Relationship between Dietary Calcium Intake, Body Mass Index and Waist - to - Height Ratio among Male University Hostel Students of Ahvaz University of Medical Sciences, Iran

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ABSTRACT

The incidence of obesity worldwide has risen in the past century. The pattern of body fat distribution is a more important determinant than general obesity. Abdominal obesity has been shown to be associated with increased risk of overall mortality in many populations. In the present study we investigated the relationship between dietary calcium intake, body mass index (BMI) and Waist - to - Height ratio (WHtR) among male university hostel students of Ahvaz University of Medical Sciences. This cross sectional study was conducted on 1012 healthy male university hostel students of Ahvaz University of Medical Sciences. Daily Calcium intake was estimated by food frequency questionnaire for one year and three 24-hour dietary recalls. Height, weight and waist circumference were measured and BMI and WHtR was calculated. Dietary data were analyzed by the N4 software. Data were analyzed with SPSS statistical software version 17, by Kolmogorov Smirnov, Pearson coefficient and ANOVA tests. Average age of students was 23.2±5.02 years. Daily calcium 240.53 mg average BMI and WHtR of students were 29.60±4.15 kg/m^2 and 0.48±0.07, ±intake was 538.36 respectively. Subjects with BMI<25 kg/m^2 had significantly higher calcium intake per day than other groups (645± 284.1 vs. 544.25±257.1 mg/day for normal vs. overweight groups; P=0.01, 645±284.1 vs. 425.69±173.01 mg/day for normal vs. obese groups; P=0.001). Subjects with higher calcium intake per day had significantly lower WHtR (P=0.01). According to the results of this study, dietary calcium intake is inversely associated with the BMI and WHtR.

Keywords: Dietary calcium, Body mass index, Waist - to - Height ratio

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INTRODUCTION

The incidence of obesity has been increased in the past century worldwide and has been declared a global epidemic by the World Health Organization in 1997 [1]. Obesity along with insulin resistance, dyslipidemia, and related conditions, defines "metabolic syndrome," which strongly predisposes suffers to some chronic diseases such as type 2 diabetes, cardiovascular disease, and early mortality [2]. Obesity is a growing concern in developing countries and is one of the leading causes of preventable death worldwide [3-5]. Although obesity is related to disease risk, body fat distribution pattern is a more important determinant than general obesity. Abdominal obesity has also been shown to be associated with increased risk of overall mortality [6]. Although obesity has strong genetic determinants, its increasing prevalence suggests that environmental factors are promoting or exacerbating the problem. It has been suggested that dairy products may reduce the risk of obesity through the properties of their components including calcium, branched chain amino acids, conjugated linoleic acid, vitamin D, protein, and medium-chain fatty acids [7]. One of the major components of dairy products is calcium which may be related to obesity [8]. Some studies have suggested a specific role for dietary calcium in modulating body weight, body mass index (BMI) or adiposity [9-13]. Calcium plays a role as a second messenger in cell signaling processes and as an activator of intracellular functional proteins involved in cellular activities [14]. An increase in intracellular calcium concentrations in adipocytes after stimulation with parathyroid hormone (PTH) and 1, 25-dihydroxyvitamin D [$1,25(OH)_2D$] is able to switch lipid metabolism from lipolysis to lipogenesis, which results in an increase in triacylglycerol storage [15,16]. Increased intracellular calcium inhibits lipolysis and stimulates lipogenic gene expression and activity, resulting in increased adipocyte lipid accumulation. Calcitriol stimulates adipocyte Ca^{2+} influx, so low-calcium diets promote adiposity, while dietary calcium suppression of calcitriol reduces adiposity [17]. This metabolic pathway would be responsible for the higher risk of overweight and obesity in individuals with a low calcium intake and for the weight loss after increases in dietary calcium intake [14]. However, some studies have not supported the potentially favorable effects of calcium and/or dairy products on obesity. Thus, the relation of calcium intake to obesity remains unclear [18-23]. In the present study we investigated the relationship between dietary calcium intake, body mass index and Waist - to - Height ratio among male university hostel students of Ahvaz University of Medical Sciences.

MATERIALS AND METHODS

This was a cross-sectional study. Participants were recruited from Ahvaz, located in southwest of Iran. The inclusion criteria were: male university hostel students of Ahvaz University of medical sciences and having intermediate physical activity. The exclusion criteria were: chronic metabolic diseases, having special diet or eating disorders and calcium supplement consumption in past 1 year. From 1100 male students who lived in dormitories, 1040 eligible were detected to participate in this study. Finally 1012 persons participate in study. Weights and heights of the students were measured by trained nutritionists. Weights were measured with light clothing and without shoes, using a portable analogue Seca Scale. Heights were measured in standing position, using a fixed tape meter with an accuracy of 0.5 cm. Waist circumference was obtained by measuring the distance around the smallest area below the rib cage and above the umbilicus with the use of a non-stretchable tape measure with an accuracy of 0.5 cm. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMIs were categorized into 4 groups as underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (≥30) [24]. Dietary information from the past year was collected by a food frequency questionnaire [25]. Study participants were asked to recall the frequency of consumption of individual food items (number of times per d/wk/mo/y) and the estimated portion size, using local weight units. Nutrients intake was also measured by three 24-hour recalls. Food recall questionnaires data were analyzed using the Nutritionist IV software (N-Squared computing, Salem, OR, USA), which was modified for Iranian foods. Data were analyzed by descriptive and analytical statistical methods using SPSS statistical software version 17 for windows. Kolmogorov Smirnov, Pearson coefficient and ANOVA tests were used for data analysis. All tests were two-tailed, and $P<0.05$ was the significance threshold.

RESULTS AND DISCUSSION

Subjects included in the study were 1012 male students residing in dormitories of Ahvaz University of Medical Sciences. The demographic characteristics of the study subjects are shown in table 1. Mean age was 23.2±5.02 years. Anthropometric characteristics of the subjects are shown in table 2. Average BMI was 29.60±4.15 kg/m^2. Average Waist circumference was 82.02±11.9 cm. Average WHtR for normal, overweight and obese participants according to BMI was 0.43, 0.48 and 0.5 respectively. Energy intake and nutritional pattern are presented in table 3. Mean of calcium intake across categories of BMI are presented in table 4. Subjects with BMI< 25 kg/m^2 had significantly higher calcium intake per day than other groups (645±284.1 vs. 544.25±257.1 mg/day for normal vs. overweight subjects; P=0.01, 645±284.1 vs. 425.69±173.01 mg/day for normal vs. obese subjects; P=0.001). Subjects with waist circumference lower than 102 cm compared to higher than 102 cm had significantly higher calcium intake and a significant inverse correlation was found between calcium intake and WHtR (Table 5). Participants were classified into three groups according to blood pressure, as follows: normal, Prehypertension and Stage 1 hypertension [26]. Normal subjects had significantly lower WHtR than other groups. Also normal subjects had significantly higher calcium intake than other groups (Table 6).

Table 1. Demographic characteristics of the participants.

Characteristics		No. (%)	Mean ± SD
Age, years			23.2±5.02
Education Status	Graduates	514 (50.8)	
	Post Graduates	362 (35.8)	
	Prof., Master & PhD	136 (13.4)	
Blood pressure, mmHg	systolic blood pressure		101.98±15.01
	Diastolic blood pressure		68.02±10.1

The present study showed an inverse relationship between dietary calcium intake, body mass index and Waist- to -Height ratio. This finding is in agreement with other reports, which have suggested that dairy-rich diets contribute to the prevention and treatment of obesity. Varenna et al. [14] in a cross-sectional study suggested significant inverse trends for BMI and prevalence of overweight with increasing dairy intake. Mirmiran et al. [9] in a cross-sectional study showed a significant inverse correlation between the servings of dairy consumption per day and BMI. García-Lorda et al. 10] in a cross-sectional study evaluated the association between daily calcium intake and body mass index (BMI) in 647 subjects (261 men and 313 women, aged 18 to 70 years) in a Mediterranean population. Study showed a negative relationship between calcium intake and BMI. Dos Santos et al. [11] in a cross-sectional study evaluated calcium intake and its relationship with BMI in adolescents. Calcium intake presented a significant negative correlation with body weight and BMI. Furthermore, adolescents in the lowest quartile of calcium intake presented higher BMI than adolescents in the highest calcium quartile.

Table 2. Anthropometric characteristics of the participants.

Characteristics	Mean ±SD
Weight (kg)	60.6±12.9
Height (cm)	171.14±6.06
Waist circumference (cm)	82.02±11.9
WHtR	0.48±0.07
BMI (kg/m^2)	29.60±4.15

Table 3. Dietary data of the participants.

Characteristics	Mean ±SD
Energy intake (kcal/day)	2109.7±649
Fat intake (g/day)	91.36 ±24.75
Carbohydrate intake (g/day)	277.17 ±81.54
Protein intake (g/day)	74.33 ±22.42
Cholesterol (mg/day)	253.73 ±128.43
SFA intake (g/day)	17.94 ±7.9
MUFA (mg/day)	16.59±10.53
PUFA (mg/day)	8.67 ±5.48
fiber intake (g/day)	20.3 ±6.93
Calcium intake (mg/day)	538.36±240.53
Vitamin A (µg/day)	566.66 ±103.01
Vitamin C (mg/day)	90.15±85.38
Vitamin B6 (mg/day)	1.96 ±0.96
Vitamin B12 (µg/day)	7.18 ±3.6
Vitamin B9 (µg/day)	143.24 ±113.01
Iron (mg/day)	19.8±7.58
Zinc (mg/day)	13.85±7.68
Selenium (µg/day)	53.7 ±28.7

Table 4. Mean of calcium intake across categories of BMI.

BMI (kg/m^2)	Mean of calcium intake (mg/day)	P
<18.5 (Normal)	645±284.1	0.01[a]
18.5-24.9 (Overweight)	544.25±257.1	0.01[b]
≥25 (Obese)	425.69±173.01	0.001[c]

[a]Normal *vs* Overweight, [b]Overweight *vs* Obese, [c]Normal *vs* Obese

Dicker et al. [12] in a cross sectional study assessed the association between calcium intakes, body mass index and waist circumference in the Israeli National Health and Nutrition Study. The study confirms the inverse relationship between daily dietary calcium intake and BMI. There was no correlation between daily dietary calcium intake and waist circumference for men, but women with a waist circumference below 88 cm consumed significantly more dietary calcium than those with a waist circumference > or = 88 cm ($P< 0.03$). Eilat-Adar et al. [13] by analyzing data from Strong Heart Study (SHS), showed that BMI and percentage of body fat were significantly lower in participants with higher vs. lower calcium intake. In contrast to our findings, some studies suggest that supplementation with dairy products or calcium either does not change body weight or the resultant changes are insignificant as compared to controls. Murakami et al. [23], in a cross-sectional study examined possible associations of calcium and dairy products intakes to BMI in young Japanese women. Intakes of calcium and dairy products were not significantly associated with BMI. Although in that study the intakes of calcium and dairy products were not associated with BMI, narrow range of age (18 to 20 y) and BMI (78% of subjects had a normal BMI) and the relatively low intakes of calcium and dairy products were limitations of study. Phillips et al. [19] examine the relation of dairy food intake with relative weight status and percentage of body fat (%BF). They find no evidence that dairy food consumption is associated with BMI z-score or %BF during adolescence. This could, also, be attributed to adolescence being a period of life associated with growth and development, when it is difficult to observe the effect of dairy products on body weight or BMI. Vergnaud et al. [27] investigate the relations of calcium intake with changes in body weight and waist circumference in middle-aged French adults. In that study there was no association between calcium intake and 6-y changes in weight and WC. That study was not primarily designed to examine the effects of calcium intake on weight and WC changes. These inconsistent results may be explained at least in part by the different populations examined, different methods used to assess obesity and dietary intake, and number and type of variables used as confounding factors.

Table 5. Relationship between dietary calcium intake Waist circumference and WHtR.

Waist circumference (cm)	calcium intake (mg/day)	WHtR	P[1]	P[2]
< 102	622±265.24	0.43±0.062	0.001	0.01
> 102	454.03±215.81	0.55±0.077		

[1]calcium intake, [2]Waist- to -Height ratio

Table 6. Relationship between blood pressure, dietary calcium intake and WHtR.

Blood pressure groups	WHtR	(dietary calcium intake mg/day)	P[1]	P[2]
Normal	0.44	619.07±232.3	0.030[a]	0.020[a]
Pre-hypertension	0.50	548.76±119.7	0.048[b]	0.010[b]
Stage1 hypertension	0.54	448.46±221.02	0.010[c]	0.001[c]

[1]WHtR: [a]Normal *vs* Prehypertension, [b]Prehypertension *vs* Stage1 hypertension, [c]Normal *vs* Stage1 hypertension; [2]Dietary Calcium Intake: [a]Normal *vs* Prehypertension, [b]Prehypertension *vs* Stage1 hypertension, [c]Normal *vs* Stage1 hypertension

Until recently, little was known about the mechanisms by which calcium intake could affect body composition. Studies showed that intracellular calcium levels could influence adipocyte fat metabolism. It has been hypothesized that a low dietary calcium intake stimulates high concentrations of parathyroid hormone and 1, 25-hydroxyvitamin D, which, in turn, activates high concentrations of intracellular calcium in adipocytes, thus stimulating lipogenesis and inhibiting lipolysis [28]. In contrast, high intracellular calcium levels (low dietary calcium) are associated with increased fat synthesis and reduced lipolysis via calcium-dependent mechanisms [15,16]. Moreover, dietary calcium could influence fat metabolism not only by modulating it within the adipocyte, but also by increasing fecal fat excretion. It has also been proposed that high calcium intake leads to the formation of indigestible calcium soaps in the gastrointestinal tract, which makes fat unavailable for absorption and thereby reduces calorie intake [29]. High dietary calcium intakes have been shown to increase fat oxidation and fecal fat excretion [30-32]. This study has several limitations. First, we did not collect information about lifestyle. Second, our results could also be affected by measurement error in dietary intake, a common limitation of cross sectional studies. However, prospective cohorts study is required that evaluates the interaction between dietary calcium intake and weight changes. Third limitation was that our study was not performed in two sexes; other investigations should consider male and female.

In the present study subjects with normal blood pressure had significantly lower WHtR than prehypertension and stage 1 hypertension groups. Also subjects with normal blood pressure had significantly higher calcium intake than prehypertension and stage1 hypertension groups. Increasing the intake of calcium may reduce blood pressure, and other minerals are also related to blood pressure [33]. McCarron et al. [34] in their analyses of the data from 10 372 individuals aged 18–74 years from the Health and Nutrition Examination Survey I (HANES I) found that dietary calcium intake was most predictive of hypertension (systolic blood pressure - 160 mmHg). Park et al. [35] showed that waist circumference, weight, and BMI were positively associated with systolic and diastolic blood pressure in young and middle aged Korean adults. Also calcium was inversely associated with both SBP and DBP (P = 0.012 and 0.010, respectively). Dickinson et al. [36] conducted a meta-analysis and demonstrated that calcium supplementation is effective in lowering blood pressure and hypertension risk. It is thought that a reduced calcium intake may increase serum parathyroid hormone (PTH) levels, which may cause the secretion of renin and angiotensin II from the kidney and eventually increase blood pressure [37,38]. According to the results of this study, dietary calcium intake is inversely associated with the BMI, WHtR and blood pressure.

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