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Association between dietary diversity and obesity in Ardebil adults: a case-control study

Mahsa Mohajeri and Shiva Hoojeghani
Faculty of Nutrition, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran

Farhad Pourfarzi
Department of Community Medicine, Digestive disease Research Centre, Ardabil University of Medical Sciences, Ardabil, Iran

Mohammad Ghahremanzadeh
Department of Agricultural Economics, University of Tabriz, Tabriz, Iran, and

Ali Barzegar
Faculty of Nutrition, Tabriz University of Medical Sciences, Tabriz, Islamic Republic of Iran

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Abstract

Purpose – Obesity is a multi-factorial problem that develops from an interaction between diet, genetics, physical activity, medication, and other factors. This paper aims to examine the association between dietary diversity score (DDS) and obesity among adults of Ardebil.

Design/methodology/approach – This case-control study was conducted on 204 cases (obese and overweight participants) and 204 controls (healthy weight individuals) matched by socioeconomic status (SES), age (older than 30 years) and sex. Dietary intake was assessed using a 24 h food recall questionnaire. Data on physical activity and socio-demographic variables were gathered. DDS was computed based on the scoring of the 14 food groups recommended by the Food and Agriculture organization guideline.

Findings – The DDS of the obese group was higher (5.02 ± 1.02) than that of the healthy weight group (4.23 ± 1.18) ($p < 0.001$). There was a significant association between DDS and body mass index (BMI) in both groups of study, but this association was more significant in the obese group ($\beta = 0.501$, $p = 0.021$) than that of healthy weight group ($\beta = 0.413$, $p = 0.042$). Vegetable food group score in both groups of the study was associated with obesity inversely ($p < 0.05$).

Originality/value – This study was conducted for the first time in Ardabil city and the results showed for the first time that there is a relationship between dietary diversity and obesity. People with a higher dietary diversity score are more likely to be obese. In fact, this study for the first time proved that people who are obese have a more varied diet but less vegetables and fruits.

Keywords Obesity, Association, Ardebil adults, Dietary diversity score (DDS), Ardebil health centers, Diet diversity score

Paper type Research paper

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1. Introduction

Obesity is one of the main risk factors for chronic disease, and its prevalence is escalating worldwide (Hales *et al.*, 2018). Obesity has a significant economic impact on global healthcare systems (Skinner *et al.*, 2018). In 2016, more than 1.9 billion adults were overweight, with more than 650 million being obese. If the present trend continues by 2030 1.12, and 2.16 billion people will suffer from being obese and overweight, respectively (Yanovski, 2018; Irshad *et al.*, 2018). Obesity is a multi-factorial problem that results from an interaction between diet, genetics, physical activity, medication, and other factors (Locke *et al.*, 2015; Jacob *et al.*, 2018; Ekkekakis *et al.*, 2016). Until now, researchers have investigated the role of single nutrients in obesity. Although these studies are essential, dietary pattern analysis has recently emerged as a new approach for assessing the relationship between diet and the risk of obesity (Strate *et al.*, 2017; Naja *et al.*, 2015; Xu *et al.*, 2015). Pattern analysis examines the effects of the overall diet rather than looking at nutrients or food consumption and may be more indicative of disease risk than individual foods or nutrients (Sibhatu *et al.*, 2015; Sun *et al.*, 2014). The dietary diversity score (DDS) is an important indicator that is used for assessing the overall diet and is associated with nutrient adequacy. Results of previous studies indicated that a higher DDS was directly associated with higher intakes of fruits, vegetables, whole grains, total intake of dietary fiber, calcium, and vitamin C, which can reduce obesity incidence. Mohajeri *et al.* in a study among patients with angina showed that higher dietary diversity score is associated with fruits and vegetables and more micronutrients. In fact, people with higher dietary dignity have more of the food they consume, and as a result, they receive the necessary nutrients, in another study Mohajeri indicated that individuals that had higher DDS score had better dietary patterns and their diet supplies their nutritional requirement (Mohajeri *et al.*, 2017; Mohajeri *et al.*, 2015; de Oliveira Otto *et al.*, 2015; Kennedy, 2004). Previous studies have not fully confirmed the DDS association with obesity, and a review study also did not find a significant association between DDS and BMI”status (Salehi-Abargouei *et al.*, 2016). The relationship between DDS and obesity are inconsistent, and more studies are required in this regard (de Oliveira Otto *et al.*, 2015; Tian *et al.*, 2017; Hasan-Ghomi *et al.*, 2015).

To our knowledge, until now, there was not any case-control study that examined DDS association with obesity in Ardebil adults. So we conducted this case-control study to investigate the association between obesity and DDS in adults in Ardebil between obese and normal weight person.

2. Methods

This case-control study, comparing among obese, overweight, and healthy weight adults aged over 30 years, was conducted from October to November 2018. The case groups included 204 obese and overweight individuals randomly chosen from Ardebil Health centers. The control group consisted of 204 normal-weight participants who were randomly selected using a multistage cluster sampling method from volunteers from 17 health centers. First, three centers were selected from the branches of each main health center. Then, out of all the records of each center, 138 cases were decided. Controls were matched in a 1-to-1 ratio to cases by socioeconomic status, age and sex.

All participants completed the consent form. This study was approved by the Ethics Committee of Ardebil University of Medical Sciences. The inclusion criteria were: age above 30 years, being literate. Pregnant and lactating women, people with special diets and diagnosed with diseases and people who consumed medications affecting their appetite or weight were excluded. Physical activity was assessed by a valid self-reported physical activity questionnaire and was expressed as metabolic equivalent hours per day

(Met-h/day). The socio-demographic details were collected by a self-reported questionnaire, including age, sex, marital status, educational level, occupational status, income, home ownership status, and family size. Educational level, professional status, income, home ownership status and family size were identified as the essential variables to determine SES.

2.1 Dietary diversity score assessment

A qualitative 24-h dietary recall (for 21 days; 7 times per month) was used for the nutritional diversity assessment of individuals. Participants were asked to recall all the foods they consumed at home and outside the home. All diets were categorized and ultimately segregated into 14 food groups. These groups include cereals, white roots and tubers, vitamin A rich vegetables, tubers, dark green leafy vegetables and other vegetables, vitamin A rich fruits and other fruits, organ, meat, fresh meats, eggs, fish, seafood, legumes, nuts, seeds, milk and milk products, oils and fats .

Food recalls were classified into their respective food groups based on which the dietary diversity was determined. The Food and Agriculture Organization (FAO) defines nutritional variety as the number of food groups an individual consumes. The dietary diversity of participants was assessed following standard guidelines for measuring individual dietary diversity by the FAO (Kennedy *et al.*, 2011). DDS was calculated based on consumption of fourteen food groups, including Cereals; white roots and tubers; vitamin A -rich vegetable and tubers; dark green leafy vegetables; other vegetables; vitamin A rich fruits; other fruits; organ, meat; fresh meats, eggs; fish and seafood; legumes, nuts and seeds; milk and milk products; and oils and fats.

2.2 Anthropometric measurements

A trained dietitian measured anthropometric measurements, including height and weight. Weight was measured with minimum clothing without shoes, using a digital scale and was recorded to the nearest 0.1 kg. Height was measured in the standing position without shoes, using a portable stadiometer and was registered to the nearest 0.1 cm. the BMI" was calculated as weight divided by the square of height (kg/m^2).

2.3 Data analysis

All statistical analyses were performed using SPSS, version 18. Quantitative data were expressed as means, and categorical data were presented as frequency (percentage). Normality of continuous data was evaluated using the Kolmogorov–Smirnov test. The independent T-test was used for comparing the quantitative variables among BMI groups. Chi-squared test was applied for assessing the association of categorical variables. Multivariable linear regression models and forward method were used for evaluating the association between DDS and food groups DDS with BMI". A p-value less than 0.05 was used to designate the statistical significance".

3. Results

In Table I, the demographic characteristic of the participants is shown. There were no significant differences between the two studied groups by demographic characteristics. Cases were significantly less physically active compared to controls ($p < 0.001$). The food group intake of participants was summarized in Table II. There was a significant difference in the consumption of the majority of food groups between the two studied groups ($p \leq 0.05$).

Table I.
Basic demographic, anthropometric variable of participants

Variables	Normal weight group	The overweight and obese group	*p**
Age (y)**#**	45.9 ± 8.2	44.8 ± 7. 3	0.40
Weight (kg)#	74.3 ± 6.6	90 ± 2.4	<0.001
Height (m)#	1.7 ± 0.043	1.7 ± 0.047	0.001
PA (Met.h/d)#	37.00 ± 0.81	31.6 ± 1.2	<0.001
Sex n(%)			0.98#
Male	68 (33.3%)	70 (34.3%)	
Female	136 (66.6%)	134 (65.6%)	
Marital status			0.86#
Single *n*(%)	78 (38.2%)	82 (40.1%)	
Married	126 (61.7%)	122 (59.8%)	
Family size n(%)			0.72#
2	0	12 (2.9%)	
3	68 (33.3%)	67 (32.8%)	
4	72 (35.2%)	61 (29.9%)	
5	64 (31.3%)	65 (31.8%)	
Home status			0.64#
Tenant	70 (34.3%)	65 (31.8%)	
Homeowner	134 (68.6%)	139 (68.1%)	
Education n(%)			0.09#
Diploma	60 (29.4%)	55 (26.9%)	
Associate degree	8 (3.9%)	13 (6.3%)	
Bachelor's degree	68 (33.3%)	60 (29.4%)	
Master's degree	68 (33.3%)	76 (37.2%)	
Occupation(%) N			0.08#
Self-employed	50 (24.5%)	62 (30.3%)	
Governmental	102 (50%)	114 (55.8%)	
Housewife	48 (23.5%)	26 (12.7%)	
Unemployed	4 (1.9%)	2 (0.98%)	

Notes: *Based on independent *T*-test; #: based on Pearson Chi-Square test; PA: physical activity; significance level: $P \leq 0.05$, #: the data are reported as Mean ± SD

The comparison of DDS among the two studied groups is shown in Table III. DDS was higher in cases than the controls (P = 0.022). The cases had a significantly (P ≤ 0.001) higher intake of cereals compared to controls, while controls had a relatively higher consumption of vegetable (P = 0.035) and dairy products (P = 0.041). However, no difference was observed between the two groups in the intake of meat and fruits. In the multivariable regression analysis, we included age, sex, socioeconomic status, physical activity, and DDS as independent variables. The stepwise forward method detected a significant association between DDS and physical activity in two studied groups; the other variables were excluded from the model. Physical activity was the best predictor of obesity in participants; moreover, its confidence was stronger in the healthy weight group than the case group (Table IV). There was a significant association between BMI" and vegetable group diversity score between the two groups of study (Table V), So that the increase of one unit in the diversity score of the vegetable group could reduce 0.769 units in BMI of normal-weight participants and 0.789 units in the case group participants. In obese participants, the dairy group diversity score had a significant inverse

Food groups#	Normal weight group	Obese group	P*
Cereals[a] (serving/day)	5.3 ± 0.41	6.1 ± 0.83	0.04
White roots and tubers (serving/day)	0.23 ± 0.002	0.49 ± 0.03	0.02
Vitamin a rich vegetables and tubers (serving/day)	0.54 ± 0.01	0.12 ± 0.05	0.03
Dark green leafy vegetables(serving/day)	1.02 ± 0.05	0.41 ± 0.02	0.01
Other vegetables(serving/day)	0.23 ± 0.002	0.02 ± 0.008	0.02
Vitamin a rich fruits(serving/day)	0.12 ± 0.01	0.02 ± 0.005	0.03
Other fruits(serving/day)	0.87 ± 0.02	0.55 ± 0.01	0.021
Organ meat(serving/day)	0.02 ± 0.001	0.65 ± 0.11	0.001
Flesh meats(serving/day)	0.44 ± 0.02	0.41 ± 0.03	0.07
Eggs(serving/day)	0.01 ± 0.002	0.01 ± 0.004	0.09
Fish and seafood(serving/day)	0.02 ± 0.005	0.02 ± 0.008	0.08
legumes, nuts and seeds(serving/day)	0.04 ± 0.009	0.05 ± 0.002	0.06
Milk and milk products(serving/day)	0.52 ± 0.02	0.04 ± 0.005	0.02
Oils and fats(serving/day)	0.42 ± 0.08	0.77 ± 0.15	0.01

Notes: *Based on independent T-test; significance level: $P \leq 0.05$; [a]all cereals includes whole and refined; #: the data is reported as Mean ± SD

Table II. Food groups intake in study participants

Diversity scores#	healthy weight group (N = 204)	obese and overweight group (N = 204)	P*
Cereals[a] and tubers group	2.6 ± 0.02	3.6 ± 0.08	≤0.001
Fruit group	1.9 ± 0.08	1.9 ± 0.04	0.22
Vegetable group	1.1 ± 0.04	0.71 ± 0.01	0.03
Meat group	1.1 ± 0.06	1.1 ± 0.042	0.16
Dairy group	1.9 ± 0.21	1.6 ± 0.02	0.04
Oil and fats group	0.45 ± 0.02	0.62 ± 0.03	0.02
DDS	4.2 ± 1.1	5.0 ± 1.0	0.02

Notes: *Based on independent T-test; significance level: $P \leq 0.05$; DDS: diet diversity score, [a]all cereals includes whole and refined; #: the score is reported as Mean ± SD

Table III. The DDS and diversity scores of food groups in the two studied groups of participants

	Control		Cases	
Model	Coefficient	P*	Coefficient	P*
1 Physical activity	−0.64	0.02	−0.736	0.04
	AJDR:0.83		AJDR:0.76	
2Physical activity	−0.83	0.01	−0.64	0.03
DDS	0.41	0.0.4	0.50	0.02
	AJDR: 0.72		AJDR:0.69	

Notes: Model 1: predictor: Physical activity; Model 2: predictors, DDS, and Physical activity, significance level: $P \leq 0.05$, DDS: dietary diversity score; *based on regression model

Table IV. Regression analysis with forwarding selection method by BMI as the dependent variable

association with BMI" in 2 models of research. Each unit increase in dairy group diversity score was associated with a 1.07 unit reduction in BMI of cases. Fruit group diversity score in cases had a significant inverse association with BMI" ($\beta = -0.375$, P = 0.012). The vegetables group's diversity score had a significant inverse association with

Table V. Multivariable-adjusted regression for the association of and diversity scores of food groups with BMI

	Model 1 Case group			Model 1 Control group			Model 2 Case group			Model 2 Control group			
	β	P	Adjusted R^2	*β*	P	Adjusted R^2	*β*	P*	Adjusted R^2	*β*	P	F	Adjusted R^2
Meat group	0.563	0.072	0. 529	0.771	0.061	0.667	0.602	0.091	0.524	0.412	0.086	8.25	0.624
Dairy group	−0.2.03	*0.012*	*0.628*	−0.2.37	0.024	0.578	−1.07	0.048	0.684	−1.356	0.014	6.32	0.554
Bread grain group	0.656	*0.038*	*0.614*	0.985	*0.019*	*0.635*	0.358	*0.019*	*0.527*	0.236	*0.025*	*7.25*	*0.697*
Fruit group	−0.375	*0.012*	*0.547*	−0.766	*0.014*	*0.752*	−0,216	*0.019*	*0.698*	−0.869	*0.044*	*4.37*	*0.498*
Vegetable group	−0.789	0.022	0.627	−1.56	0.037	0.663	−0.689	0.015	0.687	−0.985	0.028	51.98	0.654

Notes: Model 1 – adjusted on age, sex, SES; Model 2- adjusted on age, sex, SES; Physical activity; *based on regression model

BMI" in both groups' participants. The association between the habits of eating fast food and obesity in the two studied groups is presented in Table VI. The frequency of eating fast food (p = 0.031, OR =1.14 (1.04−1.26)) and the size of the soft drinks (p = 0.019, OR=1.45 (1.19-1.83)) were significantly associated with obesity/overweight.

Food intake	Obese and overweight n (%) (N = 400)	Non-obese n (%) (N = 442)	P*	OR (95%CI)
Eating breakfast regularly			0.011	
No	294 (73.5%)	104 (22.52%)		1
Yes	106 (26.5%)	338 (76.48%)		0.54 (0.49-0.76)
A place where breakfast was eaten			0.789	
At home	291 (72.75%)	185 (41.86%)		1
Eat out	109 (27.5%)	275 (58.14%)		1.26 (1.03-1.56)
Eating lunch regularly			0.914	
No	20 (5%)	24 (5.42%)		1
Yes	380 (95%)	450 (95.02%)		2.94 (2.84-3.01)
Eating between breakfast and lunch			0.023	
Never	100 (25%)	50 (11.31%)		1
Sometimes	220 (55%)	42 (9.50%)		0.62 (0.59-0.89)
Always	80 (20%)	350 (79.18%)		0.48 (0.45-0.92)
Eating between lunch and dinner			0.019	
Never	50 (12.5%)	31 (7.01%)		1
Sometimes	272 (80.5%)	103 (25.56%)		0.83 (0.74-1.04)
Always	78 (7%)	298 (67.43%)		0.61 (0.59-1.26)
Eating midnight snacks			0.038	
Never	10 (2.5%)	285 (64.47%)		1
Sometimes	86 (21.5%)	112 (25.33%)		1.14 (1.08-1.95)
Always	304 (76%)	45 (10.25%)		1.54 (1.32-1.79)
Frequency of eating fast food/week	106 (26.5%)		0.031	
4>	294 (73.5%)	275 (58.14%)		1
4≤		185 (41.86%)		1.14 (1.04-1.26)
Size of soft drinks preferred			0.019	
Don't drink	20 (5%)	284 (64.26%)		1
Small	53 (13.5%)	85 (19.24%)		1.03 (0.98-1.95)
Medium	154 (43.5%)	43 (9.78%)		1.26 (0.95-1.75)
Large	173 (43.5%)	30 (6.72%)		1.45 (1.19-1.83)
Hours watching TV/day			0.044	
3>	50 (12.5%)	268 (60.63%)		1
3≤	350 (87.5%)	174 (39.37%)		1.49 (0.97-2.03)
Eating while watching TV			0.039	
Never	30 (7.5%)	218 (49.32%)		1
Sometimes	70 (17.5%)	150 (33.93%)		1.23 (0.89-1.84)
Always	300 (75%)	74 (16.75%)		1.54 (1.07-1.76)
Frequency of playing sport/week			0.019	
Five>	220 (55%)	124 (27.61%)		1
5≤	180 (45%)	320 (72.39%)		0.53 (0.41-0.91)

Note: *Based on chi-square test

Table VI. Association between food intake, fast food habits and lifestyle with obesity status of study participant

The effect of lifestyle patterns on the obesity status of adults is presented in Table VI. There was an increasing trend in the risk of obesity/overweighting with watching TV for more than three hours a day (OR = 1.49, CI 1.32-2.03). Eating while watching TV was significantly associated with obesity/overweighting ($p = 0.039$, OR = 1.54 (1.07-1.76)). Obesity/overweighting prevalence in individuals that had played sport more than 5 per week was less than others (OR= 0.53, CI= 0.41-0.91).

4. Discussion

This research was carried out to compare DDS among obese and normal-weight Ardebil – Iran adults for the first time. This is the first study that investigated the association between dietary diversity and obesity among Ardabil population. In the whole country, this study is the second study. The results of this study can prevent obesity, which is a public health problem. DDS is a direct indicator of diet quality. Age, social status and occupation of the participants in the two groups did not differ significantly. In fact, the social status and age of people have a very significant impact on food choices. People with higher social status have higher dietary quality. Diversity in people with high social status has higher rates. The higher the diversity score is, the more is the consumption of essential vitamins and minerals (Luckett *et al.*, 2015; de Andrade Previato, 2018; Staudacher *et al.*, 2019).

Past studies have shown that obese people do not have a proper diet (de Andrade Previato, 2018). Obese group participants had a higher DDS than the healthy weight group. As a result, in Karimbeiki's (Staudacher *et al.*, 2019) study results, there is a significant difference in DDS between obese and normal weight group, and obese persons had higher DDS than controls. The result of the current study showed that there was a significant association between DDS and BMI, which is consistent with the results of previous studies (Donini *et al.*, 2016). It happens because higher dietary diversity may increase the calorie intake and as a result, leads to obesity. In a study conducted in Tehran adults, individuals with higher DDS were found to be more obese (Farhangi and Jahangiry, 2018). Mexican men with higher diet diversity score were more obese than men with less dietary diversity score, which might indicate higher energy density food consumption like fatty foods. The higher diet diversity score suggests a more energy intake from foods, which can result in obesity (Malapit *et al.*, 2015). Similar to our results the findings from a meta-analysis, including three extensive prospective cohort studies which compared 133,468 men and women, indicated that higher consumption of starchy vegetables such as peas, potatoes, and corn is associated with obesity due to their higher glycemic load (Fernandez *et al.*, 2016).

Another study found that there is a significant association between DDS and energy intake, the increased energy intake was due to the higher consumption of healthy and low-energy-dense food items such as green leafy vegetables; consequently, DDS was related to a lower risk of obesity (Ponce *et al.*, 2006). However, higher DDS does not always lead to obesity, and one should consider any food group that has the highest score among different food groups. Higher dietary diversity was not only related to both higher consumption of unhealthy foods such as sugar and fats, but also associated with a higher intake of healthy foods, including fresh fish, non-fatty meat, and vitamin-A-rich fruits and vegetables (Bertoia *et al.*, 2015). The results of different studies about the association between diet diversity and obesity are contradictory.

Studies indicated that dietary intake of majority people in all countries is lower than dietary recommendation (Sholeye Oluwafolahan, 2018; Azadbakht and Esmaillzadeh, 2011) . In our study, higher vegetable intake had an inverse association with obesity. Vegetables have low-calorie content, and increasing their intake leads to a decrease in the total calorie intake. In a study of the university students in Ghana, individuals had higher odds of being overweight/obese (BMI") if they consumed fruits and vegetables > 3 times a week (compared with those consuming less than three times per week) (Hasan-Ghomi *et al.*, 2012). Foods with a lower glycemic index and higher fiber content were more strongly inversely associated with weight changes than low-fiber and high-GL food items do (More *et al.*, 2015; Crichton and Alkerwi, 2014). The result of the present study was not consistent with the finding of the previous works. In the current research, the fruits and vegetables were considered as one group, which could be a probable reason for the observed inconsistency. Another reason for the mentioned difference is the study population. In fact, in our research, the studied community was adults over the age of 40, while the population studied in Ghana was university students.

Our results indicated that higher dairy group food consumption is inversely associated with obesity. These results are in agreement with the findings of other studies. In Luxembourg study that investigated whether dairy food consumption is related to the prevalence of global and abdominal obesity, participants in the highest tertile of whole-fat dairy intakes (milk, cheese, and yogurt) had significantly lower odds of being obese (Montagnese *et al.*, 2015). Another cross-sectional study indicated that higher total dairy food intake was significantly associated with a lowered prevalence of obesity. This relationship was particularly evident of whole-fat dairy products, namely, milk, yogurt and cheese (Montagnese *et al.*, 2015). In one meta-analysis study, this issue wasn't proved or confirmed. This study emphasized that taking calcium intake alone cannot reduce fat and body weight (Booth *et al.*, 2015). Another meta-analysis of studies revealed that increasing whole-fat and low-fat dairy food consumption results in a modest weight gain that probably occurs owing to the increase of total calories (Benatar *et al.*, 2013). Most studies have shown that dairy consumption has an inverse relationship between weight and obesity (Engel *et al.*, 2018; Wrotniak *et al.*, 2018; Farvid *et al.*, 2017). About this issue, there was not a logical conclusion.

The findings of the current research show a significant association between eating breakfast regularly and obesity. Many studies have reported that the removal of breakfast meals increases the risk of obesity in people (Wrotniak *et al.*, 2018; Farvid *et al.*, 2017). Individuals skipping the breakfast believe that jumping breakfast may help in weight reduction. Thus, obese individuals missed their breakfasts than did non-obese people. The supply of fasting blood sugar in the morning with breakfast intake will prevent further hunger and thus prevents obesity. In a study that investigated the association of breakfast skipping and obesity in Brazilian adults, the results did not support the relationship between skipping breakfast and BMI", this study has stated that the amount and type of food consumed at breakfast are related to BMI", and whether taking or not taking breakfast is not associated with obesity (Karimbeiki *et al.*, 2018). A justification for the different results to our results with the findings other studies is perhaps the type of population studied and not considering the calories received at breakfast in the current research. The total daily calorie intake is more important than taking or not taking breakfast (Haerens *et al.*, 2010; Karatzi *et al.*, 2017; Baltar *et al.*, 2018).

Eating between breakfast and launch was found to be protective factor against obesity. Eating snacks between meals, reduce the risk of obesity as individuals will eat fewer food items the next meal. It depends on the type and quantity of food consumed as a snack. Snacking between dinner and lunch was significantly associated with a lower risk of obesity among Ardebil adults. This finding is consistent with the results of other studies (Megson *et al.*, 2017; Navia *et al.*, 2017; Leech *et al.*, 2017). Results of a survey indicated that individuals that had snack intake between main meals, compared with others that didn't have a snack, were less likely to be overweight or obese and less likely to have abdominal obesity (Heinitz *et al.*, 2017). Healthy snacking between meals has a protective effect against obesity (Murakami and Livingstone, 2016).

Study populations, dietary assessment tools such as FFQ, food record, dietary recall, numbers of food groups and their subgroups are factors responsible for observed differences between the results of previous studies. Mentioned factors account for the discrepancy regarding the association between dietary diversity and obesity, as well.

To the best of our knowledge, all of the researchers studying the association between DDS and BMI" status were cross-sectional, and this is the second case-control study examining the association between DDS and obesity. The present study had some limitations in that our data were used to identify the association between DDS and obesity, and no causal inferences can be made. The effect of DDS on weight should be examined in future clinical trial studies.

5. Conclusion

In conclusion, our results showed that obese participants had higher DDS compared to healthy weight participants; therefore, there was a significant positive association between DDS and obesity. More dietary diversity is suggested to supply all the essential nutrients. According to the results of the present study, the recommendations to increase dietary diversity should consider the controlling of total energy intake to avoid weight gain and obesity. Lower consumption of vegetables and dairy products in the obese group can exacerbate obesity, and the obese group consumes more grains than the healthy weight group. All of these factors can account for obesity in overweight people. Further studies with larger sample size are needed to confirm these results.

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Corresponding author
Ali Barzegar can be contacted at: alibarzegar@hotmail.com