The Association Between Dietary Glycemic Index and Load With Mental Health

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Abstract

Background: Psychological disorders including depression, anxiety, and stress comprise a huge public health problem. The aim of this cross-sectional study is to assess the relationship between dietary glycemic index (DGI) and glycemic load (DGL) and mental disorders.

Method: Participants (n = 10,000) aged 20-69 were randomly selected from 200 clusters in Yazd from the recruitment phase of Yazd Health Study. The dietary intake of study participants was collected by a reliable and validated food frequency questionnaire (FFQ) consisting of 178 food items. DII and DIL were calculated from the FFQ data using previously published reference values. To assess psychological disorders an Iranian validated short version of a self-reported questionnaire (Depression Anxiety Stress Scales 21 [DASS21]) was used.

Results: There were no significant associations between DGI and DGL with odds of depression or anxiety in crude and adjusted models. However, individuals in the highest quartiles of DGL had the lowest odds of stress (OR: 0.69; 95% CI: 0.47–1, P-trend = 0.023). This association remained significant after adjustment for potential confounding variables in model I (OR: 0.45; 95% CI: 0.22–0.9, P-trend = 0.023), model II (OR: 0.46; 95% CI: 0.22–0.96, P-trend = 0.039) and model III (OR: 0.46; 95% CI: 0.22–0.96, P-trend = 0.039).

Conclusion: In conclusion, consumption of foods with higher GL was associated with lower odds of stress; however, no significant association was found between GI or GL and risk of depression and anxiety. Performing further studies with longitudinal design is suggested to confirm these results.

1. Introduction

Psychological disorders including depression, anxiety, and stress comprise a huge public health problem, affecting about 31–41% of the world population in 2020 [1]. The pathophysiology of mental disorders is complex, with genetic, biological, and environmental factors involved in its onset and progression [2]. The underlying mechanisms are not fully understood, which may explain the poor response (50%) of current pharmacotherapies [3].

Among the environmental factors, dietary intakes have long been demonstrated to be associated with mental disorders. For example, diets rich in fruits and vegetables have a general positive impact on mental health [4] whereas a western diet (characterized by high intake of fried food, processed meat, refined carbohydrate and confectionary) is associated with mental disorders [5]. The glycemic index (GI) and glycemic load (GL), measures of blood glucose levels to different foods, are good indicators of the quality of dietary carbohydrates [6]. The prevalence of psychological disorders is much higher in patients with diabetes [7] and several studies show a link between GI and GL and psychological disorders [8–10], suggesting glucose metabolism plays a mechanistic role. Indeed, high GI and GL foods provoke insulin secretion leading to subsequent hypoglycemia which impact on the nervous system and result in psychological disorders [11]. However, increased insulin levels from high GI/GL diets may facilitate delivery of tryptophan in the brain and increase the synthesis of serotonin, a neurotransmitter associated with mood improvement [12].

The literature in this field is equivocal, probably due to study design, sample size, duration, and other components of the diet that may explain this inconsistency [13–17]. Therefore, due to the necessity of conducting more high-quality research, we investigated the association of GI and GL with depression, anxiety, and stress in a large Iranian population.

2. Materials And Methods

2.1. Study population

We used data from the enrollment phase of Yazd Health Study (YaHS) conducted from September 2014 to December 2015. YaHS is a prospective cohort study which has been conducted on 10,000 participants aged 20–70 years since 2014. The participants were randomly selected from 200 clusters in Yazd Greater Area. The profile and details of this study were published elsewhere [18]. Written informed consent was taken from all participants. The research was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Iran (Ethic code: 931188). Data regarding current and history of chronic diseases, smoking status, socio-demographic characteristics including age, gender, marital status and education level were obtained by interview and standard questionnaires. Participants were excluded on the following: under or over estimation of energy intake (total daily energy intake less than 800 or higher than 6,500 kcal/day), pregnancy, following a special diet and taking antidepressants. After exclusion, 7384 participants (3673 men and 3711 women) participated in the study.

2.2. Dietary assessment

Dietary intake of study participants was collected by a reliable and validated food frequency questionnaire (FFQ) consisting of 178 food items designed for an Iranian population [19]. FFQs were completed during face-to-face interviews and reported dietary intakes in household measures were converted to grams and entered to the Nutritionist IV software (First Databank Inc., Hearst Corp., San Bruno, CA, USA). To calculate daily nutrient intake values for each participant, the US Department of Agriculture's (USDA) national nutrient databank was used [20].

2.3. Dietary glycemic index and load calculation

The total GI was calculated based on the following formula: $\sum (GI_a \times \text{available carbohydrate}) / \text{total available carbohydrate}$. The available carbohydrate content of foods was calculated as total carbohydrate minus fiber [21]. The total carbohydrate and fiber contents of foods were adapted from the US Department of Agriculture food-composition table [22]. Food items with low carbohydrate content (less than 3.5 g available carbohydrate per serving) like tomatoes, pickles, cabbage, cucumbers, lettuce, cheese, sausages, eggs, mayonnaise were excluded because GI values of these foods could not be tested [23]. Of the 178 and 121 food and beverage items in the FFQs of YaHS-TAMYS study, 43 (24.1%) and 32 (24.4%) items contained less than 3.5 g available carbohydrate/serving, respectively. Eventually, the calculation of GI was carried out based on the remaining 135 items in the YaHS-TAMYS. GI values for 108

food items in the YaHS-TAMYS study were adapted from the international references [24, 25]. for Iranian specific foods not covered in the international tables (6 items), the Iranian GI tables were used [26], because the GI of all food items was not covered. GI values for the remaining food items which were not available, neither in Iranian nor on the international tables, such as some traditional sweets and desserts, were gained based on physically and chemically similar foods. For example, the GI value for gaz, a traditional food item highly consumed in Yazd city and mainly made of flour, almonds, and sugar, was considered to be the same as sugar. When more than one GI value from a different brand was available, the mean GI value was applied (e.g. rice and dates). The GIs of mixed meals were obtained based on GI values of each of the meal's components [22]. For all derived GI values, glucose was used as the reference food. Finally, dietary GL was calculated by multiplying the dietary GI by the total daily available carbohydrate intake and dividing the result by 100 [22].

2.4. Anthropometric measurements

Body weight was measured using a portable digital scale analyzer with an accuracy of 0.1 kg. The participants stood in the middle of the scale, wearing the minimum possible clothing. Height was also measured in a standing position, while barefoot with the head placed in the Frankfurt position. Body Mass Index (BMI) was calculated, body weight (kg)/ height (m²).

2.5 Psychological health assessment

An Iranian validated short version of the self-report questionnaire for depression, anxiety and stress (DASS 21) consisting of seven items per subscale was used [27]. The individuals read each statement and recorded their reply according to a 4-point Likert scale ranging from 0 (Does not apply to me at all) to 3 (Applies to me very much or most of the time). The scores were summed for items of each scale. As the long form of DASS has 42 items, we multiplied the final score of each scale by two. The individuals were considered to have depression, anxiety, and stress if they obtain total scores of ≥ 10 , ≥ 8 and ≥ 15 , respectively.

2.6. Statistical analysis

The normality of data was assessed using the Kolmogorov–Smirnov test. Continuous and categorical variables were compared across quartiles of GI and GII using analysis of variance (ANOVA) and chi-square tests respectively. Logistic regression was applied to evaluate the relationship between GI and GII with psychological disorders in crude and adjusted models. Model I was adjusted for age, gender, and total energy intake. In model II, marital status, smoking, education level, employment status, salt intake and multi-vitamins use were additionally adjusted. Further adjustment was for BMI in the final model. *P-values* < 0.05 were considered statistically significant. To analyze the data, the statistical Package for Social Sciences (SPSS) (version 23.0, SPSS Inc., Chicago, Illinois, USA) was used.

3. Results

Overall, 7384 participants were included (3673 men and 3711 women). The prevalence of psychological disorders did not significantly differ among quartiles of GI and GL. BMI, marital status, education level, and multi-vitamin supplement use were significantly different among quartiles of GI. Furthermore, significant differences were seen for age, physical activity, marital status, gender, employment status, education level and multi-vitamin supplement use across quartiles of GL (Table 1).

Table 1
General characteristics of study participants across quartiles of GI and GL

Variables		General characteristics of study participants across quantiles of GI and GL									
		GI ¹					GL ²				
		Total	Q1	Q2	Q3	Q4	P-value I	Q1	Q2	Q3	Q4
Depression, yes (%)		578 (8.1)	148 (8.3)	142 (7.9)	130 (7.2)	158(8.9)	0.326	158 (8.8)	153 (8.6)	132(7.3)	135 (7.6)
Anxiety, yes (%)		754 (10.5)	186(10.4)	186(10.3)	170 (9.5)	212 (11.9)	0.113	200 (11.1)	190 (10.7)	183 (10.1)	181 (10.2)
Stress, yes (%)		238 (3.3)	58 (3.2)	65 (3.6)	54 (3)	61 (3.4)	0.776	68 (3.8)	69 (3.9)	54 (3)	47 (2.7)
BMI (kg/m2)	< 18.5	247 (3.3)	61 (3.2)	63 (3.3)	75 (4)	48 (2.5)	0.015	57 (3)	55 (2.9)	73 (3.9)	62 (3.3)
	18.5_24.9	2335 (30.8)	594 (31.4)	618 (32.6)	586 (30.9)	537 (28.4)		576 (30.4)	628 (33.2)	577 (30.7)	554 (29.3)
	> 25	4988 (65.9)	1237 (65.4)	1213 (64)	1233 (65.1)	1305 (69)		1259 (66.5)	1209 (63.9)	1244 (65.7)	1276 (67.4)
Age (%)	20–29 years	1586 (21.5)	419 (22.7)	404 (21.8)	404 (217)	359 (19.6)	0.052	322(17.4)	404 (22)	433 (23.4)	427 (23.2)
	30_39 years	1598 (20.8)	383 (20.8)	395 (21.4)	380 (20.4)	440 (24)		324 (17.5)	405 (22)	429(23.1)	440 (23.9)
	40_49 years	1586 (21.5)	387 (21)	413 (22.3)	393 (21.1)	393 (21.4)		404 (21.8)	397 (21.6)	399(21.5)	386(21)
	50–59 years	1402 (19)	377 (20.4)	347 (18.8)	348 (18.7)	330(18)		392 (21.2)	341 (18.5)	323 (17.4)	346(18.8)
	60_69 years	1215 (16.4)	279 (15.1)	290 (15.7)	334 (18)	312 (17)		409 (22.1)	293(15.9)	270 (14.6)	243 (13.2)
Physical activity (Met_min/week)		901.1 II ±905.1	890.8 ± 883.1	894.5 ± 910.5	877.5 ± 875	942.4 ± 950.3	0.156	826.6 ± 876.7	896.8 ± 896.4	932.8 ± 903	949 ± 939.7
Marriage (%)	Single	856 (11.6)	232 (12.6)	225 (12.2)	206 (11.1)	193 (10.6)	0.019	178 (9.6)	224 (12.2)	220 (11.9)	234 (12.8)
	Married	6264 (85.1)	1575 (85.6)	1567 (84.8)	1570 (85.9)	1570 (85.9)		1587 (86)	1541 (84.2)	1585 (85.6)	1551 (84.6)
	Widowed or Divorced	240 (3.3)	61 (3.3)	40 (2.2)	75 (4.1)	64 (3.5)		80 (4.3)	65 (3.6)	46 (2.5)	49 (2.7)
Smoking status (%)	Never smoker	6328 (87.8)	1582 (87.6)	1576 (87)	1617(89)	1553 (87.5)	0.496	1609 (88.4)	1567 (86.9)	1587(87.7)	1565 (88.3)
	Current smoker	766 (10.6)	194 (10.7)	207 (11.4)	177 (9.7)	188 (10.6)		190 (10.4)	200 (11.1)	192 (10.6)	184 (10.4)
	Ex_smoker	29 (1.6)	29 (1.6)	22 (1.2)	33 (1.9)	113 (1.6)		22 (1.2)	36 (2)	31 (1.7)	24 (1.4)
Gender, male (%)		3673 (49.7)	909 (49.1)	927 (50.2)	917 (49.5)	920 (50.2)	0.877	831 (44.8)	923 (50.3)	967 (52)	952 (51.9)
Job (%)	Unemployed	1415 (19.5)	353 (19.6)	325 (17.9)	357 (19.6)	380 (21.1)	0.336	358 (19.8)	359 (19.9)	306 (16.8)	392 (21.7)
	Government employee	3537 (48.8)	898 (49.8)	898 (49.5)	904 (49.6)	837 (46.5)		960 (53.1)	898 (49.7)	876 (48.1)	803 (44.4)
	Manual worker	247 (3.4)	60 (3.3)	66 (3.6)	56 (3.1)	65 (3.6)		61 (3.4)	53 (2.9)	67 (3.7)	66 (3.6)
	Freelance job	2046 (28.2)	492 (27.3)	530 (29.1)	505 (27.7)	519 (28.8)		428 (23.7)	497 (27.5)	572 (31.4)	549 (30.3)
Education (%)	Illiterate	1776 (24.1)	438 (23.7)	418 (22.7)	500 (27)	420 (23.1)	0.004	562 (30.5)	401 (21.8)	406 (22)	407 (22.3)
	Middle school	2095 (28.5)	501 (27.2)	508 (27.6)	514 (27.7)	527 (31.4)		527 (28.6)	549 (29.9)	494 (26.7)	525 (28.7)
	Diploma	2289 (31.1)	611 (33.1)	590 (32)	553 (29.8)	535 (29.4)		520 (28.2)	557 (30.3)	629 (34)	583 (31.9)

Variables		GI ¹					GL ²				
		Total	Q1	Q2	Q3	Q4	P-value I	Q1	Q2	Q3	Q4
	Bachelors degree	995 (13.5)	253 (13.7)	261 (14.2)	204 (12.9)	241 (13.2)		201 (10.9)	270 (14.7)	260 (14.1)	264 (14.4)
	Master and doctor	205 (2.8)	42 (2.3)	65 (3.5)	47 (2.5)	51 (2.8)		35 (1.9)	62 (3.4)	59 (3.2)	49 (2.7)
Multi-vitamins supplement (%)	Never	6407 (88.2)	1727 (94.3)	1715(91.1)	1619 (86.4)	1346 (71.9)	0.01>	1741 (94.2)	1727 (93.7)	1691 (90)	1248 (66.8)
	1–3/month	482 (6.5)	44 (2.4)	67 (3.6)	95 (5.1)	276 (14.8)		34(1.8)	37 (2)	64 (3.4)	347 (18.6)
	Minimal once a week	549 (7.4)	60 (3.3)	85 (4.6)	159 (8.5)	245 (13.5)		73 (4)	79 (4.3)	124 (6.6)	273 (14.6)
1GI, Glycemic Index; 2GL, Glycemic load											
1 Obtained from χ2 test and one-way anova for categorical and continuous variables, respectively.											
Data are presented as mean ± standard deviation (SD) or number (percent)											

Dietary nutrients and energy adjusted food groups are presented in Table 2. There were significant differences between all dietary nutrients and food groups including, energy intake; percentage energy from protein, carbohydrate, and fat intake; cholesterol; saturated fatty acid; vitamin E; vitamin C; folic acid; magnesium; fruits; vegetables; red meat; fish, dairy; whole grains; refined grains; sugars; salt; legumes and nuts.

Table 2
Dietary intake of study participants among the Quartiles of GI & GL

Quartiles of GI ¹						Quartiles of GL ²					
	Total	Q1	Q2	Q3	Q4	<i>P</i> -value ¹	Q1	Q2	Q3	Q4	<i>P</i> -value
Nutrients											
Energy intake (kcal)	2897 ± 1378	2438 ± 1061	2864 ± 1351	3634 ± 1351	2897 ± 1378	<0.001	1646 ± 419.3	2199 ± 494.1	3019 ± 744.9	4721 ± 1111	<0.001
Protein (% of total daily energy)	16.16 ± 0.04	16.82 ± 0.04	16.73 ± 0.03	16.24 ± 0.04	14.86 ± 0.04	<0.001	17.84 ± 0.04	16.59 ± 0.03	16.11 ± 0.03	14.10 ± 0.04	<0.001
Carbohydrate (% of total daily energy)	56.12 ± 0.09	53.81 ± 0.08	54.58 ± 0.08	56.00 ± 0.08	60.09 ± 11.21	<0.001	52.55 ± 0.07	55.40 ± 0.07	55.87 ± 0.09	60.67 ± 0.10	<0.001
Fat (% of total daily energy)	33.61 ± 0.09	32.90 ± 0.07	32.67 ± 0.07	32.85 ± 0.07	0.36 ± 0.12	<0.001	33.24 ± 0.06	31.53 ± 0.06	33.38 ± 0.09	36.28 ± 0.11	<0.001
Cholesterol (mg)	394.8 ± 391.3	363.5 ± 396.1	394.1 ± 326.6	391.1 ± 336.4	430.6 ± 483.4	<0.001	286.3 ± 322.9	318.4 ± 206.4	432.7 ± 390.9	542 ± 521.8	<0.001
SFA (g)	31.04 ± 18.36	27.13 ± 15.36	29.58 ± 17.43	30.48 ± 17.28	36.98 ± 21.39	<0.001	19.56 ± 9.62	24.3 ± 11.47	32.47 ± 15.22	47.8 ± 20.82	<0.001
Vitamin E (mg/day)	11.36 ± 11.66	11.92 ± 11.85	11.52 ± 11.80	10.98 ± 12.02	11.01 ± 10.92	0.038	7.70 ± 7.16	9.55 ± 8.93	12.72 ± 13.28	15.45 ± 14.19	<0.001
Vitamin C (mg)	210.5 ± 188.7	196.2 ± 169	218.3 ± 214.3	219.2 ± 169.6	208.5 ± 197.1	<0.001	115.1 ± 54.12	166.8 ± 92	243.2 ± 148.4	317.1 ± 292.6	<0.001
Folic acid (µg)	379.8 ± 228	354.6 ± 215.5	361.9 ± 217.7	370.8 ± 216.6	432.1 ± 251.8	<0.001	230.7 ± 93.18	300 ± 127.6	410.8 ± 193.8	577.8 ± 276.8	<0.001
Magnesium (mg)	339.3 ± 179.6	309.6 ± 155.2	322.9 ± 166.2	336.2 ± 180.7	339.3 ± 179.6	<0.001	199.7 ± 58.38	262.8 ± 79.31	359 ± 125.2	535.7 ± 198.7	<0.001
Food groups (g/1000Kcal)											
Fruits	184.3 ± 138.4	205.6 ± 145.1	202.3 ± 141.8	192.3 ± 130.3	136.9 ± 124.1	<0.001	187.8 ± 109.9	204.8 ± 128.1	202.8 ± 151.3	184.3 ± 138.4	<0.001
Vegetables	96.6 ± 77.29	112 ± 82.82	104.1 ± 78.03	97.77 ± 75.50	72.76 ± 66.25	<0.001	119.6 ± 81.3	104.7 ± 69.75	96.78 ± 81.41	65.57 ± 65.10	<0.001
Red meat	20.46 ± 18.37	22.60 ± 17.77	24.60 ± 21.13	20.12 ± 16.43	14.51 ± 16.16	<0.001	25.29 ± 20.43	23.65 ± 16.75	20.90 ± 19.34	11.99 ± 13.15	<0.001
Fish	7 ± 13.56	5.90 ± 11.50	6.70 ± 12.80	7.48 ± 14.42	7.91 ± 15.14	<0.001	5.85 ± 9.99	5.65 ± 10.98	7.65 ± 14.93	8.85 ± 16.90	<0.001
Dairy	89.84 ± 60.16	106.99 ± 76.74	94.95 ± 53.32	89.96 ± 53.41	67.47 ± 45.57	<0.001	104.2 ± 53.30	95.85 ± 52.83	86.20 ± 59.35	73.09 ± 69.35	<0.001
Legumes and nuts	25.20 ± 19.14	29.78 ± 25.53	25.64 ± 18.63	24.07 ± 14.99	21.31 ± 14.35	<0.001	27.80 ± 18.12	25.24 ± 18.01	25.30 ± 20.19	22.46 ± 19.80	<0.001
Whole grains	29.95 ± 27.33	26.68 ± 20.58	32.32 ± 24.55	33.81 ± 27.92	27.01 ± 33.82	<0.001	34.97 ± 24.53	37.83 ± 28.35	29.25 ± 28.89	17.77 ± 22.65	<0.001
Refined grains	85.67 ± 58.18	126.70 ± 66.74	93.05 ± 47.27	67.95 ± 41.92	55 ± 45.87	<0.001	100.5 ± 54	102 ± 49.75	82.02 ± 59.34	58.11 ± 58.05	<0.001
Sugars	12.63 ± 11.64	10.21 ± 7.58	11.88 ± 9.05	13.36 ± 11.61	15.07 ± 15.98	<0.001	12.14 ± 9.27	12.74 ± 9.42	12.80 ± 12.58	12.84 ± 14.47	0.210
Salt	2.94 ± 3.68	3.21 ± 2.94	3.22 ± 3.45	3.14 ± 3.89	2.21 ± 4.21	<0.001	4.24 ± 3.83	3.61 ± 3.11	2.41 ± 3.37	1.52 ± 3.73	<0.001
¹ GI, Glycemic Index; ² GL, Glycemic load											
¹ Obtained from one-way anova											

The association between GI and GL with the respective prevalence of depression, anxiety and stress in crude and adjusted models are presented in Table 3. There were no significant associations between GI and GL with odds of depression or anxiety in crude and adjusted models. However, individuals in the

highest quartiles of GL had the lowest odds of stress (*OR: 0.69; 95% CI: 0.47–1, P-trend = 0.023*). This association remained significant after adjustment for potential confounding variables in model I (*OR: 0.45; 95% CI: 0.22–0.9, P-trend = 0.023*), model II (*OR: 0.46; 95% CI: 0.22–0.96, P-trend = 0.039*) and model III (*OR: 0.46; 95% CI: 0.22–0.96, P-trend = 0.039*).

Table 3
Multivariable-adjusted ORs (and 95% CIs) for depression, anxiety and stress across quartiles of GI and GL

GI ¹ quartile		GL ² quartiles								
	Q1	Q2	Q3	Q4	P-trend [‡]	Q1	Q2	Q3	Q4	P-trend
<i>Depression</i>										
Crude	1.00	0.94 (0.74_1.20) [†]	0.86 (0.67_1.10)	1.08 (0.85_1.36)	0.672	1.00	0.96 (0.75_1.22)	0.78(0.61_1.01)	1.10(0.87_1.39)	0.717
Model I [*]	1.00	0.96 (0.75_1.22)	0.87(0.68_1.12)	1.16 (0.90_1.48)	0.403	1.00	1.01 (0.79_1.29)	0.86 (0.64_1.15)	0.97 (0.63_1.50)	0.546
Model II ^{**}	1.00	0.96 (0.74_1.24)	0.84(0.64_1.10)	1.11(0.85_1.46)	0.679	1.00	1.00(0.77_1.30)	0.86(0.63_1.18)	0.97(0.61_1.56)	0.579
Model III ^{***}	1.00	0.96(0.74_1.24)	0.84(0.64_1.10)	1.12(0.85_1.46)	0.674	1.00	1.00(0.77_1.30)	0.86(0.63_1.18)	0.97(0.61_1.55)	0.569
<i>Anxiety</i>										
Crude	1.00	0.99(0.80_1.22)	0.90(0.72_1.12)	1.16(0.94_1.43)	0.248	1.00	0.95(0.77_1.17)	0.89(0.72_1.10)	0.90(0.73_1.12)	0.292
Model I [*]	1.00	1.00(0.80_1.24)	.91(0.73_1.13)	1.22(0.98_1.52)	0.157	1.00	0.96(0.77_1.20)	0.90(0.70_1.17)	0.94(0.64_1.38)	0.568
Model II ^{**}	1.00	0.99(0.78_1.25)	0.89(0.70_1.13)	1.17(0.92_1.49)	0.343	1.00	0.94(0.74_1.20)	0.90(0.68_1.19)	0.91(0.60_1.38)	0.542
Model III ^{***}	1.00	0.99(0.78_1.25)	0.89(0.70_1.13)	0.94(0.87_1.02)	0.343	1.00	0.94(0.74_1.20)	0.90(0.68_1.18)	0.91(0.60_1.38)	0.527
<i>Stress</i>										
Crude	1.00	1.11(0.77_1.60)	0.92(0.63_1.35)	1.06(.73_1.53)	0.990	1.00	1.02(0.72_1.44)	0.77(0.54_1.11)	0.69(0.47_1.00)	0.023
Model I [*]	1.00	1.13(.79_1.63)	0.93(0.63_1.36)	1.12(.76_1.65)	0.839	1.00	0.97(0.67_1.38)	0.64(0.41_1.00)	0.45(0.22_0.90)	0.023
Model II ^{**}	1.00	1.02(0.69_1.51)	0.87(0.57_1.31)	1.09(.072_1.65)	0.881	1.00	1.07(0.68_1.50)	0.65(0.40_1.05)	0.46(0.22_0.96)	0.039
Model III ^{***}	1.00	1.02(0.69_1.51)	0.87(0.57_1.31)	1.10(0.72_1.66)	0.873	1.00	0.98(0.68_1.42)	0.72(0.40_1.05)	0.46(0.22_0.96)	0.039
¹ GI, Glycemic Index; ² GL, Glycemic load										
[†] These values are odds ratios (95% CIs).										
[‡] Obtained from logistic regression										
[*] Adjusted for age, gender and total energy intake										
^{**} Additionally adjusted for physical activity, marital status, smoking, education, job status, multi-vitamins use										
^{***} Further adjustment for BMI.										

4. Discussion

This cross-sectional study assessed the association of dietary GI and GL with psychological disorders in an Iranian population. No significant association was observed between dietary GI and odds of depression, anxiety, and stress in crude and adjusted models. There was also no significant relationship between dietary GL and odds of depression or anxiety in crude and adjusted models; however, higher dietary GL was associated with lower odds of stress in all models.

A systematic review and meta-analysis by Salari-moghaddam [28] *et al* was performed on studies with different designs to investigate the possible relation between dietary GI or GL and depression. In line with our results, no significant association between dietary GI or GL and odds of depression was found in cross-sectional studies. Although a positive association was observed between dietary GI and risk of depression in cohort studies, the number of studies was limited (n = 2) with significant heterogeneity between them [28].

Our results showed no significant association between dietary GI or GL and odds of anxiety. In agreement with the current study, Haghighatdoost *et al*, after adjusting for confounders (marital status, education, physical activity, smoking, dietary intakes, and BMI) showed similar findings [13]. Another study with a cross-over clinical trial design examined the effects of a high GL diet on mental health. Consuming 28 days of a high GL diet did not alter tension-anxiety compared to the diet with a low GL [29].

There was also no association between dietary GI and stress. However, in line with a previous study [13], participants of our study in the higher quartiles of dietary GL experienced lower levels of stress. This inverse association can be attributed to the effects of sugar-rich foods on the hypothalamic-pituitary-adrenal (HPA) axis. Under stressful conditions, the HPA releases stress hormones (corticosteroids) that increase the desire for sugar rich foods that provide inhibitory feedback on the hypothalamus. Therefore, participants of the higher quartiles of GL consumed more sugar-rich foods, which can lower stress by decreasing HPA axis activity [30, 31]. Furthermore, serotonin is a neurotransmitter that has an essential role in mood regulation. Foods with high GL induce insulin secretion which facilitates tryptophan uptake and serotonin production in the brain and thereby lowers stress [12]. However, it must be kept in mind that long-term consumption of food with high GL leads to blood glucose fluctuations and increase the risk of diabetes [32]. Thus, caution should be taken to account when interpreting these results since several studies reported that patients with diabetes have a higher risk of mental disorders compared to healthy people[33–35].

Besides the potential strengths of our study such as a large sample size and controlling for possible confounders, there are some limitations. First, the cross-sectional data of this study prevents any inference of causality between GL and stress. Furthermore, no biochemical measures were assessed in our study, which might limit the detection of patients with chronic disease.

Conclusion

In conclusion, consumption of foods with higher GL was associated with lower likelihood of stress; however, no significant association was found between GI or GL and risk of depression and anxiety. Performing further studies with longitudinal design is suggested to confirm these results.

Declarations

Ethics approval and consent to participate

We confirm that all methods were carried out in accordance with Shahid Sadoughi University of Medical Sciences guidelines and regulations. Written informed consent was taken from all participants. The research was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Iran (Ethic code: 931188).

Consent for publication

Not applicable.

Availability of data and materials

The data and materials of the current study are available from the corresponding author on reasonable request

Competing interests

Not applicable.

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Authors' contributions

S.K, Ma.M, A.N and A.A: designed and conducted the study; M.D and MoM: analysed the data; M.D and AA: wrote the manuscript S.K, ID, and Mo.M: critically revised the manuscript; S.K, A.N and Ma.M: supervised the study. The final version of the manuscript was approved by all authors.

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References

1. Wu T, Jia X, Shi H, Niu J, Yin X, Xie J, Wang X: **Prevalence of mental health problems during the COVID-19 pandemic: A systematic review and meta-analysis.** *Journal of Affective Disorders* 2021, **281**:91-98.
2. Gray L, Hannan AJ: **Dissecting cause and effect in the pathogenesis of psychiatric disorders: genes, environment and behaviour.** *Current molecular medicine* 2007, **7**(5):470-478.
3. Pfau ML, Ménard C, Russo SJ: **Inflammatory Mediators in Mood Disorders: Therapeutic Opportunities.** *Annu Rev Pharmacol Toxicol* 2018, **58**:411-428.
4. Guzek D, Głąbska D, Groele B, Gutkowska K: **Fruit and Vegetable Dietary Patterns and Mental Health in Women: A Systematic Review.** *Nutrition reviews* 2021.
5. Oddy WH, Allen KL, Trapp GSA, Ambrosini GL, Black LJ, Huang RC, Rzehak P, Runions KC, Pan F, Beilin LJ *et al*: **Dietary patterns, body mass index and inflammation: Pathways to depression and mental health problems in adolescents.** *Brain, behavior, and immunity* 2018, **69**:428-439.
6. Jenkins DJ, Wolever TM, Taylor RH, Barker H, Fielden H, Baldwin JM, Bowling AC, Newman HC, Jenkins AL, Goff DV: **Glycemic index of foods: a physiological basis for carbohydrate exchange.** *The American journal of clinical nutrition* 1981, **34**(3):362-366.

7. Kan C, Silva N, Golden SH, Rajala U, Timonen M, Stahl D, Ismail K: **A systematic review and meta-analysis of the association between depression and insulin resistance.** *Diabetes care* 2013, **36**(2):480-489.
8. Mwamburi DM, Liebson E, Folstein M, Bungay K, Tucker KL, Qiu WQ: **Depression and glycemic intake in the homebound elderly.** *J Affect Disord* 2011, **132**(1-2):94-98.
9. Aparicio A, Robles F, López-Sobaler AM, Ortega RM: **Dietary glycaemic load and odds of depression in a group of institutionalized elderly people without antidepressant treatment.** *European journal of nutrition* 2013, **52**(3):1059-1066.
10. Murakami K, Miyake Y, Sasaki S, Tanaka K, Yokoyama T, Ohya Y, Fukushima W, Kiyohara C, Hirota Y: **Dietary glycemic index and load and the risk of postpartum depression in Japan: the Osaka Maternal and Child Health Study.** *J Affect Disord* 2008, **110**(1-2):174-179.
11. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ: **The prevalence of comorbid depression in adults with diabetes: a meta-analysis.** *Diabetes care* 2001, **24**(6):1069-1078.
12. Markus CR: **Effects of carbohydrates on brain tryptophan availability and stress performance.** *Biological psychology* 2007, **76**(1-2):83-90.
13. Haghighatdoost F, Azadbakht L, Keshteli AH, Feinle-Bisset C, Daghighzadeh H, Afshar H, Feizi A, Esmailzadeh A, Adibi P: **Glycemic index, glycemic load, and common psychological disorders.** *The American journal of clinical nutrition* 2016, **103**(1):201-209.
14. Lament DJ, Dye L, Mansfield MW, Lawton CL: **Acute glycaemic load breakfast manipulations do not attenuate cognitive impairments in adults with type 2 diabetes.** *Clinical nutrition (Edinburgh, Scotland)* 2013, **32**(2):265-272.
15. Ma Y, Olendzki BC, Merriam PA, Chiriboga DE, Culver AL, Li W, Hébert JR, Ockene IS, Griffith JA, Pagoto SL: **A randomized clinical trial comparing low-glycemic index versus ADA dietary education among individuals with type 2 diabetes.** *Nutrition (Burbank, Los Angeles County, Calif)* 2008, **24**(1):45-56.
16. Gopinath B, Flood VM, Burlutsky G, Louie JC, Mitchell P: **Association between carbohydrate nutrition and prevalence of depressive symptoms in older adults.** *The British journal of nutrition* 2016, **116**(12):2109-2114.
17. Minobe N, Murakami K, Kobayashi S, Suga H, Sasaki S: **Higher dietary glycemic index, but not glycemic load, is associated with a lower prevalence of depressive symptoms in a cross-sectional study of young and middle-aged Japanese women.** *European journal of nutrition* 2018, **57**(6):2261-2273.
18. Mirzaei M, Salehi-Abargouei A, Mirzaei M, Mohsenpour MA: **Cohort Profile: The Yazd Health Study (YaHS): a population-based study of adults aged 20–70 years (study design and baseline population data).** *International journal of epidemiology* 2018, **47**(3):697-698h.
19. Esfahani FH, Asghari G, Mirmiran P, Azizi F: **Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study.** *Journal of epidemiology* 2010, **20**(2):150-158.
20. [<https://fdc.nal.usda.gov/>]
21. Wolever TM, Yang M, Zeng XY, Atkinson F, Brand-Miller JC: **Food glycemic index, as given in glycemic index tables, is a significant determinant of glycemic responses elicited by composite breakfast meals.** *The American journal of clinical nutrition* 2006, **83**(6):1306-1312.
22. Haytowitz D, Lemar L, Pehrsson P, Exler J, Patterson K, Thomas R, Nickle M, Williams J, Showell B, Khan M: **USDA national nutrient database for standard reference, release 24.** *US Department of Agriculture: Washington, DC, USA* 2011.
23. Ma Y, Olendzki B, Chiriboga D, Hebert JR, Li Y, Li W, Campbell M, Gendreau K, Ockene IS: **Association between dietary carbohydrates and body weight.** *American journal of epidemiology* 2005, **161**(4):359-367.
24. Atkinson FS, Brand-Miller JC, Foster-Powell K, Buyken AE, Goletzke J: **International tables of glycemic index and glycemic load values 2021: a systematic review.** *The American Journal of Clinical Nutrition* 2021, **114**(5):1625-1632.
25. Foster-Powell K, Holt SH, Brand-Miller JC: **International table of glycemic index and glycemic load values: 2002.** *The American journal of clinical nutrition* 2002, **76**(1):5-56.
26. Taleban F, Esmaeili M: **Glycemic index of Iranian foods.** *National Nutrition and Food Technology Research Institute publication* 1999.
27. Sahebi A, Asghari MJ, Salari RS: **Validation of depression anxiety and stress scale (DASS-21) for an Iranian population.** 2005.
28. Salari-Moghaddam A, Saneai P, Larijani B, Esmailzadeh A: **Glycemic index, glycemic load, and depression: a systematic review and meta-analysis.** *European journal of clinical nutrition* 2019, **73**(3):356-365.
29. Breymeyer KL, Lampe JW, McGregor BA, Neuhauser ML: **Subjective mood and energy levels of healthy weight and overweight/obese healthy adults on high-and low-glycemic load experimental diets.** *Appetite* 2016, **107**:253-259.
30. Ulrich-Lai YM, Ostrander MM, Herman JP: **HPA axis dampening by limited sucrose intake: reward frequency vs. caloric consumption.** *Physiol Behav* 2011, **103**(1):104-110.
31. Adam TC, Epel ES: **Stress, eating and the reward system.** *Physiol Behav* 2007, **91**(4):449-458.
32. Livesey G, Taylor R, Livesey HF, Buyken AE, Jenkins DJA, Augustin LSA, Sievenpiper JL, Barclay AW, Liu S, Wolever TMS *et al*: **Dietary Glycemic Index and Load and the Risk of Type 2 Diabetes: Assessment of Causal Relations.** 2019, **11**(6).
33. Boden MT: **Prevalence of mental disorders and related functioning and treatment engagement among people with diabetes.** *Journal of psychosomatic research* 2018, **106**:62-69.
34. Lin EH, Von Korff M, Alonso J, Angermeyer MC, Anthony J, Bromet E, Bruffaerts R, Gasquet I, de Girolamo G, Gureje O *et al*: **Mental disorders among persons with diabetes—results from the World Mental Health Surveys.** *Journal of psychosomatic research* 2008, **65**(6):571-580.
35. Lopez-Herranz M, Jiménez-García R: **Mental Health among Spanish Adults with Diabetes: Findings from a Population-Based Case-Controlled Study.** 2021, **18**(11).