Original Article

Association Between Different Dietary Carbohydrate and Risk of Depression, Anxiety, and Stress Among Female Adolescents

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Abstract

Purpose: Mental disorders account for a large part of the burden of disease in young population. The present study aimed to investigate the relationship between carbohydrate intakes and the risk of depression, anxiety, and stress among female adolescents. **Methods:** In this cross-sectional study, 263 female adolescents aged 15–18 years participated. Depression, anxiety, and stress scores were determined by DASS-21 (Depression Anxiety Stress Score-21 items) questionnaire, and dietary intakes were assessed using a validated 168-item food frequency questionnaire. Crude and multivariable-adjusted odds ratios (OR) and 95% confidence intervals (CIs) were estimated through logistic regression analysis. **Results:** Adolescents with depression consumed more glucose and sucrose and less lactose compared to adolescents without depression. After adjustment for all confounders, higher intakes of glucose and sucrose were significantly associated with increased risk of depression (OR_{glu} = 1.3, P = 0.035 and OR_{suc} = 1.41, P = 0.034), anxiety (OR_{glu} = 1.3, P = 0.019 and OR_{suc} = 1.81, P = 0.027), and stress (OR_{glu} = 1.41, P = 0.046 and OR_{suc} = 1.8, P = 0.044). In addition, increasing lactose intake was significantly associated with reducing the risk of depression (OR = 0.96, P = 0.013) and stress (OR = 0.96, P = 0.015). **Conclusions:** This study found significant associations between dietary carbohydrate intake and mental disorders among female adolescent.

Keywords: *Anxiety, carbohydrate, depression, diet, stress*

Introduction

Mental disorders account for a large part of the burden of disease in young people in all societies.[1] Since most mental disorders begin during youth, roughly 20% of children and adolescents globally suffer from mental health issues.[2] Increasing responsibility, academic pressure, and the challenges of acquiring knowledge and skills can increase vulnerability to depression, stress, and anxiety in students. As a result, this affects their mental health and may even disrupt their social and cultural lives.[3] Therefore, the majority of mental health problems, such as anxiety, stress, and depression, show their initial signs and symptoms during the teenage years.[4] According to the available evidence, 31.9% of teens between the ages of 13 and 18 are diagnosed with an anxiety disorder every year and 31.5% of adolescents report symptoms of depression.[5,6] Females are also more likely to suffer from mental health problems than males.[7] National reports indicate a high prevalence of mental health disorders such depression and anxiety in Iranian children and adolescents.[8,9] Depression is a complex disorder that originates from the interaction between genetic and environmental factors, but its pathogenic mechanism is still not fully understood. However, lifestyle factors such as diet seem to play a decisive role.[10,11]

It has been reported that carbohydrate (CHO) consumption may possess mood-enhancing characteristics. Compared to healthy populations, patients with mental health problems attempt to self-medicate by increasing their daily intake of CHO-rich foods and beverages.[12,13] On the other hand, studies have indicated that in addition to the metabolic health concerns associated with high consumption of simple sugars,[14] long-term consumption of CHO-rich foods has negative effects on psychological well-being and may even lead to depression.[15] It is well established that a balanced carbohydrate intake is responsible for optimal serotonin and thus a good mood. The serotoninergic system disorder is involved in the pathogenesis of various

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mood disorders.[16] The serotoninergic system, in particular, is vulnerable to CHO manipulation, and changes in mood after CHO administration appear to be due to changes in serotonin availability.[17] However, the results of existing studies are contradictory.

Considering the high prevalence of mental health problems among female adolescents and the possible role of carbohydrate intakes, this study was performed to investigate the relationship between intakes of different type of carbohydrate and the risk of depression, anxiety, and stress in female high school students between the ages of 15 and 18 years.

Methods

Study population

Using a multistage stratified cluster selection procedure, 263 female adolescents aged 15 to 18 years were recruited for this cross-sectional study. Participants were selected at random from high schools in three educational districts in Tehran, Iran, designated as rich, middle class, and underprivileged (according to the definition of Ministry of Education). Initially, 280 participants were picked at random from the engaging schools. Those who smoked, had history of chronic diseases, used antidepressants or sedative agents, physician-diagnosed depression or anxiety disorders, and those who followed a certain diet were excluded from the study. Seventeen subjects were excluded from the analysis due to missing data (>70 blank items) on the food frequency questionnaire (n = 5) or log scales of total energy intake that were <3 or >3 SD from the mean (n = 12). Consequently, the data of 263 participants were analyzed.

All procedures in this study were approved by the Ethics Committee of the National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences in Tehran, Iran (ID: 054577), and the research was carried out in accordance with the principles outlined in the Declaration of Helsinki. Every participant voluntarily provided written informed consent.

Evaluation of depression, anxiety, and stress

The intensity of depression, anxiety, and stress was measured in the current study using the Persian version of the Depression, Anxiety, Stress Scale-21 (DASS-21), a short form of the primordial questionnaire (DASS-42), which was originally provided by Lovibond and Lovibond.[18] This questionnaire is divided into three subscales, each with seven items. The final score for each subscale is obtained by summing the scores of related questions. The validity and reliability of the Persian version of the DASS-21 have been verified previously.[19,20] In the current study, we divided the participants into two groups based on their Lovibond scores for depression, anxiety, and stress.[18] Those within a normal range were considered as healthy, while the remainder were categorized as unhealthy.

Dietary and lifestyle variables

A valid and reliable semiquantitative food frequency questionnaire (FFQ) was used to gather the participant's dietary consumption during the prior year.[21] The FFQ had 168 food items, each with a specific serving size. Each participant's food intake frequency was determined on a daily, weekly, or monthly basis. Using a manual for home measurements, the daily standard serving size for all food products was converted to daily grams of food consumption.[22] Since the Iranian food composition table (IFCT) is incomplete, the energy content of each food item was computed using the United States Department of Agriculture (USDA) food composition data provided in Nutritionist 4 software (First Databank; Hearst, San Bruno, CA, USA).[23] It should be noted that the calorie and macronutrient content of many IFCT food items (for example, bread and fruits) are roughly equivalent to alternative food items in the USDA food composition table, with a correlation of >0.9.[24] A professional interviewer administered a systematic questionnaire to collect information on participants' sociodemographic factors.

Body weight in light clothing was measured to the nearest 0.1 kg using a digital scale (Seca 881, Germany), and height was measured to the nearest 0.5 cm using a portable nonstretch meter while participants stood without shoes. Body mass index (BMI) was computed by dividing body weight (kilograms) by body height squared (meters). Earlier, this questionnaire was administered to a representative sample of Iranian women, giving consistent results.[25] Also, waist and hip circumferences were measured at baseline using standard procedures, and the waist-to-hip ratio (WHR) was calculated.

Body image concern

The Persian version of eating disorder examination questionnaire (EDE-Q-28) was used for body image evaluation.[26] This questionnaire was self-administered, and good reliability and construct validity of EDE-Q weight concern and shape concern subscales have been reported in females.

Statistical analysis

Statistical analysis was performed by SPSS software version 19 (SPSS Inc., Chicago, Illinois). We used the Kolmogorov–Smirnov test and histogram chart to check the normality of variables. In the present study, we described participant's baseline characteristics and dietary intakes as mean ± standard deviation (SD) for quantitative variables and numbers (percentage) for qualitative variables. Depression, stress, and anxiety scores were expressed as the median and interquartile range (IQR). Independent sample *t*-test and Chi-square were applied for determining the

differences between cases and controls for variables with normal distribution and categorical variables, respectively.

Data on dietary intake were quantitatively analyzed, and the association between dietary carbohydrates and risk of each mental disorder were estimated using binary logistic regression in two models including crude model (model 1) and adjusted for confounding factors including energy intake, BMI, and dietary fiber (model 2). *P* values < 0.05 were considered statistically significant.

Results

In participants with depression, the median and IQR of depression, anxiety, and stress scores were significantly higher than those who did not have depression. Furthermore, body image impairment was significantly higher among participants diagnosed with depression compared to their healthy peers (*P* value < 0.001). Table 1 presents the general characteristics and anthropometric measures. Anthropometric measurements did not show any significant difference between the two groups.

Table 2 provides information concerning the dietary intakes of participants. The results showed that those with depression had significantly higher glucose (26 ± 18 vs 22 ± 9, *P* = 0.025) and sucrose (32 ± 14 vs 27 ± 12, *P* = 0.033) intake and lower lactose intake (15 ± 9 vs 19 ± 13, *P* = 0.019) than those without depression. Other dietary components did not show significant differences between the two groups. Crude and adjusted odds ratios and 95% confidence intervals for depression, anxiety, and stress and carbohydrate intake are illustrated in Tables 3–5, respectively. In the crude model, glucose, sucrose, and lactose intake showed a significant association with the risk of depression. This relationship was direct for glucose and sucrose and inverse for lactose. The association between sugar intake and risk of depression turned to be significant (OR: 1.2, *P* = 0.005) after adjusting for confounding variables including energy intake, BMI, and dietary fiber.

In the crude and adjusted model, intake of sugar (OR = 1.23, *P* = 0.045), glucose (OR = 1.2, *P* = 0.039), and sucrose (OR = 1. 3, *P* = 0.048) was significantly associated with increased risk of anxiety. Investigating the relationship between carbohydrate intake and the risk of stress showed a significant and direct relationship between the intake of total carbohydrates, sugar, glucose, sucrose, and maltose, which after adjusting the effect of confounders, sugar turned to be nonsignificant. In addition, increasing lactose intake was significantly associated with reducing the risk of stress (OR = 0.96, *P* = 0.015).

Table 1: Characteristics of study participants based on the depression status

	Subjects with depression (*n*=115)	Subjects without depression (*n*=148)	*P*
Age (y)	16.2±0.96	16.1±0.97	0.836
Depression score*	14 (12-24)	4 (2-6)	<0.001
Anxiety score*	12 (6-18)	4 (2-8)	<0.001
Stress score*	20 (14-26)	8 (4-14)	<0.001
Body image			<0.001
Normal	91 (79%)	138 (93%)	
Impaired	24 (21%)	10 (7%)	
Weight, kg	58.7±12	59±11.5	0.517
Height, cm	162.3±5.5	163±6	0.383
BMI, kg/m^2	22.2±4.2	22.3±4	0.475
Waist, cm	72.3±8.7	72.4±7.5	0.127
Hip, cm	96±9.3	97±8.7	0.379
WHR	0.75±0.05	0.74±0.04	0.188

Values are means±SDs for continuous variables and number (percentages) for categorical variables. *Median and interquartile range. Independent sample *t*-test for quantitative variables and χ^2 test for qualitative variables. BMI: Body mass index; WHR: Waist-to-hip ratio

Table 2: Dietary intakes of study participants

	Subjects with depression (*n*=115)	Subjects without depression (*n*=148)	*P*[1]
Calorie intake (Kcal/d)	2618±876	2548±808	0.501
Protein (g/day)	87±30	90±33	0.485
Fat (g/day)	91±34	93±36	0.662
Carbohydrate (g/day)	381±141	357±118	0.070
Fiber (g/1000 Kcal)	13±3	13.5±3	0.338
Sugar (g/day)	151±69	142±52	0.076
Glucose (g/day)	26±18	22±9	0.025
Galactose (g/day)	2.5±2	2.5±2	0.911
Fructose (g/day)	31±20	27±13	0.076
Sucrose (g/day)	32±14	27±12	0.033
Lactose (g/day)	15±9	19±13	0.019
Maltose (g/day)	1.1±0.7	0.9±0.4	0.189

Values are means±SDs. [1]Independent sample *t*-test

Discussion

The purpose of this study was to examine the relationship between different types of dietary carbohydrate consumption and the risk of depression, anxiety, and stress in Iranian adolescent females. The findings of this study showed that adolescents with depression consume more glucose and sucrose and less lactose than adolescents without depression. This cross-sectional study also indicated that higher consumption of sugar, glucose, and sucrose was associated with decreasing the risk of psychological disorders, including depression, anxiety, and stress among adolescent female, while an increase in the consumption of lactose was associated with a decrease in the risk of depression and stress.

Our results support previous studies on the causal relationship between sugar intake and depression.[15,27-30] This relationship can be attributed to several potential

Table 3: Crude and adjusted odds ratios and 95% confidence intervals of depression and carbohydrate intake

	Model 1		Model 2	
	OR (CI 95%)	*P*	OR (CI 95%)	*P*
Carbohydrate	1 (0.9-1.1)	0.774	1.1 (0.9-1.2)	0.145
Sugar	1.1 (0.95-1.2)	0.282	1.2 (1-1.3)	0.005
Glucose	1.2 (1-1.4)	0.033	1.3 (1-1.6)	0.035
Galactose	0.99 (0.88-1.1)	0.911	0.97 (0.85-1.1)	0.972
Fructose	1.1 (1-1.2)	0.082	(0.9-1.2)	0.073
Sucrose	1.16 (0.99-1.3)	0.029	1.41 (0.99-1.73)	0.034
Lactose	0.97 (0.95-0.99)	0.029	0.96 (0.94-0.99)	0.013
Maltose	1.36 (0.99-2.1)	0.167	1.78 (0.9-3.4)	0.084

Based on binary logistic regression model. Model 1: crude, Model 2: adjusted for energy intake, BMI, dietary fiber

Table 4: Crude and adjusted odds ratios and 95% confidence intervals of anxiety and carbohydrate intake

	Model 1		Model 2	
	OR (CI 95%)	*P*	OR (CI 95%)	*P*
Carbohydrate	1 (0.99-1.1)	0.244	1.11 (0.99-1.2)	0.198
Sugar	1.23 (0.99-1.39)	0.045	1.4 (1-1.8)	0.008
Glucose	1.2 (1-1.4)	0.039	1.3 (0.99-1.7)	0.019
Galactose	0.96 (0.85-1.1)	0.517	0.93 (0.82-1.1)	0.337
Fructose	1 (0.99-1)	0.238	1.1 (0.98-1.2)	0.434
Sucrose	1.3 (0.98-1.4)	0.048	1.8 (1.1-2.3)	0.027
Lactose	0.99 (0.97-1.1)	0.393	0.97 (0.96-1)	0.250
Maltose	1.6 (1-2.5)	0.050	1.8 (0.94-3.5)	0.076

Based on binary logistic regression model. Model 1: crude, Model 2: adjusted for energy intake, BMI, dietary fiber

Table 5: Crude and adjusted odds ratios and 95% confidence intervals of stress and carbohydrate intake

	Model 1		Model 2	
	OR (CI 95%)	*P*	OR (CI 95%)	*P*
Carbohydrate	1.2 (1-1.4)	0.042	1.54 (1-2.1)	0.025
Sugar	1.4 (0.99-1.8)	0.049	1.2 (0.8-1.59)	0.051
Glucose	1.21 (1-1.41)	0.041	1.41 (1.2-1.7)	0.046
Galactose	1.06 (0.9-1.2)	0.352	1.3 (0.4-2.77)	0.062
Fructose	1.1 (1-1.3)	0.106	1.09 (1-1.2)	0.353
Sucrose	1.59 (0.93-1.9)	0.028	1.8 (0.95-3)	0.044
Lactose	0.98 (0.95-1)	0.053	0.96 (0.94-0.99)	0.015
Maltose	1.9 (1.2-3)	0.006	2.7 (1.3-5.5)	0.006

Based on binary logistic regression model. Model 1: crude, Model 2: adjusted for energy intake, BMI, dietary fiber

mechanisms including the brain derived neurotrophic factor (BDNF) system. BDNF is a crucial peptide involved in synaptic plasticity, neuronal survival, and axon growth.[31] Prior research has indicated that long-term diets consisting of refined carbohydrates lead to diminishing mRNA levels of BDNF in rats.[32] These results are in line with human studies that have shown that patients experiencing depressive symptoms tend to exhibit lower BDNF levels than healthy individuals. Interestingly, those who undergo treatment will experience increased serum BDNF levels posttreatment.[33]

It has also been reported that inflammatory biomarkers are associated with consumption of simple carbohydrates, which can be allied with an increased risk of depression.[34,35] One possible mechanism in this regard can be insulin resistance, which is induced by consuming simple carbohydrates and leads to physical and psychological issues, which are strongly associated with patients who are reported to have depressive disorders. Moreover, simple sugars have a high glycemic index, which exacerbates insulin resistance. This approach could further clarify why lactose, which is commonly found in milk and other dairy products and has a lower glycemic index, may reduce the risk of depression.[36]

It seems that the relationship between depression and carbohydrate intake is a vicious cycle, not only carbohydrate intake is associated with an increased risk of depression, but depression is associated with carbohydrate cravings. Carbohydrate intake has also been shown in a number of studies to reduce depressive symptoms and improve mood.[12,37] It has been stated that the consumption of carbohydrates increases the secretion of serotonin through the changes in insulin secretion and plasma tryptophan concentration, which consequently leads to the reduction of specific psychological symptoms, such as premenstrual syndrome.[38] This mechanism may explain why people with depression tend to consume more sugar than normal people. However, it is difficult to generalize these findings to conditions with a long duration and long induction period such as depressive disorder.

Another finding of the present study was the increase in the risk of stress and anxiety with the increase in the intake of simple carbohydrates, including glucose and sucrose. These findings were in line with the study conducted in diabetic patients, in which it was shown that high carbohydrate intake was significantly associated with an increase in anxiety score, although this association was not significant with stress score.[39] Consistently, a relatively recent systematic review and meta-analysis on 11 studies reported that although very low calorie diets with low amounts of carbohydrate reduced depressive symptoms, they had no effect on anxiety.[40] These results could be due to the low number of studies assessing anxiety. The results of the recent prospective study also confirm the findings of the present study, in which a significant relationship was found between dietary carbohydrate intake and anxiety.[41] Inflammatory mechanisms can be an explanation for this relationship, which has been proven to play a role in most common mental disorders.[42]

Some limitations of the present study should be noted. First, due to the cross-sectional design of the study, it is difficult to establish a cause and effect relationship. Considering that α was 0.05 and power was 80%, our sample size may be considered sufficient. However, larger

samples may be considered to increase the power of the study. The outcomes of the study, depression, stress, and anxiety, were evaluated using self-report questionnaires. Also, the use of self-report food frequency questionnaires could result in recall bias. The statistical population of adolescent female limited the generalizability of the results. Despite these limitations, to the best of our knowledge, this is the first case–control study aimed to assess the associations between carbohydrate intake and the risk of depression, anxiety, and stress. Validated questionnaires were used to collect the data.

Conclusion

In conclusion, the present study provided evidence on the association between carbohydrate consumption and depression and anxiety and stress in adolescent female. These findings demonstrated that limiting the consumption of simple sugar may exert positive impacts on mental health. Future prospective studies and clinical trials are required to strengthen present evidence and confirm these findings.

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Conflicts of interest

There are no conflicts of interest.

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