Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity (2020) 25:379–387
https://doi.org/10.1007/s40519-018-0609-8

ORIGINAL ARTICLE

Breakfast consumption pattern and its association with overweight and obesity among university students: a population-based study

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Received: 23 June 2018 / Accepted: 25 October 2018 / Published online: 9 November 2018

Abstract

Purpose To determine the association between breakfast consumption habit and overweight and obesity in a sample of Iranian university students.

Methods A sample of 78,905 university students, aged 18 years or older, was recruited from 28 provinces in Iran to assess breakfast consumption pattern. Breakfast consumption habit was evaluated using a pre-tested questionnaire. Weight and height were measured using standard protocol and then body mass index (BMI) was calculated. Overweight (obesity included) and obesity were defined as BMI ≥ 25 and BMI ≥ 30 kg/m^2, respectively.

Results Mean age of participants was 21.50 ± 4.01. After controlling for potential confounders, participants who ate breakfast > 4 days/week had 15% lower risk of overweight compared with those who ate < 1 day/week (OR: 0.85, 95% CI 0.78–0.92). Such significant association was also seen in female students (OR: 0.82, 95% CI 0.72–0.93); however, it was marginally significant in male ones (OR: 0.89, 95% CI 0.79–1.00). In addition, a significant inverse association was found between breakfast consumption and obesity (OR: 0.74, 95% CI 0.64–0.85) such that after adjusting for potential confounders, students who consumed breakfast > 4 days/week were 33% less likely to be obese compared with those who consumed it < 1 day/week (OR: 0.67, 95% CI 0.57–0.78). Such significant inverse association was also seen in either gender.

Conclusions Breakfast consumption was inversely associated with odds of overweight and obesity in university students.

Level of evidence Level V, cross-sectional descriptive studies.

Keywords Breakfast · Feeding behavior · Obesity · Overweight · BMI

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Introduction

Obesity is one of the most pressing health concerns today and its prevalence is increasing at an alarming rate [1, 2]. In US, overweight or obesity is prevalent among 55% of adult population [3]. National estimates in Iran have shown a prevalence of 50% among adults [4]. Obesity imposes a large burden to the healthcare system and is a known risk factor for a number of chronic diseases including diabetes, hypertension, osteoarthritis, coronary heart disease (CHD), some cancers, migraine headaches and even mortality [5–8]. Therefore, finding the determinants of obesity is of great importance.

The combined effects of genetic, environmental and dietary behavioral factors contribute to the obesity epidemic [9]. Among dietary behavioral factors, breakfast consumption has been investigated in relation to obesity. Breakfast is considered the most important meal in a day. Eating breakfast may be associated with better nutrition and diet quality [10]. Also, it has been shown that individuals who consume breakfast every day may have better mental health and higher score of happiness than breakfast skippers [11]. In a population-based study in US, participants who ate breakfast had lower intake of daily dietary fat and higher intake of vitamin C and folate compared with those who did not [12]. It has been shown that breakfast consumption is associated with healthier eating pattern [13]. In a study in Canada, participants who skipped breakfast ≥ 1 time/week, selected energy-dense foods in lunch and dinner and ate more snacks compared with those who consumed breakfast every day [13]. Although breakfast consumption increases the energy intake at the beginning of a day, it affects the food selection and energy intake in other meals [14]. Therefore, it might be considered as a contributing factor in the etiology of obesity.

Although some studies have assessed the association between breakfast consumption pattern and obesity among university students, findings are conflicting. Two studies have shown that breakfast consumption is associated with decreased risk of overweight and obesity [15, 16], while others failed to find any significant association [17–19]. In a cross-sectional study on African-American Students, breakfast skipping was positively associated with risk of overweight and obesity [15]. In mentioned studies, most confounding variables such as dietary factors have not been taken into account [17–19]. In addition, most studies on the association between breakfast consumption pattern and obesity are from western societies and few data are available from Asia, in particular from the Middle East. Based on food culture in this region, lunch and dinner meals are more important than breakfast and, therefore, breakfast is skipped more than other meals. It is more relevant among university students who wake up late at morning and usually skip breakfast. Moreover, studies that examined the association between breakfast consumption habit and obesity in Middle Eastern population had mostly low sample size and were mostly done on children and adolescents, not adults or university students [18, 20–22]. The current study aimed to assess the association between breakfast consumption pattern and obesity among a large population of Iranian university students.

Materials and methods

Participants

This cross-sectional study was performed in the framework of mental and physical health assessment of university student (MEPHASOUS) project which was designed by health organization of the Ministry of Science and Technology (MST), Tehran, Iran, in 2012–2013. The purpose of this study was to assess the present health issues and behaviors of Iranian university students. Detailed information about the study design, participants and data collection methods has been published elsewhere [23]. Briefly, all students who were admitted at 74 governmental eligible universities (from 28 provinces of Iran), affiliated to MST, were invited to participate in this project. Students were included if newly admitted in university and aged 18 years and older. To gather data from students, they were invited to the health center of universities. Data on demographic characteristics, anthropometric measures, medical history and dietary habits were collected from each student. From university students who were invited, 84,332 individuals participated in the mentioned project. However, 78,905 (93.5%) ones presented complete information and included in the current analysis. All participants provided signed informed written consent forms. The whole project was approved by the ethics committee of the MST, Tehran, Iran.

Data collection

A pre-tested questionnaire was used to gather data on demographic characteristics, health-related behaviors and dietary habits [23]. The first part of the questionnaire was about age, gender (male/female), marital status (single/married), education [advanced diploma/bachelor of science (BSc)/master of science (MSc)/medical science (MD)/philosophy of doctor (Ph.D)] and smoking (non-smoker/rarely/< 10 cigarettes/week/> 10 cigarettes/week). We considered students who were in advanced diploma, BSc and MD courses as undergraduate and those in MSc and PhD courses as graduate students. In addition, students who smoked rarely or more than one cigarette per week were considered as current smoker.

One part of the mentioned questionnaire was about sleep pattern containing two questions: "how is your pattern of sleeping and waking?" and "how many hours do you sleep in a day?" The response categories for the first question were "regular", "irregular" and for the second question was as follows: "< 6 h/day", "6–8 h/day", "8–10 h/day", "> 10 h/day. To assess physical activity, we asked this question: "how often do you exercise lasting 30 min?" The response categories of this question were "rarely", "1–2 times/week", "3–4 times/week", "> 5 times/week". Students who did exercise three times/week or more were considered as physically active. In addition, we considered those who did exercise one to two times/week as somewhat active and those who did rarely as inactive.

Dietary habits

Another part of the mentioned questionnaire evaluated dietary intake of some food groups as well as breakfast consumption pattern. Participants were asked to report the consumption frequency of fruits (rarely, ≤ 1 serv/day, 2–3 serv/day, > 3 serv/day), vegetables (not weekly, 1 serv/week, 2–3 serv/week, 1 serv/day), dairy (not weekly, 1 serv/week, 2–3 serv/week, 1 serv/day), fast foods (rarely, 1 time/week, 2–3 times/week, everyday) and carbonated beverages (rarely, 1–2 times/week, everyday) during the last year. In Iranian food culture, fruits are consumed more frequently than vegetables, dairy, fast foods and carbonated beverages. Therefore, in this questionnaire, the frequency response categories for fruits consumption were daily compared with vegetables, dairy, fast foods and carbonated beverages which had weekly response categories. Breakfast consumption pattern was evaluated by this question: "how many days do you eat breakfast in a week?" Participants were asked to answer the question by these response categories: < 1 day/week, 1–2 days/week, 3–4 days/week, > 4 days/week.

Anthropometric measures

Weight was measured with minimal clothing and without shoes by analogue scale with a precision of 100 g and height was measured in a standing position without shoes by a tape measure with the nearest 0.5 cm. Body mass index (BMI) was calculated using formula: weight in kilograms divided by height in square meters. Overweight (obesity included) and obesity were defined as BMI ≥ 25 and BMI ≥ 30 kg/m^2, respectively.

Statistical analysis

Participants were categorized based on breakfast consumption pattern as follows: < 1 day/week, 1–2 days/week, 3–4 days/week, > 4 days/week. One-way analysis of variance (ANOVA) was applied to evaluate differences in continuous variables across categories of breakfast consumption pattern. To assess the distribution of students in terms of categorical variables including demographic characteristics and dietary habits across categories of breakfast consumption pattern, Chi-square test was used. Analysis of covariance (ANCOVA) in different models was used to compare the means of weight and BMI across categories of breakfast consumption pattern. In the first model, age was used for adjustment. In the second model, further adjustment was made for marital status, education, physical activity, smoking and sleep pattern. We additionally adjusted for dietary intake of fruits, vegetables, dairy, fast foods and carbonated beverages in the final model. All mentioned variables except age were included to models as categorical variables. The categories of these variables are described in the previous paragraphs. To find the association of breakfast consumption pattern with overweight and obesity, binary logistic regression was used with the same adjustment as mentioned above. In this analysis, students who ate breakfast < 1 day/week were considered as the reference group. To compute the overall trend of odds ratios across increasing categories of breakfast consumption pattern, we considered these categories as an ordinal variable in the logistic regression models. All statistical analyses were separately done for both genders using SPSS software (version 19.0; SPSS Inc, Chicago IL). *P* values were considered significant at < 0.05.

Results

Mean age of students participated in the current study was 21.50 ± 4.01 and 54.6% were female. Overweight and obesity were prevalent among 22.6% and 4.8% of students, respectively. In addition, 4.9% of students ate breakfast < 1 day/week.

General characteristics and dietary habits of male and female students across categories of breakfast consumption pattern are shown in Table 1. Males who ate breakfast > 4 days/week were more likely to be older, married, graduate, physically active, have regular sleep pattern, and less likely to be current smoker compared with those who consumed it < 1 day/week. In addition, mean of body weight and BMI, as well as the prevalence of overweight and obesity among males, were different across categories of breakfast consumption pattern. In terms of dietary intakes, male students who consumed breakfast frequently had higher intake of fruits, dairy, and lower intake of fast foods and carbonated beverages than those who consumed it infrequently. Such findings were also seen for female students. However, the prevalence of overweight and obesity among them was not significantly different across categories of breakfast consumption pattern.

Table 1 Demographic characteristics and dietary habits of males and females across categories of breakfast consumption pattern

Variables	< 1 day/week	1–2 days/week	3–4 days/week	> 4 days/week	*P* value*
Males					
N	2040	5388	9683	18,685	
Age (year)	21.0 ± 3.4	21.2 ± 3.6	21.5 ± 3.9	21.6 ± 4.3	< 0.001
Weight (kg)	71.6 ± 14.2	71.9 ± 14.4	71.2 ± 14.0	71.5 ± 13.9	0.03
BMI (kg/m^2)	23.0 ± 4.1	23.1 ± 4.2	22.9 ± 4.4	22.9 ± 4.1	0.02
Marital status (married) (%)	3.7	5.9	7.0	7.8	< 0.001
Education (graduate) (%)	35.5	38.9	41.3	38.8	< 0.001
Current smoker (%)	25.7	14.3	10.8	9.3	< 0.001
Physical activity (active)[a] (%)	35.8	37.3	41.7	48.8	< 0.001
Sleep pattern (regular) (%)	29.5	37.6	50.7	67.2	< 0.001
Overweight and obesity (%)	26.5	28.5	26.2	26.9	0.006
Obesity (%)	6.7	6.7	5.9	5.7	< 0.001
Dietary intakes					
Fruit (≥ 1 serv/day) (%)	32.1	44.0	54.3	62.8	< 0.001
Vegetable (daily) (%)	13.4	4.9	6.9	13.1	< 0.001
Dairy (daily) (%)	13.5	15.1	17.1	27.2	< 0.001
Fast food (daily) (%)	9.4	1.8	1.0	0.7	< 0.001
Carbonated beverages (daily) (%)	20.7	11.9	8.3	6.6	< 0.001
Females					
N	1835	6375	10,685	24,217	
Age (year)	20.9 ± 3.6	20.9 ± 3.6	21.3 ± 3.7	21.8 ± 4.1	< 0.001
Weight (kg)	58.8 ± 11.4	58.3 ± 11.0	57.9 ± 10.6	58.3 ± 10.4	< 0.001
BMI (kg/m^2)	22.3 ± 4.0	22.1 ± 3.9	22.0 ± 3.8	22.1 ± 3.7	0.001
Marital status (married) (%)	10.2	11.3	12.1	13.7	< 0.001
Education (graduate) (%)	29.8	30.9	37.8	42.2	< 0.001
Current smoker (%)	8.0	6.3	7.5	7.3	0.01
Physical activity (active)[a] (%)	30.5	32.5	34.4	38.0	< 0.001
Sleep pattern (regular) (%)	36.2	45.5	55.8	71.2	< 0.001
Overweight and obesity (%)	20.3	19.5	18.5	18.9	0.2
Obesity (%)	5.3	4.6	3.9	3.6	< 0.001
Dietary intakes					
Fruit (≥ 1 serv/day) (%)	53.5	59.4	66.0	72.0	< 0.001
Vegetable (daily) (%)	12.2	11.2	13.1	19.8	< 0.001
Dairy (daily) (%)	18.1	19.9	20.5	30.4	< 0.001
Fast food (daily) (%)	3.3	1.6	0.6	0.6	< 0.001
Carbonated beverages (daily) (%)	9.5	6.3	4.5	3.2	< 0.001

Data are presented as mean (SD) or percent

BMI body mass index

*Obtained from ANOVA or Chi square, where appropriate

[a]Those who exercised three times/week or more lasting 30 min each time

Multivariable-adjusted means for anthropometric measures across categories of breakfast consumption pattern are presented in Table 2. Students in the highest category of breakfast consumption pattern had significantly lower weight and BMI compared with those in the lowest category (weight; 64.14 ± 0.06 vs. 65.58 ± 0.22, $P < 0.001$, BMI; 22.52 ± 0.01 vs. 22.68 ± 0.06, $P = 0.001$). These differences remained significant even after controlling for potential confounders including demographic and dietary variables (weight; 64.18 ± 0.07 vs. 65.51 ± 0.23, $P < 0.001$, BMI; 22.45 ± 0.02 vs. 22.86 ± 0.06, $P < 0.001$). Gender-stratified analysis revealed such significant associations in male and female students either before or after taking potential confounders into account.

Multivariable-adjusted odds ratios and 95% CIs for overweight and obesity across categories of breakfast

Table 2 Multivariable-adjusted means for weight and BMI across categories of breakfast consumption pattern

Variables	< 1 day/week	1–2 days/week	3–4 days/week	> 4 days/week	*P* value*
Weight (kg)					
Whole					
Crude	65.58 ± 0.22	64.58 ± 0.13	64.27 ± 0.08	64.14 ± 0.06	< 0.001
Model 1	65.73 ± 0.22	64.70 ± 0.12	64.28 ± 0.09	64.09 ± 0.06	< 0.001
Model 2	65.49 ± 0.23	64.69 ± 0.13	64.32 ± 0.10	64.16 ± 0.06	< 0.001
Model 3	65.51 ± 0.23	64.67 ± 0.13	64.30 ± 0.10	64.18 ± 0.07	< 0.001
Males					
Crude	71.61 ± 0.31	71.98 ± 0.19	71.27 ± 0.14	71.57 ± 0.10	0.03
Model 1	71.81 ± 0.31	72.08 ± 0.19	71.24 ± 0.14	71.54 ± 0.10	0.005
Model 2	71.68 ± 0.32	72.03 ± 0.19	71.27 ± 0.14	71.55 ± 0.10	0.01
Model 3	72.35 ± 0.32	72.43 ± 0.19	71.33 ± 0.14	71.33 ± 0.10	< 0.001
Females					
Crude	58.88 ± 0.25	58.32 ± 0.13	57.95 ± 0.10	58.41 ± 0.06	< 0.001
Model 1	58.98 ± 0.25	58.42 ± 0.13	57.97 ± 0.10	58.37 ± 0.06	< 0.001
Model 2	58.99 ± 0.25	58.39 ± 0.13	57.98 ± 0.10	58.38 ± 0.07	< 0.001
Model 3	59.49 ± 0.25	58.65 ± 0.13	58.08 ± 0.10	58.21 ± 0.07	< 0.001
BMI (kg/m^2)					
Whole					
Crude	22.68 ± 0.06	22.61 ± 0.03	22.45 ± 0.02	22.52 ± 0.01	0.001
Model 1	22.75 ± 0.06	22.66 ± 0.03	22.46 ± 0.02	22.49 ± 0.01	< 0.001
Model 2	22.72 ± 0.06	22.65 ± 0.03	22.46 ± 0.02	22.50 ± 0.02	< 0.001
Model 3	22.86 ± 0.06	22.72 ± 0.03	22.48 ± 0.02	22.45 ± 0.02	< 0.001
Males					
Crude	23.01 ± 0.09	23.12 ± 0.05	22.91 ± 0.04	22.94 ± 0.03	0.02
Model 1	23.09 ± 0.09	23.15 ± 0.05	22.90 ± 0.04	22.93 ± 0.03	0.001
Model 2	23.05 ± 0.09	23.14 ± 0.05	22.91 ± 0.04	22.93 ± 0.03	0.008
Model 3	23.25 ± 0.09	23.26 ± 0.05	22.93 ± 0.04	22.86 ± 0.03	< 0.001
Females					
Crude	22.32 ± 0.08	22.17 ± 0.04	22.03 ± 0.03	22.19 ± 0.02	0.001
Model 1	22.37 ± 0.08	22.22 ± 0.04	22.05 ± 0.03	22.16 ± 0.02	0.001
Model 2	22.34 ± 0.09	22.20 ± 0.04	22.04 ± 0.03	22.18 ± 0.02	0.002
Model 3	22.51 ± 0.09	22.29 ± 0.04	22.08 ± 0.03	22.12 ± 0.02	< 0.001

Data are presented as mean ± SE

Model 1: adjusted for age (continuous)

Model 2: additionally adjusted for marital status, education, physical activity, smoking and sleep pattern

Model 3: further adjustment for dietary intake of fruits, vegetables, dairy, fast foods and carbonated beverages

BMI body mass index

*Obtained from analysis of covariance (ANCOVA)

consumption pattern are indicated in Table 3. A marginally significant inverse association was found between breakfast consumption and risk of overweight (OR: 0.93, 95% CI 0.86–1.01). This association became significant after taking potential confounders into account; such that participants who ate breakfast > 4 days/week had 15% lower risk of overweight compared with those who ate it < 1 day/week (OR: 0.85, 95% CI 0.78–0.92). Such significant association was also seen among female students (OR: 0.82, 95% CI 0.72–0.93), however, it was marginally significant in male ones (OR: 0.89, 95% CI 0.79–1.00). In terms of obesity, participants with more frequent consumption of breakfast were 26% less likely to be obese compared with those who consumed it infrequently (OR: 0.74, 95% CI 0.64–0.85). Such significant association was also observed after considering potential confounders (OR: 0.67, 95% CI 0.57–0.78). Moreover, a significant inverse association was found between breakfast consumption pattern and obesity among males and females either before or after adjustment of covariates (males; OR: 0.78, 95% CI 0.64–0.96, females; OR: 0.55,

Table 3 Multivariable-adjusted odds ratios and 95% CIs for obesity across categories of breakfast consumption pattern

Variables	< 1 day/week	1–2 days/week	3–4 days/week	> 4 days/week	*P* trend*
Overweight or obesity (BMI ≥ 25 kg/m^2)					
Whole					
Crude	1	1.00 (0.92–1.09)	0.92 (0.85–1.00)	0.93 (0.86–1.01)	0.007
Model 1	1	1.00 (0.91–1.09)	0.90 (0.83–0.97)	0.90 (0.83–0.97)	< 0.001
Model 2	1	1.01 (0.93–1.11)	0.92 (0.85–1.00)	0.93 (0.85–1.01)	0.002
Model 3	1	0.99 (0.90–1.08)	0.88 (0.80–0.96)	0.85 (0.78–0.92)	< 0.001
Males					
Crude	1	1.11 (0.98–1.24)	0.98 (0.88–1.10)	1.02 (0.92–1.13)	0.31
Model 1	1	1.09 (0.97–1.22)	0.94 (0.85–1.05)	0.97 (0.88–1.08)	0.04
Model 2	1	1.10 (0.97–1.23)	0.96 (0.86–1.08)	1.00 (0.89–1.11)	0.17
Model 3	1	1.08 (0.96–1.22)	0.90 (0.80–1.01)	0.89 (0.79–1.00)	< 0.001
Females					
Crude	1	0.95 (0.83–1.08)	0.89 (0.79–1.01)	0.91 (0.81–1.03)	0.17
Model 1	1	0.95 (0.83–1.08)	0.88 (0.77–0.99)	0.89 (0.79–1.00)	0.02
Model 2	1	0.96 (0.84–1.10)	0.91 (0.80–1.03)	0.93 (0.82–1.06)	0.34
Model 3	1	0.92 (0.80–1.05)	0.85 (0.74–0.96)	0.82 (0.72–0.93)	< 0.001
Obesity (BMI ≥ 30 kg/m^2)					
Whole					
Crude	1	0.92 (0.79–1.07)	0.79 (0.68–0.91)	0.74 (0.64–0.85)	< 0.001
Model 1	1	0.92 (0.79–1.07)	0.78 (0.67–0.90)	0.73 (0.63–0.84)	< 0.001
Model 2	1	0.94 (0.80–1.10)	0.81 (0.69–0.94)	0.76 (0.66–0.88)	< 0.001
Model 3	1	0.91 (0.78–1.07)	0.75 (0.64–0.88)	0.67 (0.57–0.78)	< 0.001
Males					
Crude	1	1.00 (0.82–1.23)	0.87 (0.72–1.06)	0.84 (0.70–1.01)	0.004
Model 1	1	1.00 (0.81–1.22)	0.86 (0.71–1.05)	0.83 (0.69–1.00)	0.003
Model 2	1	1.03 (0.83–1.27)	0.91 (0.74–1.11)	0.88 (0.72–1.07)	0.02
Model 3	1	1.05 (0.84–1.31)	0.85 (0.69–1.05)	0.78 (0.64–0.96)	< 0.001
Females					
Crude	1	0.86 (0.68–1.10)	0.71 (0.57–0.90)	0.67 (0.54–0.83)	< 0.001
Model 1	1	0.86 (0.68–1.10)	0.71 (0.56–0.89)	0.66 (0.53–0.82)	< 0.001
Model 2	1	0.87 (0.69–1.11)	0.73 (0.57–0.92)	0.69 (0.55–0.86)	< 0.001
Model 3	1	0.80 (0.63–1.02)	0.64 (0.51–0.81)	0.55 (0.44–0.70)	< 0.001

Data are presented as OR (95% CI)

Model 1: adjusted for age (continuous)

Model 2: additionally adjusted for marital status, education, physical activity, smoking and sleep pattern

Model 3: further adjustment for dietary intake of fruits, vegetables, dairy, fast foods and carbonated beverages

BMI body mass index

*Obtained from binary logistic regression

95% CI 0.44–0.70). However, in males, this association was significant only in the fully adjusted model.

Discussion

In the current study, we found that breakfast consumption habit was negatively associated with overweight and obesity. Such finding was also seen even after taking potential confounders into account. Furthermore, gender-stratified analysis showed a significant inverse association between breakfast consumption habit, overweight and obesity either in male or female students. To the best of our knowledge, this is among the first studies that examined the association between breakfast consumption pattern, overweight and obesity in a large sample size of university students in the Middle East.

It has been shown that skipping breakfast is associated with increased risk of non-communicable diseases including cardiovascular diseases, diabetes mellitus, some cancer

and psychological disorders [24–27]. Skipping breakfast is common among university students, in particular, those who live in a dormitory. The prevalence of obesity in this population is also increasing [2]. Therefore, the association between breakfast consumption pattern and obesity among university students seems to be of great importance. Based on our findings, breakfast consumption habit was inversely associated with overweight and obesity. In line with our findings, Jaesin et al. in a cross-sectional study on 268 African American college students showed a significant positive association between breakfast skipping and overweight (obesity included) [15]. In another study on Midwestern university students, healthy lifestyle practices such as daily breakfast consumption were associated with reduced risk of metabolic syndrome in which abdominal obesity is a component of this syndrome [16]. It had been shown that skipping breakfast more than eating dinner was positively associated with both waist circumference and BMI [28]. In a longitudinal study, both skipping breakfast and overconsumption of screen media were related to greater risk of overweight and abdominal obesity among schoolchildren [29]. Opposite to our findings, in a study on university students of Belgrade, Serbia, breakfast consumption pattern was not consistently associated with BMI or overweight/obesity prevalence [17]. Such non-significant association was also reported in a study that was done on a university undergraduate population in Nigeria [19] and in a study on clinical phase medical students in Saudi Arabia [18].

The differences in results on the association between breakfast consumption pattern and obesity among university students might be explained by different quality of studies. For example, in all mentioned studies that showed no significant association [17–19], none of confounding variables were controlled to obtain an independent association between breakfast consumption pattern and obesity, while in our study, some important confounders including demographic variables, physical activity and some dietary factors were adjusted. However, we did not control for other dietary factors including energy, legume and nuts, red meat and whole grains, as information on these was not collected, and it can be considered as a limitation of our study. However, most students participated in the current study were living in a dormitory and had most of their foods from university restaurants. University restaurants in Iran usually present one kind of food during each meal. Therefore, variation in dietary intakes among students participated in the study was low. Furthermore, variation in eating pattern during a week may affect the association between breakfast consumption and obesity. Hoffmann et al. reported that individuals on weekends (Friday through Sunday) consumed more calories from breakfast, dinner, and alcohol, and consequently had higher total daily calorie intake and fewer total calorie expenditure than on weekdays [30].

Lack of knowledge about the benefits of breakfast consumption and lack of time to prepare it are contributing factors for missing breakfast, especially among university students [31, 32]. Some studies have shown that increasing awareness and knowledge about healthy eating can affect frequency of breakfast consumption beneficially [33, 34]. It also affects food choices in meals during a day [35]. In a clinical trial, Baum et al. reported that educational nutrition messaging via a nutrition label, front-of-pack information, or via text messaging resulted in higher intake of healthy snacks and lower calorie intake between meals [36]. Furthermore, snack consumption whether healthy or unhealthy is another reason for meal skipping. In a cross-sectional study, snack consumption was associated with greater odds of meal skipping, particularly breakfast [37].

The main hypotheses that explained the inverse association between breakfast consumption pattern and obesity is about better regulation of blood glucose and appetite in individuals who consume breakfast every day, which may theoretically lead to a reduction in energy intake during a day [38]. Recommendation of consumption of breakfast is independent of the amount of energy intake in this meal or other meals, because some clinical trials did not limit energy intake and showed that eating breakfast frequently was associated with a prevention in weight gain [38, 39]. In addition, skipping breakfast induces a shift in the gene expression of body's biological clock resulting in a nocturnal lifestyle pattern. This pattern is associated with greater risk of obesity [40]. Earlier studies have shown a decrease in spontaneous physical activity for breakfast skipper at the beginning of a day [41, 42]. Furthermore, people who eat breakfast frequently are more likely to do health-related behaviors including regular sleep pattern, better food choices and being non-smoker compared with those who do not (as seen in our study) [43–46]. In a prospective study, during 1-year follow-up, mean fat intake of breakfast skippers was increased by 2.7% of total energy intake, while it was decreased by 1.2% in breakfast eaters. In addition, individuals who consumed breakfast frequently had a higher intake of thiamin, niacin, and folate than those who were breakfast skippers [47].

The present study has several strengths. This study is the first to link breakfast consumption pattern to overweight and obesity in a large sample of university students in the Middle East. However, some limitations should be considered in the interpretation of our findings. Due to cross-sectional design of our study, we cannot infer a causal link between breakfast consumption pattern and obesity. Participants with obesity may consume breakfast frequently to lose weight. However, this effect may attenuate the odds of obesity across students who skip breakfast or consume it infrequently; therefore, actual estimates may be even stronger than those observed. In contrast, some obese individuals may omit breakfast as a strategy to lose weight. This confounding effect strengthens

the risk estimates falsely. Overall, by findings from this cross-sectional study, we cannot draw a causal link between breakfast consumption and obesity. Therefore, prospective studies are needed to confirm our findings. Although several confounders were controlled on the association between breakfast consumption pattern and obesity, the role of other residual confounding variables (e.g., energy intake, menopausal status and psychological factors) cannot be excluded, as information on these was not collected.

In conclusion, eating breakfast frequently was inversely associated with overweight and obesity either before or after taking potential confounders into account. Gender-stratified analysis revealed such inverse association in male and female students.

Acknowledgements Authors appreciate the valuable assistance of all subjects. We also would like to thank the authorities of Health Center of Tarbiat Modares University, Tehran, Iran, for their cooperation.

Funding This study was supported by Health Center of Tarbiat Modares University, Tehran, Iran.

Compliance with ethical standards

Conflict of interest Authors declared no personal or financial conflicts of interest.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all subjects included in the study.

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