, p=0.03), and SBP (r = 0.33, p = 0.02). Correlation between pickle intake, BMI, WC, DBP, and SBP remained significant after adjusting for total energy intake. WHR was not correlated to pickle intake in both crude and adjusted models.

Table 4 shows the odds ratio for obesity and hypertension across tertiles of pickle consumption. Those in the highest tertile of pickle intake had greater risk of overweight and obesity (odds ratio [OR], 4.02; 95% confidence interval [CI], 1.26–6.73; p = 0.001) and hypertension (OR, 3.78; 95% CI, 1.42–6.06; p = 0.001) in compared with the first tertile. There was no significant association between pickle consumption and risk of central obesity. Similar findings were observed after adjusting for total energy intake.

Table 5 shows the regression coefficients between pickle consumption and energy intake, BMI, WC, WHR, and BP. There was a direct significant association between pickle consumption and energy intake (β = 0.31, p = 0.01), BMI (β = 0.23, p = 0.01), DBP (β = 0.24,

Table 3. Correlation coefficients between pickle consumption and BMI, WC, BP, and energy intake among Isfahanian youths

Correlation coefficients	BMI	WC	WHR	SBP	DBP	Energy intake
Pickle consumption						
r*	0.35	0.36	0.21	0.33	0.31	0.35
p-value†	0.01	0.01	0.08	0.02	0.03	0.01
Adjusted model‡						
r*	0.26	0.25	0.18	0.29	0.29	-
p-value†	0.03	0.04	0.10	0.03	0.03	-

BMI, body mass index; WC, waist circumference; BP, blood pressure; WHR, waist to hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*This shows the correlation coefficient; †p-values are resulted from Pearson's correlation; ‡This is adjusted for energy intake.

Table 4. Odds ratio and 95% confidence interval for being overweight or obese and centrally obese in different tertiles of pickle consumption among Iranian female youths

Variables	Tertiles of pickle consumption			p*
	1st (< 12 g/day) (n = 96)	2nd (12–18 g/day) (n = 96)	3rd (> 18 g/day) (n = 97)	
Overweight and obesity‡				
Crude model	1 (ref)	3.45 (1.19–5.98)	4.02 (1.26–6.73)	0.001
Model 1†	1 (ref)	3.11 (0.87–6.07)	3.67 (1.11–6.09)	0.001
Central adiposity				
Crude model	1 (ref)	4.35 (0.89–6.98)	4.42 (1.06–6.93)	0.16
Model 1†	1 (ref)	4.30 (1.00–6.71)	4.39 (1.03–6.89)	0.11
High blood pressure⁵				
Crude model	1 (ref)	3.49 (1.39–5.58)	3.78 (1.42–6.06)	0.001
Model 1†	1 (ref)	3.43 (1.25–5.41)	3.65 (1.31–5.92)	0.001

Values are odds ratios and 95% confidence interval.
*p-values are resulted from Mantel-Hanzel test; †Model 1 was adjusted for energy intake; ‡Body mass index ≥ 25 kg/m²; §Systolic blood pressure > 120 mmHg and diastolic blood pressure > 80 mmHg.

Table 5. Regression coefficients between pickle consumption and BMI, WC, and BP among Iranian female youths

Regression coefficients	BMI	WC	WHR	SBP	DBP	Energy intake
Pickle consumption						
β*	0.23	0.14	0.11	0.23	0.24	0.31
p-value†	0.01	0.07	0.10	0.01	0.01	0.01
Adjusted model‡						
β*	0.21	0.12	0.09	0.22	0.22	-
p-value†	0.01	0.09	0.18	0.01	0.01	-

BMI, body mass index; WC, waist circumference; BP, blood pressure; WHR, waist to hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure.
*This shows the regression coefficient; †p-values are resulted from linear regression; ‡This is adjusted for energy intake.

p = 0.03), and SBP (β = 0.23, p = 0.02). Correlation between pickle intake and BMI, WC, DBP, and SBP remained significant after adjusting for total energy intake. We could not detect any significant association between pickle consumption and WC, and WHR in both crude and adjusted models.

DISCUSSION

The findings of the current study revealed that there were a significant association between pickle consumption and higher BMI and BP among Iranian female students. To our knowledge, the present study provided the first analysis of the association between pickle consumption and anthropometric indices and BP among Iranian females.

In the present study those with higher pickle consumption had the highest intake of carbohydrate, protein, fat, and subsequently total energy intake. This result indicates that in this population, increasing in the amount of pickle consumption might be mostly associated with increasing in energy intake from all food groups. In none of the previous studies that shown an inverse association between vegetable consumption and BMI the effects of vegetable in the form of the pickle on the weight gain and BP status has not been evaluated [21,23]. Previous studies focused on vegetables in raw or cooked form and they reported an inverse association between vegetable consumption, weight gain, and BP [21,23]. In some population they act just as an appetizer, however, in some populations like rural areas these kinds of foods may be consumed all over the winter when the vegetable availability is low. Cultural difference in dietary habits in each population is an important issue in the field of nutritional epidemiology. Pickle consumption is a traditional dietary characteristic among Iranians. There are different kinds of pickle in Iran in a large number of varieties. Pickle is available both in industrialized and homemade forms. In the present study we focused on vegetables in the pickled form which are considered as salty and appetizing foods. As we assessed the dietary intake of university students, we found that they consumed pickle in a significant amount. It is possible that students who do not have access to fresh vegetables might prefer the use pickled vegetables along with their meals.

We did not find any association between pickle consumption and WC. WC has no standard measurement method, ethical or international standard variation and specific cutoff point for chronic diseases. Therefore, these limitations may justify our findings.

The positive association between pickle consumption and total energy intake in the present study confirm this result that pickle consumption may increase whole food intake. Furthermore, the energy adjusted correlations between anthropometric values and pickle consumption revealed that energy intake modify this correlation to some extent but not totally. Salt and vinegar is the major ingredient in pickle. Acetic acid is the active ingredient in vinegar that may cause reduction in hypertension, hyperlipidemia, and obesity [26]. Previous studies reported that vinegar delays gastric emptying and has low glycemic index [33]. However, our findings suggest the possible association between pickle consumption and weight gain and increased BP among Iranian female youths. Many studies have shown that high dietary salt intake induces both initiation and progression of BP increasing and it is strongly associated with other important diseases such as stroke, left ventricular hypertrophy, renal disease, obesity, renal stones, and stomach cancer [25]. Moreover, high dietary salt is positively associated with elevated BP [33] and has been recognized as a risk

factor for stomach cancer [34]. In current study systolic and diastolic pressure might be significantly associated with pickle intake that can be attributed to salt content of pickle. Pickle is appetizing and salty foods and previous studies showed that high salt intake increased risk for hypertension and obesity [34]. So, it should be studied in future whether pickled vegetables have opposite effect on health as compared to raw or cooked vegetables. Nowadays, nutritionists emphasize on increasing the variety of vegetable and fruit intake [35]. Although pickle consumption increases the variety score of vegetable group, it may be associated with increased amount of energy intake which may be related to the risk of obesity. Pickle consumption in low amounts may provide palatability but high amounts of pickle consumption may be associated with higher food consumption and higher energy intake. According to the published papers obesity and central adiposity is one of the public health problem in Iran [36,37], therefore, we need to focus on their determinants carefully.

To our knowledge, the present study is the first to examine the association between pickle intake and BMI and BP in Iranian young female adults, there are several limitations. A limitation was cross-sectional design of the current study. Therefore, the causal association could not be revealed. We used tertiles of pickle intake. So, misclassification of the participants might be occurred. As this study was conducted on a convenience sample of female student, the results may specify to the female university students and not to all female in Iran. Some confounding variables such as drinking and smoking did not measure in the present study. Our findings may be affected by these variables

CONCLUSION

In conclusion, there might be a significant association between pickle consumption and obesity as well as increased BP among Iranian female college students. Prospective studies are needed to confirm this association. Future studies should focus on molecular mechanism which related pickle consumption to obesity. Also, the effect of pickle consumption on appetite hormones should be evaluated.

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