The Association Between Dietary Insulin Index and Load With Mental Health

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Abstract

Background: Depression, anxiety, and stress are common mental problems in different populations. The aim of this cross-sectional study is to investigate the association between dietary insulin index (DII) and insulin load (DIL) and psychological 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. 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: No significant association was observed between DIL and DII with odds of depression or anxiety in crude and adjusted models. The individuals in the highest quartiles of DIL had the lowest odds of stress (OR: 0.69; 95% CI: 0.48–1.01, P-trend = 0.047). This association remained significant after adjustment for potential confounders in model II (OR: 0.38; 95% CI: 0.16–0.91, P-trend = 0.039) and the third and final model (OR: 0.39; 95% CI: 0.16–0.91, P-trend = 0.041).

Conclusion: Overall, consumption of foods with higher II as well as IL was associated with lower feelings of stress; however, no significant relation was observed between DII or DIL and risk of depression and anxiety. Further studies with longitudinal design are needed to confirm these results.

Introduction

Depression, anxiety, and stress are major mental health concerns in different populations. Recent global prevalence of depression, anxiety, and distress have been reported at 31.4%, 31.9% and, 41.1% respectively which is much higher than normal levels due to the COVID-19 pandemic (1). Poor mental health imposes considerable costs on international health systems. A wealth of evidence shows psychological distress is associated with disability, early mortality, and increased onset of chronic disease such as metabolic syndrome, diabetes, cardiovascular disease, and Alzheimer's disease (2-5).

The prevalence of depression, anxiety, and stress is much higher in diabetic patients and the role of insulin resistance and hyperinsulinemia in the progression of mental disease is well-established (6-8). Diet has a considerable effect on serum insulin levels and a high glycemic index (GI) and high glycemic load (GL) diet may be related to the higher risk of depression (9). GI and GL indicate the ability of foods to raise blood glucose levels compared to glucose or white bread (10). While high serum glucose levels correlates with insulin levels, foods containing certain amino acids and fatty acids can induce insulin secretion with a dampened effect on glucose levels (11-13). Thus, an insulin index (II) has been suggested to measure postprandial insulin levels in response to isoenergetic amounts of different foods (14). The dietary insulin index (DII) and dietary insulin load (DIL) can be calculated by considering the II of each food by its energy content and the frequency of consumption in the diet (15). Because the II indicates insulin responses directly it is arguably a better predictor of disease related to insulin resistance compared to GI. To our knowledge, recently, only one study investigated the relationship between DII and DIL with psychological disorders, which indicated higher DII, and DIL was related with greater odds of depression (16). Considering the role of hyperinsulinemia in psychological disorders and the necessity of more studies with larger sample sizes, we investigated this hypothesis in a large Iranian population.

Materials And Methods

Study population

In the current study, we used data from a Yazd Health Study (YaHS) conducted from September 2014 in Yazd, central region of Iran. YaHS is a prospective cohort study, 10,000 participants aged 20-69 were randomly selected for the recruitment phase from 200 clusters in Yazd Greater Area. Profile and details of this study were previously published elsewhere (17). 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 about current and past history of chronic diseases, smoking status, socio-demographic characteristics including age, gender, marriage 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.

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 (18). 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 (19).

Dietary insulin index and load calculation

Briefly, food insulin index (FII) refers to the incremental insulin area under the curve over 2 h in response to the consumption of a 1000-kJ (239 Kcal) portion of the test food divided by the area under the curve after ingestion of a 1000-kJ portion of the reference food. The insulin indices for 61 food items were obtained from previous publications (20-22). For the remaining 71 food items that were not available in the published food lists, the FII of similar food items was used by the correlation between their energy, fiber, carbohydrate, protein, and fat content.

To determine DIL, we first calculated the insulin load of each food with the following formula:

Insulin load of food = Insulin index of food × energy content of food (kcal/d)

Secondly, by summing up the insulin load of each food, the DIL was obtained. We calculated the average DII for all foods by dividing DIL by total dietary intake of energy.

Anthropometric measurements

Body weight was measured using a portable digital scale analyser 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).

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 (23). 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.

Statistical analysis

The normality of data was assessed using the Kolmogorov–Smirnov test. Continuous and categorical variables were compared across quartiles of DIL and DII using analysis of variance (ANOVA) and chi-square tests respectively. Logistic regression was applied to evaluate the relationship between DII and DIL 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.

Results

The general characteristics of study participants among quartiles of DIL and DII are indicated in Table 1. The final sample size included in our analyses was 7384 participants (3673 men and 3711 women). The prevalence of psychological disorders did not significantly differ between quartiles of DIL and DII, except for anxiety prevalence, which was greater in the highest quartile of DII. Significant differences were observed for BMI, age, marital status, gender, employment status, education level and multi-vitamin supplement use across quartiles of DIL. These significant differences were only obtained for employment status, education level, and multi-vitamin supplement use among quartiles of DII. The distribution of smoking status did not differ throughout quartiles of DII and DIL.

Table 1
General characteristics of participants across quartiles of DIL and DII

Variable		Dietary insulin load ¹					dietary insulin index ²					
		Total	Q1	Q2	Q3	Q4	P-value I	Q1	Q2	Q3	Q4	P-value
Depression, yes (%)		578 (8.1)	154 (8.6)	157 (8.8)	138 (7.6)	129 (7.3)	0.268	149 (8.3)	146 (8.1)	120 (6.7)	163 (9.2)	0.057
Anxiety, yes (%)		754 (10.5)	196 (11)	195 (10.9)	188 (10.3)	175 (9.9)	0.685	199 (11.1)	180 (9.9)	164 (9.2)	211 (11.8)	0.041
Stress, yes (%)		238 (3.3)	70 (3.9)	62 (3.5)	57 (3.1)	49 (2.8)	0.264	64 (3.6)	64 (3.5)	49 (2.7)	61 (3.4)	0.456
BMI (kg/m2)		27 ± 5.09 ^{II}	27.28 ± 5.01	26.82 ± 5.23	26.92 ± 5.06	26.97 ± 5.05	0.036	27.22 ± 5.10	26.83 ± 5.00	26.93 ± 5.08	27.01 ± 5.18	0.12
Age (%)	20-29 years	1586 (21.5)	318 (17.2)	404 (21.9)	421 (22.6)	443 (24.1)	<0.01	395 (21.6)	398 (21.4)	418 (22.4)	395 (21.4)	0.499
	30_39 years	1598 (21.6)	310 (16.8)	402 (21.8)	448 (24.1)	438 (23.8)		382 (20.9)	408 (21.9)	413 (22.4)	395 (21.4)	
	40_49 years	1586 (21.5)	402 (21.8)	409 (22.2)	388 (20.8)	387 (21.1)		408 (22.3)	398 (21.4)	395 (21.4)	385 (20.9)	
	50-59 years	1402 (19)	377 (20.4)	350 (19)	340 (18.3)	335 (18.2)		347 (19)	367 (19.7)	314 (17)	374 (20.3)	
	60_69 years	1215 (16.4)	438 (23.7)	277 (15)	265 (14.2)	235 (12. 8)		299 (16.3)	293 (15.7)	307 (16.6)	316 (17.1)	
Marriage (%)	Single	856 (11.6)	171 (9.3)	227 (12.4)	228 (12.2)	230 (12.5)	<0.01	227 (12.4)	224 (12.1)	212 (11.5)	193 (10.5)	0.505
	Married	6264 (85.1)	1575 (85.6)	1547 (84.8)	1588 (85.3)	1554 (84.8)		1539 (84.1)	1570 (84.6)	1575 (85.6)	1580 (86)	
	Widowed or Divorced	240 (3.3)	95 (5.2)	50 (2.7)	46 (2.5)	49 (2.7)		63 (3.4)	61 (3.3)	52(2.8)	64 (3.5)	
Smoking status (%)	Never smoker	6327 (87.8)	1560 (87.3)	1604 (88.5)	1564 (87.6)	1578 (87.8)	0.796	1598 (88.2)	1578 (87.2)	1601 (88.1)	1551 (87.7)	0.708
	Current smoker	766 (10.6)	204 (11.4)	178 (9.8)	192 (10.6)	192 (10.7)		189 (10.4)	197 (10.9)	187 (10.3)	193 (10.9)	
	Ex_smoker	113 (1.6)	23 (1.3)	30 (17)	32 (1.8)	28 (1.6)		25 (1.4)	35 (1.9)	29 (1.6)	24 (1.4)	
Gender, male (%)		3673 (49.7)	809 (43.8)	931 (50.6)	983 (51.7)	950 (51.9)	<0.01	899 (48.9)	910 (48.9)	917 (49.7)	947 (51.4)	0.388
Employment (%)	Unemployed	1415 (19.5)	363 (20.2)	343 (19)	324 (17.7)	385 (21.3)	<0.01	1415 (19.5)	3537 (48.8)	247 (3.4)	2046 (28.2)	0.015
	Government employee	3537 (48.8)	976 (54.2)	895 (49.5)	867 (47.5)	799 (44.1)		348 (19.4)	392 (18)	330 (18.2)	408 (22.5)	
	Manual worker	247 (3.4)	60 (3.3)	52 (2.9)	75 (4.1)	60 (3.3)		898 (50.1)	920 (50.4)	897 (49.4)	822 (45.4)	
	Freelance job	2046 (28.2)	401 (22.3)	518 (28.7)	561 (30.7)	566 (31.3)		58 (3.2)	68 (3.7)	62 (3.4)	59 (3.3)	
Education (%)	Illiterate	1776 (24.1)	577 (31.4)	385 (20.9)	412 (22.1)	402 (22.1)	<0.01	439 (23.9)	471 (25.4)	421 (23)	445 (24.2)	0.01
	Middle school	2095 (28.5)	503 (27.4)	552 (30)	508 (27.3)	532 (29.2)		490 (26.7)	495 (26.7)	514 (28)	596 (32.4)	
	diploma	2289 (31.1)	527 (28.7)	566 (30.8)	615 (33)	581 (31.9)		589 (32.1)	563 (30.4)	593 (32.3)	544 (29.6)	
	Bachelors degree	995 (13.5)	195 (10.6)	270 (14.7)	266 (14.3)	264 (14.5)		256 (14)	271 (14.6)	253 (13.8)	215 (11.7)	
	Master and doctor	205 (2.8)	35 (1.9)	65 (3.5)	61 (3.3)	44 (2.4)		60 (3.3)	55 (3)	53 (2.9)	37 (2)	
Multi-vitamins supplement (%)	Never	6407 (88.2)	1722 (94.3)	1727 (94.2)	1666 (91)	1292 (72.7)	<0.01	1549 (85.2)	1616 (88.9)	1607 (89.8)	1635 (88.8)	<0.01

Variable		Dietary insulin load ¹					dietary insulin index ²					
		Total	Q1	Q2	Q3	Q4	P-value ^I	Q1	Q2	Q3	Q4	P-value
	1-3/month	482 (6.6)	41 (2.2)	46 (2.5)	74 (4)	321 (18.1)		147 (8.1)	103 (5.7)	94 (5.3)	138 (7.5)	
	Minimal once a week	378 (5.2)	63 (3.5)	60 (3.3)	90 (4.9)	165 (9.3)		123 (6.8)	99 (5.4)	88 (4.9)	68 (3.7)	
BMI, body mass index												
¹ Obtained from χ² test and one-way anova for categorical and continuous variables, respectively.												
² Data are presented as mean ± standard deviation (SD)												

Dietary nutrients and energy adjusted food groups are shown 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 across quartiles of dietary insulin index and load

Dietary insulin load							Dietary insulin index				
	Total	Q1	Q2	Q3	Q4	<i>P</i> -value ¹	Q1	Q2	Q3	Q4	<i>P</i> -value
Nutrients											
Energy intake (kcal)	2897 ± 1378	1580± 298	2161 ± 376	1318± 569	4828± 1015	0.001>	3207± 1394	2822± 1306	2658 ± 1301	2900 ± 1449	0.001>
Protein (% of total daily energy)	0.16 ± 0.04	0.17± 0.03	0.16 ± 0.04	0.14 ± 0.04	0.16 ± 0.04	0.001>	0.17± 0.05	0.16± 0.03	0.15± 0.03	0.14± 0.03	0.001>
Carbohydrate (% of total daily energy)	0.54 ± 0.08	0.55 ± 0.08	0.55 ± 0.09	0.58± 0.11	0.56 ± 0.09	0.001>	0.48± 0.09	0.55± 0.07	0.57± 0.07	0.62± 0.08	0.001>
Fat (% of total daily energy)	0.35 ± 0.10	0.32± 0.07	0.31 ± 0.07	0.34± 0.08	0.35 ± 0.10	0.001>	0.39± 0.09	0.33± 0.07	0.31± 0.07	0.29± 0.08	0.001>
Cholesterol (mg)	394.8 ± 391.2	242.7 ±108.4	323.3 ± 290.5	433.3 ± 350.5	580.1 ± 574.1	0.001>	522.8 ± 567.6	395.9 ± 310.8	345.7 ± 252.2	315.04 ± 324.4	0.001>
SFA (g)	31.04 ±18.36	17.87 ± 6.08	23.51 ± 8.23	33.16 ± 13.52	49.64 ± 21.93	0.001>	39.22 ± 22.34	30.54 ± 16.02	27.52 ± 15.34	26.90 ± 16.15	0.001>
Vitamin E (mg/day)	11.36 ± 11.66	7.14 ± 5.71	9.23 ± 7.85	12.73 ± 12.95	16.34 ± 15.27	0.001>	16.16 ± 17.91	11.0 ± 9.15	9.83 ± 7.90	8.45 ± 6.59	0.001>
Vitamin C (mg)	210.5 ± 188.7	115.1 ± 59.8	163.03 ± 89.7	236.09 ± 145.5	327.1 ± 289.9	0.001>	225.7 ± 171.1	224.3 ± 199.9	197.2 ± 173.1	195.03 ± 206.07	0.001>
Folic acid (µg)	379.8 ± 228	220.68 ± 77.38	297.9 ± 127.06	414.1 ± 183.9	586.75 ± 275.4	0.001>	447.9 ± 264.7	387.9 ± 233.0	394.5 ± 197.1	334.02 ± 192.5	0.001>
Magnesium (mg)	193.4 ± 52.2	193.4 ± 52.2	285.7 ±75.0	361.2 ±112.7	543.9 ±194.80	0.001>	388.7±197.07	340.4±171.8	312.3±165.4	315.9±172.4	0.001>
Food groups (g/1000Kcal)											
Fruits	184.3 ± 138.4	193.8 ± 111.5	197.1 ± 128.8	194.3 ± 141.2	151.8 ± 162.09	0.001>	165.6 ± 113	185.02 ± 125.4	189.1 ± 128.1	197.4 ± 176.6	0.001>
Vegetables	96.6 ± 77.2	104.6 ± 69.8	97.46 ± 82.99	86.65 ± 69.25	96.68 ± 77.29	0.001>	107.07 ± 98.2	100.6 ± 66.6	98.03 ± 74.16	80.99 ± 62.76	0.001>
Red meat	20.46 ± 18.37	22.41 ± 15.65	22.46 ± 14.61	22.47 ± 21.33	14.49 ±19.74	0.001>	20.87 ± 20.36	21.78 ± 18.49	21.09 ± 17.56	18.09 ± 16.67	0.001>
Fish	7.00 ± 13.56	5.60 ± 6.64	6.02 ± 11.62	7.50 ± 14.90	8.79 ± 18.13	0.001>	7.58 ± 14.64	7.80 ± 13.06	7.53 ± 16.64	5.07 ± 8.22	0.001>
Dairy	89.84 ± 60.15	104.89 ± 54.36	95.01 ± 53.72	86.57 ± 61.00	72.88 ± 66.10	0.001>	98.17 ± 80.10	94.38 ±55.93	91.45 ± 50.61	75.35 ± 45.55	0.001>
Legumes and nuts	25.20 ± 19.14	26.40 ±15.25	25.37 ± 18.19	26.21 ± 22.49	22.82 ± 19.73	0.001>	29.15 ± 24.82	25.23 ± 17.59	24.43 ± 16.13	21.98 ± 15.95	0.001>
Whole grains	29.95 ± 27.33	35.96 ± 27.37	37.26 ± 27.87	28.17 ± 27.47	18.41 ± 21.99	0.001>	22.63 ± 24.35	28.14 ± 25.99	32.12 ± 24.91	36.93 ± 31.47	0.001>
Refined grains	85.67 ± 58.18	100.4 ± 55.67	102.7 ± 50.99	79.7 ± 52.7	59.69 ±62.02	0.001>	71.67 ± 47.77	87.49 ± 55.64	96.35 ± 57.31	85.67 ± 58.18	0.001>
Sugars	12.63 ± 11.64	12.25 ± 9.83	12.13 ± 8.79	12.70 ± 11.94	13.45 ± 14.99	0.001>	7.12 ± 6.25	9.84 ± 7.35	12.87 ± 8.70	20.61 ± 16.51	0.001>

Dietary insulin load						Dietary insulin index					
Salt	2.94 ± 3.68	4.17 ± .79	3.56 ± 3.20	2.30 ± 3.30	1.75 ± 3.86	0.001>	2.59 ± 3.34	2.87 ± 3.39	3.31 ± 3.90	3.01 ± 4.00	0.001>
DII, Dietary insulin index; DIL, Dietary insulin load											
[†] Obtained from one-way anova											

The association between DIL and DII with prevalence's of depression, anxiety and stress in crude and adjusted models are presented in Table 3. There were no significant associations between DIL and DII with odds of depression or anxiety in crude and adjusted models. However, individuals in the highest quartiles of DIL had the lowest odds of stress (OR: 0.69; 95% CI: 0.48–1.01, P-trend = 0.047). This association remained significant after adjustment for potential confounding variables in model II (OR: 0.38; 95% CI: 0.16–0.91, P-trend = 0.039) and model III (OR: 0.39; 95% CI: 0.16–0.91, P-trend = 0.041).

Table 3
Multivariable-adjusted ORs (and 95% CIs) for depression, anxiety and stress across quartiles of dietary insulin index and load

DIL ¹						DII ²					
	Q1	Q2	Q3	Q4	P-trend [‡]	Q1	Q2	Q3	Q4	P-trend	
Depression											
Crude	1.00	1.02 (0.81_1.29) [†]	0.87 (0.68_1.10)	0.83 (0.65_1.06)	0.073	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	1.04 (0.81_1.33)	0.88 (0.64_1.21)	0.86 (0.51_1.44)	0.491	1.00	0.93 (0.73_1.19)	0.75 (0.58_0.96)	1.08 (0.85_1.37)	0.846	
Model II**	1.00	1.02 (0.79_1.33)	0.86 (0.61_1.20)	0.78(0.45_1.35)	0.375	1.00	0.94 (0.77_1.21)	0.74 (0.57_0.97)	1.05 (0.82_1.35)	0.944	
Model III***	1.00	1.03 (0.79_1.34)	0.86 (0.62_1.21)	0.79 (0.45_1.37)	0.399	1.00	0.95 (0.74_1.22)	0.75 (0.57_0.98)	1.06 (0.83_1.36)	0.972	
Anxiety											
Crude	1.00	0.99 (0.80_1.22)	0.93 (0.75_1.15)	0.89 (0.71_1.10)	0.242	1.00	0.87 (0.71_1.08)	0.80 (0.64_0.99)	1.07 (0.87_1.31)	0.686	
Model I*	1.00	1.00 (0.80_1.25)	0.91 (0.69_1.20)	0.84 (0.53_1.33)	0.479	1.00	0.87 (0.70_1.07)	0.78 (0.62_0.97)	1.05 (0.85_1.30)	0.781	
Model II**	1.00	0.96 (0.76_1.22)	0.86 (0.64_1.15)	0.73 (0.45_1.19)	0.251	1.00	0.88 (0.71_1.10)	0.77 (0.61_0.97)	1.01 (0.81_1.26)	0.847	
Model III***	1.00	0.97 (0.76_1.22)	0.86 (0.64_1.15)	0.74 (0.46_1.21)	0.270	1.00	0.89 (0.71_1.11)	0.77 (0.61_0.98)	1.02 (0.81_1.26)	0.877	
Stress											
Crude	1.00	0.88 (0.62_1.25)	0.79 (0.55_1.13)	0.69 (0.48_1.01)	0.047	1.00	0.98 (0.69_1.40)	0.75 (0.51_1.10)	0.95 (0.66_1.36)	0.499	
Model I*	1.00	0.83 (0.57_1.21)	0.65 (0.40_1.05)	0.45 (0.20_1.01)	0.058	1.00	0.95 (0.67_1.36)	0.69 (0.47_1.02)	0.93 (0.65_1.34)	0.417	
Model II**	1.00	0.83 (0.56_1.23)	0.62 (0.37_1.02)	0.38 (0.16_0.91)	0.039	1.00	0.98 (0.68_1.42)	0.72 (0.48_1.08)	0.88 (0.60_1.29)	0.284	
Model III***	1.00	0.83 (0.56_1.24)	0.62 (0.37_1.03)	0.39 (0.16_0.91)	0.041	1.00	0.98 (0.68_1.42)	0.72 (0.48_1.08)	0.88 (0.60_1.29)	0.288	
DII, Dietary insulin index; DIL, Dietary insulin load											
[†] These values are odds ratios (95% CIs).											
[‡] Obtained from logistic regression by considering quartiles of DIL & DII as ordinal variable.											
*Adjusted for age, gender and total energy intake											
** Additionally adjusted for marital status, smoking, education, job status, salt intake, multi-vitamin supplement use											
***Further adjustment for BMI.											

Discussion

The aim of the present study was to cross sectionally investigate the relationship between DII and DIL with indices of mental health. The results showed no significant relation between DIL and DII with odds of depression or anxiety in crude and adjusted models; however, higher DIL was associated with lower

odds of stress.

To our knowledge there is only one previous study that investigated the association between DII and DIL and psychological disorders. In the *Anjom-Shoae et al (16)* study, which was conducted in Isfahan, Iran, in line with our results, there was no association between DIL and DII with odds of anxiety or depression among men. However, in contrast to our results, women in the higher quartiles of DII and DIL showed higher odds of depression. This disagreement of results might be due to the use of different questionnaires for measuring dietary intake and psychological disorders. It should be noted that our larger sample size (n = 7384 compared to 3172) is probably more representative for the general population.

Although data in the field of DII and DIL are limited, several studies assessed the relationship between GI or GL with psychological disorders (24-27). A systematic review and meta-analysis showed no significant association between either dietary GI or GL and odds of depression in cross-sectional studies, which partially agrees with our data as most of the food with higher GI and GL have also higher DII and DIL respectively (14). However, a significant positive relation was observed between dietary GI and depression in clinical trials and cohort studies (28).

Confirming the findings of a previous study (16), our results revealed no significant link between DII or DIL and anxiety. However, we found an inverse association between DIL and odds of stress. Only one previous study investigated this hypothesis, which reported no significant relation between DII or DIL and psychological distress (16). As mentioned above, using different questionnaires and our use of a larger sample size may explain this inconsistency. Moreover, another study showed that higher dietary GL is associated with lower odds ratio of psychological distress (24). It is well-established that foods with higher GL give rise to more insulin secretion and thus a higher IL. Insulin release following consumption of carbohydrate-rich foods leads to elevated plasma tryptophan levels and is associated with increased synthesis of serotonin, a neurotransmitter involved in mental function (29). Furthermore, stress is controlled by the hypothalamic-pituitary-adrenal (HPA) axis. It has been shown that consumption of sugar-rich foods reduce the feeling of stress by decreasing the HPA axis (30, 31). The participants of the highest quartiles of DIL of this study consumed more sugars, which might lead them to experience lower levels of stress. However, controlling stress in this way is temporary, and regular consumption of these foods can lead to obesity (31). In our analysis, the relationship between DIL and stress remained after adjustment for BMI; however, stress correlates with visceral obesity (32). Further research with a nuanced approach to body composition measurement is warranted.

The present study has several limitations. First, we cannot infer causality due to the cross-sectional design of the study. Second, no biochemical indices were measured in our study, which limits the detection of participants with chronic disease. Third, the II of some food items were not available in the food lists of the previous studies thus, we used the similar food items as substitutes. On the other hand our studies' strengths included a large sample size and controlled for potential confounders such as supplements and dietary intake.

In conclusion, consumption of foods with higher II as well as IL were associated with lower stress; however, no significant relation was observed between II or IL and risk of depression and anxiety. Further studies with longitudinal design are needed to confirm these results.

Declarations

Ethical 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

There is no conflict of interest to declare.

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Authors Contribution

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

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