Rostampour et al. BMC Nutrition (2025) 11:100
https://doi.org/10.1186/s40795-025-01082-6

BMC Nutrition

RESEARCH

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Dietary glycemic and insulin indices in association with sleep quality and duration in patients undergoing angiography

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Abstract

Background and aims Research examining the relationship between glycemic and insulin indices and sleep quality and duration is scarce and has yielded contradictory results. This study evaluated the relationship between dietary glycemic and insulin indices and the quality and quantity of sleep among adults referred for angiography.

Methods The present cross-sectional study was conducted on 653 participants referred for angiography at Afshar Hospital, Yazd, central Iran. Sleep parameters were evaluated through the Pittsburgh Sleep Quality Index (PSQI). Dietary intakes were assessed using a validated food frequency questionnaire (FFQ). Binary logistic regression was employed to determine the association between dietary glycemic and insulin indices and sleep quality and quantity among patients with cardiovascular risk factors.

Results After adjusting for factors including age, sex, energy intake, marital status, education level, occupation, economic condition, body mass index, smoking status, drug addiction, physical activity, depression score, syntax score, diabetes status, and caffeine intake, analyses revealed a significant positive association between the dietary insulin index (DII) and sleep disorders (OR = 2.42; 95%CI: 1.20–4.87, $P_{trend} = 0.003$). Additionally, the dietary glycemic index (DGI) was positively associated with sleep latency (OR = 1.81; 95%CI: 1.06–3.10, $P_{trend} = 0.04$). No significant relationship was observed between dietary glycemic or insulin load and overall sleep quality or its components.

Conclusion In conclusion, greater DII might be associated with the odds of sleep disorders. Also, higher DGI was linked to the likelihood of sleep latency among adults undergoing angiography. Further prospective studies are necessary to corroborate our results.

Keywords Sleep quality, Adults, Cross-sectional, Insulin index, Glycemic index

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Introduction

Sleep is a vital and complex biological process affecting several physiological functions such as brain activity, metabolism, appetite regulation, immune and hormonal status, and cardiovascular health [1–7]. It is becoming more evident that insufficient sleep duration and poor sleep quality pose serious health risks [8]. Sleep deprivation, both in terms of quantity and quality, has been linked to an increased risk of diseases such as cancer, cardiovascular disease, and diabetes [9–11].

Various factors, including job status, age, educational level, household income, and residential area, influence sleep quality and quantity [12]. Dietary intake also plays a significant role in sleep patterns [13]. It has been demonstrated that a diet high in fruits, vegetables, whole grains, and lean protein sources can enhance sleep [14, 15]. In addition, consuming nuts and dairy products may beneficially affect sleep duration and quality [16, 17], while inadequate protein and carbohydrate intake may result in shorter sleep duration [18]. Studies have shown that poor sleep quality and duration are associated with decreased insulin secretion [19] and sensitivity [20], respectively. Dietary carbohydrates are particularly noted for raising blood glucose levels after meals and stimulating postprandial insulin secretion [21]. Dietary carbohydrate intake alone cannot fully explain the body's glycemic response; therefore, several indices have been proposed. The dietary glycemic index (GI) evaluates the impact of dietary carbohydrates on blood sugar levels after meals, using white bread or glucose as comparative references [22, 23]. The glycemic load (GL) is an indicator that considers both the quality and quantity of carbohydrates in a diet, determined by multiplying foods' glycemic index (GI) by the content of available carbohydrates [24]. Besides carbohydrates, other compounds, including specific amino acids, fructose, and fatty acids, can significantly affect insulin secretion [25, 26]. Therefore, the food insulin index (FII) in healthy subjects is ascertained by comparing the insulin-stimulating potential of a specific food with a reference food of the same caloric value [27]. Furthermore, dietary insulin load (DIL), derived from FII, energy content, and food frequency, is proposed to offer a more precise estimation of insulin demand than glycemic load or carbohydrate content alone [28].

A limited number of studies have tried to evaluate the association between dietary GI or GL, dietary insulin index (DII) or DIL, and Sleep quality and duration in adults [29–32]. The results of a large cross-sectional study on Iranian adults indicated a positive relationship between DGL and odds of long sleep duration [30]. In the study conducted by Daniel et al. [31], which was focused on male athletes, a low glycemic diet did not significantly affect sleep duration. On the other hand, another study highlighted that diets with a high GI may increase the risk of insomnia in postmenopausal women [32]. Sarsangi et al. [29] also demonstrated that higher DIL and DII are related to a lower likelihood of sleep disorder. Considering the limited and inconsistent data on the subject, in the present study, we aimed to evaluate the relationship between DII, DIL, DGI, and DGL and sleep quality and quantity in adults referred for angiography in Yazd, Iran.

Methods

This cross-sectional study was conducted in Yazd City, central Iran, with 720 recruited participants. The study was part of a broader investigation focusing on individuals aged 35–75 years referred to Afshar Central Heart Hospital for angiography between June 2020 and November 2021. Information about our study design, participants, and data collection was expressed extensively in its published protocol [33]. In brief, using standard questionnaires, trained staff collected data about current health conditions and the history of diseases, smoking status, physical activity, and socio-demographic characteristics.

The study focused on individuals aged 35 to 75, as heart disease is most common in this range [34]. Those under 35 were excluded due to the genetic nature of early-onset cases [35] and this was not in the scope of the current study, while those over 75 were excluded to ensure accurate responses [36].

Participants were excluded from the study if they had kidney disease, liver failure, or a history of heart conditions, including chronic heart failure, previous percutaneous coronary intervention, myocardial infarction, or coronary artery bypass grafting. Other exclusion criteria included a history of cancer, acquired immunodeficiency syndrome (AIDS), immune system disorders, mental or cognitive impairments, morbid obesity (body mass index [BMI] >40 kg/m^2), pregnancy, breastfeeding, or restrictions on oral food intake [33]. Participants with a reported total energy intake exceeding 5500 kcal/day or below 800 kcal/day ($n = 67$) were excluded from the current analysis. This omission led to 653 participants who left for the final analysis.

The present study was conducted based on the Declaration of Helsinki and has been approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Iran (ethics approval code: IR.SSU.SPH.REC.1402.201). An informed consent was obtained from all participants.

Dietary assessment

A validated 182-item food frequency questionnaire (FFQ) was applied to assess the usual dietary intake of participants during the previous year [33, 37]. This study adapted a previously validated 178-item FFQ designed to evaluate the dietary habits of adults residing in Yazd, Iran [37]. Trained nutritionists asked participants to report how often they consumed each item over the past year using a 10-point scale, with options ranging from"never"to"ten or more times per day."These frequencies were then converted to daily consumption rates. The daily intake was calculated in grams by multiplying the reported frequency by a predefined standard portion size.

Assessment of dietary glycemic index and load

The glycemic index was derived from previous references [38–42]. Moreover, the glycemic index of Iranian food items was obtained using the glycemic index tables [43] and the glycemic index list of Iranian foods [44]. The food lists, as well as their GI, are provided in Supplementary Table 1. If certain food items'glycemic index (GI) was not reported in the referenced studies, the GI values of compositionally similar foods were used as substitutes. For instance, the GI value of Sohan, mainly made of flour, nuts, and sugar, was considered the same as sugar. GI for mixed meals was calculated by considering the GI values of the individual components of each meal. Foods' total carbohydrate and fiber contents were derived from the US Department of Agriculture food composition Table [45]. Foods' available carbohydrate content was obtained by subtracting the fiber content from the total carbohydrates [46]. Glucose was the reference food for all extracted GIs. For each participant, dietary glycemic index (DGI) and dietary glycemic load (DGL) were provided by using the following formula [46]:

$$\text{DGI}: \sum(\text{GI each food item} \times \text{available amount of carbohydrate of that food}) / \text{ total available carbohydrate}$$

$$\text{DGL}: (\text{DGI} \times \text{ total available carbohydrate})/100$$

Assessment of dietary insulin index and load

Food insulin index (FII) was defined as the incremental insulin area under the curve during 120 min in response to intake of 1000-kJ (239 kcal) portion of the test food divided by the area under the curve after consuming a reference food with the same energy content. The food lists, as well as their FII, are provided in Supplementary Table 1. The FII was extracted from the tables of previous publications [27, 40, 47–50]. For foods without an insulin index that is available in the lists of previous studies, the insulin index of foods with similar energy and macronutrient content was used. The insulin index of Yazd traditional foods was estimated based on their ingredients; for example, Pashmak consists of sugar and flour. So, its insulin index was considered the same as that of sugar. First, the following formula was used to determine the insulin load of each food: FII of that food ×energy content per 1 g (kcal) ×amount of that food consumed (g/d). The DIL was obtained by summing each food insulin load, and DII was calculated by dividing DIL by total energy intake.

Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to evaluate sleep quality in the previous month [51]. The validity and reliability of this questionnaire have been previously confirmed in the Iranian population [52]. This questionnaire consists of 18 questions and seven domains, including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each domain is scored from zero to three (0 indicates no problem, and 3 indicates a severe problem), and the overall score is calculated by summing the scores of all seven domains. A score above five is considered poor sleep quality. Sleep duration was obtained using the difference between sleep and wake time, and a sleep duration of less than 6 h was deemed insufficient.

Other variables

Trained nutritionists did anthropometric measurements. A digital scale (Omron BF51 Japan) was used to measure weight to the nearest 100 g when participants wore minimum clothes, and height was measured in the standard position with an accuracy of 0.1 cm. Body mass index (BMI) was calculated by dividing weight (Kg) by height squared (m^2). Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) [44]. Physical activity levels were estimated using the metric of metabolic equivalent task (MET) minutes per week. Depressive symptoms were assessed with the Patient Health Questionnaire-9 (PHQ-9), a nine-item tool that evaluates the frequency of depressive symptoms over the past two weeks [53]. The validity and reliability of this questionnaire were previously confirmed within the Iranian population [54]. This questionnaire consists of 9 questions with options ranging from"not at all"(0) to"nearly every day"(3), resulting in a total score between 0 and 27. Based on these scores, depression severity was categorized into two groups: no or mild depression (0–9) and moderate or severe depression (10–27), using established thresholds [53, 55].

Table 1 General characteristics of participants across quartiles of dietary insulin index and dietary insulin load[a]

Variables	Dietary insulin index					Dietary insulin load				
	Q1	Q2	Q3	Q4	*P*-value	Q1	Q2	Q3	Q4	*P*-value
Age (years)	56.28±10.63	55.84±8.92	57.64±9.23	56.96±10.30	0.38	58.14±9.17	58.07±9.78	55.66±9.95	54.85±9.91	0.003
BMI (kg/m2)	27.61±4.69	27.56±4.11	27.49±4.36	27.74±4.25	0.97	27.77±4.42	28.17±4.40	27.15±4.47	27.30±4.07	0.16
Sex (N, %)					0.83					<0.001
Male	97(59.5)	102(62.6)	100(61)	94(57.7)		60(36.8)	88(54)	115(70.1)	130(79.8)	
Female	66(40.5)	61(37.4)	64(39)	69(42.3)		103(63.2)	75(46)	49(29.9)	33(20.2)	
Physical activity(MET-h/week)	5877.26±9118.25	3629.46±6986.01	3291.89±5884.60	3295.47±5824.74	0.002	2457.14±4580.84	4138.85±6975.41	4727.47±8740.95	4784.68±7464.96	0.01
Occupation (N, %)					0.59					<0.001
Employee	8(4.9)	7(4.3)	12(7.4)	5(3.1)		5(3.1)	11(6.8)	7(4.3)	9(5.6)	
Worker	15(9.2)	12(7.4)	16(9.9)	14(8.6)		11(6.7)	8(4.9)	21(13)	17(10.5)	
Retired	18(11)	26(16)	24(14.8)	25(15.4)		14(8.6)	29(17.9)	31(19.1)	19(11.7)	
Freelance	60(36.8)	60(37)	47(29)	47(29)		36(22.1)	41(25.3)	52(32.1)	85(52.5)	
Housewife/Unemployed	62(38)	57(35.2)	63(38.9)	71(43.8)		97(59.5)	73(45.1)	51(31.5)	32(19.8)	
Education level (N, %)					0.14					<0.001
Illiterate	46(28.2)	30(18.5)	38(23.6)	40(24.8)		60(37)	38(23.5)	35(21.7)	21(13)	
Elementary/high school	116(71.2)	132(81.5)	119(73.9)	119(73.9)		102(63)	122(75.3)	125(77.6)	137(84.6)	
University	1(0.6)	0(0)	4(2.5)	2(1.2)		0(0)	2(1.2)	1(0.6)	4(2.5)	
Marital status (N, %)					0.09					0.05
Single	4(2.5)	1(0.6)	1(0.6)	0(0)		3(1.8)	0(0)	2(1.2)	1(0.6)	
Married	144(89.4)	152(95.6)	151(92.6)	147(90.2)		142(81.7)	145(91.2)	152(93.3)	155(96.3)	
Divorced/widow	13(8.1)	6(3.8)	11(6.7)	16(9.8)		18(11)	14(8.8)	9(5.5)	5(3.1)	
Economic status (N, %)					0.44					0.006
Low	50(30.7)	62(38)	54(32.9)	67(41.1)		67(41.1)	61(37.4)	59(36)	46(28.2)	
Medium	73(44.8)	66(40.5)	76(46.3)	60(36.8)		74(45.4)	70(42.9)	66(40.2)	65(39.9)	
High	40(24.5)	35(21.5)	34(20.7)	36(22.1)		22(13.5)	32(19.6)	39(23.8)	52(31.9)	
Smoking status (N, %)					0.08					<0.001
Nonsmoker	119(73)	98(60.1)	114(69.5)	108(66.3)		136(83.4)	115(70.6)	101(61.6)	87(53.4)	
Current/former smoker	44(27)	65(39.9)	50(30.5)	55(33.7)		27(16.6)	48(29.4)	63(38.4)	76(46.6)	
Drug addiction (N, %)					0.51					<0.001
Nonaddicted	134(82.7)	126(77.8)	135(83.3)	125(79.1)		146(89.6)	137(85.1)	123(75.5)	114(72.6)	
Current/former addicted	28(17.3)	36(22.2)	27(16.7)	33(20.9)		17(10.4)	24(14.9)	40(24.5)	43(27.4)	
Diabetes (N, %)					0.38					0.003
Yes	62(38.3)	58(35.6)	61(37.4)	47(29.7)		75(46.3)	57(35.2)	44(27.3)	52(32.3)	
No	100(61.7)	105(64.4)	102(62.6)	111(70.3)		87(53.7)	105(64.8)	117(72.7)	109(67.7)	

[a] Values are mean± SD or percentages. The Chi-square test was used for qualitative variables and the analysis of variance (ANOVA) test was used for continues variables

Table 2 Age, sex and energy adjusted food groups and nutrients intake based on the quartiles of dietary insulin index and dietary insulin load[a]

	Dietary insulin index					Dietary insulin load				
Nutrients	**Q1**	**Q2**	**Q3**	**Q4**	***P*-value**	**Q1**	**Q2**	**Q3**	**Q4**	***P*-value**
Energy (kcal/d)	2702.32 ± 76.66	2601.43 ± 76.73	2490.88 ± 76.49	2580.77 ± 75.95	0.28	1527.30 ± 37.40	2110.22 ± 36.12	2770.14 ± 36.21	3970.70 ± 37.13	< 0.001
Carbohydrate (g/d)	359.70 ± 4.34	399.98 ± 4.33	415.02 ± 4.33	414.33 ± 4.29	< 0.001	357.83 ± 7.09	383.61 ± 5.13	401.87 ± 4.63	446.28 ± 8.30	< 0.001
Fiber (g/d)	38.12 ± 0.91	39.70 ± 0.91	40.46 ± 0.91	36.48 ± 0.91	0.01	36.92 ± 1.43	37.91 ± 1.04	40.19 ± 0.94	39.70 ± 1.68	0.28
Total Fat (g/d)	86.59 ± 1.45	71.24 ± 1.45	67.42 ± 1.45	63.77 ± 1.44	< 0.001	85.64 ± 2.41	78.26 ± 1.74	72.47 ± 1.57	52.39 ± 2.82	< 0.001
Protein (g/d)	105.42 ± 1.97	98.56 ± 1.97	92.38 ± 1.97	91.59 ± 1.95	< 0.001	105.50 ± 3.13	97.56 ± 2.26	96.23 ± 2.05	88.53 ± 3.67	0.03
Thiamine (mg/d)	1.67 ± 0.03	1.73 ± 0.03	1.79 ± 0.03	1.76 ± 0.03	0.06	1.64 ± 0.05	1.63 ± 0.04	1.81 ± 0.03	1.86 ± 0.06	0.009
Riboflavin (mg/d)	17.82 ± 0.32	16.97 ± 0.32	16.40 ± 0.32	15.29 ± 0.32	< 0.001	16.88 ± 0.51	15.94 ± 0.37	17.23 ± 0.34	16.41 ± 0.60	0.03
Niacin (mg/d)	37.11 ± 1.34	37.87 ± 1.34	35.74 ± 1.34	40.95 ± 1.33	0.04	35.48 ± 2.11	37.69 ± 1.53	37.91 ± 1.38	40.64 ± 2.46	0.62
Pantothenic Acid (mg/d)	6.85 ± 0.12	6.95 ± 0.12	6.67 ± 0.12	6.41 ± 0.11	0.005	6.80 ± 0.18	6.52 ± 0.13	6.81 ± 0.12	6.75 ± 0.21	0.26
Vitamin B_6 (mg/d)	2.78 ± 0.06	2.75 ± 0.06	2.66 ± 0.06	2.48 ± 0.06	0.001	2.64 ± 0.09	2.59 ± 0.06	2.79 ± 0.06	2.65 ± 0.10	0.09
Folate (mcg/d)	453.95 ± 11.01	449.65 ± 11.01	463.15 ± 10.99	429.72 ± 10.89	0.17	440.57 ± 17.22	439.37 ± 12.47	455.19 ± 11.24	461.12 ± 20.15	0.83
Vitamin B_{12} (mcg/d)	5.18 ± 0.37	4.06 ± 0.37	4.11 ± 0.37	4.07 ± 0.37	0.09	4.02 ± 0.58	3.84 ± 0.42	4.03 ± 0.38	5.54 ± 0.68	0.15
Choline (mg/d)	403.75 ± 11.74	370.91 ± 11.74	341.74 ± 11.72	327.51 ± 11.62	< 0.001	380.37 ± 18.61	346.62 ± 13.47	367.74 ± 12.15	348.51 ± 21.77	0.26
Vitamin C (mg/d)	229.64 ± 10.04	257.05 ± 10.03	264.17 ± 10.01	241.26 ± 9.93	0.07	219.91 ± 15.67	231.52 ± 11.35	263.03 ± 10.23	277.65 ± 18.33	0.15
Vitamin A (mcg/d)	875.24 ± 36.13	801.57 ± 36.11	816.32 ± 36.04	732.88 ± 35.74	0.05	809.11 ± 56.46	834.23 ± 40.88	856.17 ± 36.85	724.20 ± 66.05	0.17
Vitamin E (mg/d)	15.28 ± 0.39	13.28 ± 0.39	11.78 ± 0.39	10.13 ± 0.38	< 0.001	14.31 ± 0.64	13.75 ± 0.46	12.76 ± 0.42	9.59 ± 0.75	< 0.001
Sodium (mg/d)	3618.92 ± 132.27	3147.28 ± 132.20	3279.20 ± 131.97	3122.25 ± 130.86	0.03	3365.53 ± 206.67	3186.14 ± 149.64	3542.72 ± 134.91	3068.17 ± 241.80	0.10
Potassium (mg/d)	4737.47 ± 94.01	4826.63 ± 93.96	4882.29 ± 93.79	4501.65 ± 93.01	0.02	4542.35 ± 146.63	4538.39 ± 106.17	4974.39 ± 95.72	4888.90 ± 171.56	0.03
Calcium (mg/d)	824.49 ± 19.36	813.41 ± 19.35	795.73 ± 19.32	734.78 ± 19.15	0.005	801.23 ± 30.34	763.37 ± 21.96	828.08 ± 19.80	774.58 ± 35.49	0.09
Iron (mcg/d)	15.78 ± 0.25	15.27 ± 0.25	14.98 ± 0.25	15 ± 0.25	0.09	14.80 ± 0.40	14.99 ± 0.29	15.63 ± 0.26	15.60 ± 0.46	0.36
Zinc (mg/d)	14.79 ± 0.27	14.20 ± 0.27	13.61 ± 0.27	14.07 ± 0.27	0.02	13.86 ± 0.43	13.70 ± 0.31	14.68 ± 0.28	14.42 ± 0.50	0.15
Food groups										
Fruits (g/d)	779.95 ± 41.58	938.22 ± 41.56	1005.24 ± 41.49	956.03 ± 41.14	0.001	699.46 ± 64.73	796.94 ± 46.87	1032.07 ± 42.25	1152.33 ± 75.73	< 0.001
Vegetables (g/d)	391.51 ± 17.89	354.63 ± 17.88	344.04 ± 17.85	285.23 ± 17.70	< 0.001	359.24 ± 28.15	367.25 ± 20.38	365.63 ± 18.37	281.61 ± 32.93	0.08
Whole grain (g/d)	23.54 ± 3.43	23.92 ± 3.34	23.51 ± 3.34	35.89 ± 3.31	0.02	25.83 ± 5.24	25.85 ± 3.80	22.91 ± 3.42	32.48 ± 6.13	0.43
Refined grain (g/d)	273.23 ± 13.59	336.14 ± 13.59	329.24 ± 13.56	359.43 ± 13.45	< 0.001	279.12 ± 21.39	326.46 ± 15.49	311.37 ± 13.97	381.91 ± 25.03	0.02
Dairy (g/d)	323.89 ± 17.50	295 ± 17.49	274.91 ± 17.46	248.77 ± 17.31	0.02	304.43 ± 27.40	261.96 ± 19.84	303.79 ± 17.89	271.71 ± 32.06	0.24
Legumes (g/d)	56.39 ± 3.58	48.39 ± 3.58	43.47 ± 3.58	47.87 ± 3.55	0.08	46.28 ± 5.61	47.74 ± 4.06	47.62 ± 3.66	54.46 ± 6.57	0.81
Red meat (g/d)	44.44 ± 4.01	42.20 ± 4.01	38.31 ± 4	39.97 ± 3.97	0.72	39.86 ± 6.26	41.21 ± 4.53	44.97 ± 4.08	38.79 ± 7.32	0.72
Processed meat (g/d)	8.50 ± 2.46	8.36 ± 2.46	14.30 ± 2.45	9.66 ± 2.43	0.28	11.52 ± 3.84	10.67 ± 2.78	8.94 ± 2.51	9.71 ± 4.50	0.95
Nuts (g/d)	17.41 ± 1.15	12.46 ± 1.15	10.52 ± 1.15	8.43 ± 1.14	< 0.001	15.69 ± 1.84	12.92 ± 1.33	12.31 ± 1.20	7.80 ± 2.15	0.16
Caffeine (mg/day)	149.63 ± 9.58	159.64 ± 9.57	171.39 ± 9.56	143.88 ± 9.48	0.19	180.98 ± 14.94	153.98 ± 10.82	146.33 ± 9.75	143.28 ± 17.48	0.24

[a] Data are presented as mean ± SE; *P* values are resulted from the analysis of covariance (ANCOVA)

Table 3 Multivariable-adjusted ORs (and 95% CIs) for sleep quality and its components across quartiles of dietary insulin index, dietary insulin load, dietary glycemic index, and dietary glycemic load

	Dietary insulin index					Dietary insulin load				
	Q1	Q2	Q3	Q4	P-trend	Q1	Q2	Q3	Q4	P-trend
Subjective sleep quality										
Crude	1	1.18(0.70,1.98)	1.19(0.72,1.99)	1.04(0.62,1.77)	0.86	1	0.87(0.53,1.43)	0.75(0.45,1.24)	0.70(0.42,1.17)	0.14
Model 1[a]	1	1.17(0.68,2.00)	1.29(0.75,2.20)	1.06(0.61,1.84)	0.75	1	1.24(0.69,2.21)	1.45(0.68,3.10)	1.92(0.60,6.14)	0.28
Model 2[b]	1	1.07(0.56,2.05)	1.26(0.66,2.38)	1.24(0.65,2.39)	0.43	1	1.47(0.73,2.95)	2.10(0.85,5.18)	2.73(0.71,10.52)	0.11
Sleep latency										
Crude	1	1.20(0.77,1.88)	1.17(0.75,1.82)	0.94(0.60,1.49)	0.80	1	0.65(0.41,1.02)	0.55(0.35,0.87)	0.45(0.29,0.72)	0.001
Model 1	1	1.21(0.76,1.93)	1.18(0.74,1.88)	0.91(0.57,1.46)	0.69	1	0.70(0.42,1.18)	0.66(0.34,1.28)	0.48(0.18,1.33)	0.18
Model 2	1	0.83(0.49,1.42)	0.97(0.57,1.65)	0.84(0.49,1.45)	0.70	1	0.90(0.50,1.60)	0.77(0.36,1.64)	0.60(0.19,1.90)	0.42
Sleep duration										
Crude	1	0.84(0.51,1.40)	0.87(0.52,1.43)	0.48(0.27,0.85)	0.02	1	0.78(0.45,1.35)	1.15(0.69,1.93)	1.07(0.64,1.81)	0.49
Model 1	1	0.86(0.51,1.45)	0.91(0.54,1.52)	0.50(0.28,0.89)	0.03	1	0.67(0.36,1.25)	0.80(0.38,1.70)	0.51(0.16,1.66)	0.42
Model 2	1	0.92(0.51,1.67)	1.06(0.59,1.90)	0.56(0.29,1.08)	0.15	1	0.58(0.29,1.16)	0.75(0.32,1.75)	0.37(0.10,1.37)	0.28
Sleep efficiency										
Crude	1	1.41(0.83,2.42)	1.36(0.79,2.31)	1.25(0.72,2.17)	0.49	1	0.71(0.42,1.20)	0.80(0.48,1.33)	0.72(0.43,1.21)	0.28
Model 1	1	1.41(0.82,2.43)	1.33(0.77,2.31)	1.23(0.70,2.15)	0.55	1	0.62(0.34,1.13)	0.69(0.33,1.47)	0.46(0.14,1.50)	0.25
Model 2	1	1.43(0.76,2.70)	1.65(0.89,3.06)	1.52(0.80,2.88)	0.18	1	0.64(0.33,1.24)	0.90(0.39,2.07)	0.58(0.16,2.13)	0.60
Sleep disorders										
Crude	1	1.06(0.62,1.79)	1.48(0.89,2.45)	1.33(0.79,2.24)	0.15	1	0.93(0.57,1.52)	0.50(0.29,0.85)	0.80(0.49,1.31)	0.12
Model 1	1	1.12(0.64,1.98)	1.79(1.03,3.10)	1.47(0.84,2.58)	0.07	1	1.08(0.60,1.93)	0.61(0.28,1.35)	0.99(0.30,3.21)	0.50
Model 2	1	1.57(0.77,3.21)	3.03(1.52,6.02)	2.42(1.20,4.87)	0.003	1	0.96(0.48,1.93)	0.69(0.27,1.75)	1.71(0.30,4.60)	0.78
Use of sleep medicine										
Crude	1	1.43(0.76,2.71)	1.31(0.69,2.48)	1.87(1.00,3.48)	0.08	1	1.19(0.69,2.07)	0.42(0.21,0.82)	0.72(0.39,1.30)	0.04
Model 1	1	1.48(0.76,2.87)	1.40(0.72,2.72)	1.97(1.04,3.74)	0.06	1	1.59(0.84,3.02)	0.69(0.27,1.77)	1.56(0.40,6.03)	0.97
Model 2	1	1.47(0.68,3.19)	1.31(0.61,2.81)	1.95(0.91,4.16)	0.13	1	1.26(0.60,2.65)	0.57(0.19,1.68)	0.85(0.18,4.12)	0.54
Daytime dysfunction										
Crude	1	1.65(0.97,2.81)	1.37(0.80,2.33)	1.42(0.82,2.44)	0.36	1	1.09(0.65,1.83)	1.01(0.60,1.70)	1.06(0.63,1.78)	0.90
Model 1	1	1.71(0.99,2.97)	1.47(0.84,2.57)	1.46(0.83,2.56)	0.30	1	1.28(0.71,2.32)	1.33(0.62,2.85)	1.41(0.44,4.49)	0.50
Model 2	1	1.59(0.83,3.07)	1.17(0.60,2.27)	1.50(0.77,2.91)	0.44	1	1.22(0.61,2.42)	1.15(0.46,2.84)	0.96(0.25,3.74)	0.91
Total sleep quality										
Crude	1	1.47(0.92,2.34)	1.20(0.76,1.90)	1.34(0.83,2.14)	0.38	1	0.64(0.40,1.02)	0.60(0.38,0.97)	0.48(0.30,0.77)	0.003
Model 1	1	1.50(0.91,2.47)	1.16(0.71,1.91)	1.33(0.80,2.21)	0.47	1	0.65(0.37,1.14)	0.72(0.36,1.46)	0.49(0.17,1.43)	0.27
Model 2	1	1.31(0.74,2.32)	1.05(0.59,1.86)	1.21(0.68,2.18)	0.75	1	0.62(0.33,1.16)	0.77(0.34,1.74)	0.41(0.12,1.38)	0.29
	Dietary glycemic index					**Dietary glycemic load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.67(0.98,2.85)	1.86(1.09,3.15)	1.40(0.81,2.42)	0.22	1	0.63(0.37,1.06)	1.06(0.65,1.73)	0.82(0.50,1.37)	0.93
Model 1	1	1.36(0.77,2.43)	1.85(1.06,3.22)	1.52(0.86,2.70)	0.09	1	0.88(0.48,1.59)	1.45(0.83,2.51)	1.40(0.73,2.66)	0.10
Model 2	1	1,69(0.86,3.34)	2.05(1.06,4.00)	1.66(0.84,3.28)	0.12	1	0.95(0.47,1.91)	1.57(0.80,3.05)	1.48(0.69,3.13)	0.13
Sleep latency										
Crude	1	1.71(1.09,2.68)	1.39(0.89,2.17)	1.52(0.97,2.39)	0.15	1	0.45(0.28,0.71)	0.79(0.50,1.23)	0.60(0.38,0.94)	0.18
Model 1	1	1.45(0.89,2.35)	1.37(0.85,2.19)	1.80(1.12,2.91)	0.03	1	0.57(0.34,0.94)	1.00(0.61,1.66)	0.94(0.53,1.66)	0.43
Model 2	1	1.49(0.87,2.57)	1.49(0.87,2.57)	1.81(1.06,3.10)	0.04	1	0.52(0.22,0.92)	0.96(0.54,1.69)	0.95(0.50,1.80)	0.42
Sleep duration										
Crude	1	0.80(0.47,1.38)	0.76(0.44,1.31)	1.34(0.81,2.23)	0.29	1	1.16(0.67,2.02)	1.50(0.88,2.55)	1.31(0.76,2.25)	0.23
Model 1	1	0.88(0.50,1.57)	0.87(0.50,1.52)	1.52(0.90,2.57)	0.15	1	1.03(0.56,1.91)	1.51(0.84,2.72)	1.26(0.65,2.47)	0.26
Model 2	1	1.04(0.55,1.94)	0.79(0.42,1.50)	1.46(0.81,2.64)	0.34	1	0.98(0.50,1.94)	1.49(0.78,2.88)	1.09(0.52,2.31)	0.48
Sleep efficiency										
Crude	1	1.32(0.76,2.27)	1.55(0.91,2.64)	1.44(0.84,2.47)	0.15	1	0.71(0.41,1.22)	0.97(0.58,1.62)	1.04(0.62,1.75)	0.61

Table 3 (continued)

Model 1	1	1.29(0.72,2.30)	1.62(0.93,2.80)	1.65(0.94,2.89)	0.06	1	0.81(0.45,1.48)	1.10(0.62,1.94)	1.41(0.74,2.68)	0.15
Model 2	1	1.16(0.62,2.17)	1.63(0.89,3.00)	1.56(0.84,2.88)	0.09	1	0.97(0.50,1.56)	1.17(0.62,2.21)	1.67(0.82,3.40)	0.11
Sleep disorders										
Crude	1	1.54(0.92,2.59)	1.37(0.81,2.32)	1.44(0.85,2.44)	0.27	1	0.55(0.33,0.92)	0.65(0.40,1.07)	0.71(0.43,1.17)	0.24
Model 1	1	1.41(0.79,2.52)	1.42(0.80,2.51)	1.66(0.94,2.95)	0.10	1	0.62(0.34,1.12)	0.72(0.41,1.28)	0.92(0.48,1.78)	0.99
Model 2	1	1.41(0.72,2.78)	1.27(0.64,2.54)	1.65(0.84,3.25)	0.20	1	0.66(0.33,1.34)	0.66(0.33,1.31)	0.94(0.44,2.04)	0.91
Use of sleep medicine										
Crude	1	1.83(0.97,3.44)	1.74(0.92,3.28)	1.42(0.73,2.73)	0.39	1	0.34(0.18,0.66)	0.80(0.46,1.39)	0.57(0.32,1.02)	0.25
Model 1	1	1.49(0.76,2.92)	1.71(0.89,3.29)	1.54(0.78,3.05)	0.19	1	0.42(0.20,0.88)	0.99(0.54,1.82)	0.82(0.39,1.70)	0.72
Model 2	1	1.67(0.75,3.69)	1.71(0.79,3.73)	2.03(0.92,4.44)	0.09	1	0.36(0.15,0.85)	0.92(0.44,1.91)	0.98(0.42,2.27)	0.43
Daytime dysfunction										
Crude	1	0.81(0.47,1.37)	0.99(0.59,1.66)	1.10(0.66,1.83)	0.56	1	1.08(0.64,1.81)	0.93(0.55,1.58)	1.29(0.77,2.16)	0.44
Model 1	1	0.69(0.39,1.23)	0.90(0.52,1.54)	1.10(0.64,1.89)	0.55	1	1.30(0.72,2.35)	1.04(0.58,1.87)	1.66(0.86,3.18)	0.26
Model 2	1	0.66(0.34,1.27)	0.83(0.44,1.59)	1.05(0.56,1.98)	0.71	1	1.32(0.66,2.63)	1.07(0.54,2.13)	1.47(0.69,3.13)	0.49
Total sleep quality										
Crude	1	1.68(1.05,2.67)	1.37(0.87,2.17)	1.61(1.01,2.56)	0.10	1	0.40(0.25,0.64)	0.63(0.39,1.01)	0.58(0.36,0.93)	0.14
Model 1	1	1.43(0.86,2.40)	1.35(0.82,2.23)	2.01(1.21,3.33)	0.01	1	0.49(0.28,0.85)	0.79(0.46,1.36)	0.91(0.49,1.68)	0.53
Model 2	1	1.33(0.74,2.37)	1.28(0.72,2.28)	1.76(0.99,3.11)	0.07	1	0.52(0.28,0.97)	0.74(0.40,1.38)	0.92(0.46,1.85)	0.67

[a] Model 1: Adjusted for age, sex, and energy intake

[b] Model 2: Further adjusted for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/wk), depression score, syntax score, diabetes(yes/no) and caffeine intake

The Gensini score (GS) and syntax score II (SS-II) were used to measure the degree and severity of coronary artery stenosis [56, 57]. In GS, atherosclerotic lesions are divided into scores of 1, 2, 4, 8, and 32 based on the percentage of lumen obstruction [58]. The GS scores below 23 indicated non-severe coronary artery occlusion, while scores of 23 or above suggested severe coronary artery occlusion [59]. The Syntax Score II (SS-II) encompassed anatomical parameters to assess the severity of coronary artery disease (CAD). SS II values less than 22 were considered low severity, and values greater than 22 as moderate to high severity of coronary artery stenosis [59, 60].

Statistical analysis

Subjects were classified into quartiles based on the DIL, DII, DGL, and DGI. Categorical and continuous variables were compared across quartiles using the chi-square test and variance analysis (ANOVA). Qualitative variables were presented as numbers (percentages), and quantitative variables were mean ± standard deviation (SD). The analysis of covariance (ANCOVA) was utilized to compare age, sex, and energy-adjusted nutrients and food group intake across the quartiles of DII, DIL, DGI, and DGL. Binary logistic regression was used to evaluate the association between DII, DIL, DGL, and DGI and the odds of low sleep quality and other sleep abnormalities in crude and adjusted models. Model 1 was adjusted for age, energy, and sex; Model 2 included additional adjustments for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/wk), Patient Health Questionaire-9 (PHQ9) score, syntax score, diabetes(yes/no) and caffeine intake. The first quartile of DIL, DII, DGI, or DGL was considered the reference category for all models. We also conducted a stratified analysis based on sex and diabetes status. All statistical analyses were performed using SPSS software (version 26.0; SPSS Inc, Chicago, IL). A *p*-value equal to or less than 0.05 was considered statistically significant.

Results

After excluding those with implausible energy intake, 653 participants were included in the analysis. The average age of the subjects was 56.68 ± 9.80, and men constituted 60.2% of the participants. The general characteristics of study participants across quartiles of DIL and DII are represented in Table 1. Furthermore, the general characteristics of study participants across quartiles of DGI and DGL are indicated in Supplementary Table 2. All presented variables differed significantly across DIL except for BMI in the DIL quartile ($P > 0.05$). Additionally, individuals with higher DII were less physically active ($P < 0.05$). Participants in the highest quartile of DGL and DGI were primarily male and likely younger than those in the lowest quartile of DGL and DGI ($P < 0.05$). The distribution of participants in terms of educational level, economic status, occupation, smoking status, and drug addiction was significantly different according to the

Table 4 Association between dietary insulin and glycemic indices and domains of sleep quality among women

	Dietary insulin index					Dietary insulin load				
	Q1	Q2	Q3	Q4	P-trend	Q1	Q2	Q3	Q4	P-trend
Subjective sleep quality										
Crude	1	1.17(0.56,2.43)	0.87(0.42,1.80)	0.93(0.45,1.95)	0.67	1	1.15(0.61,2.15)	1.18(0.56,2.46)	0.99(0.43,2.30)	0.76
Model 1[a]	1	1.15(0.54,2.45)	0.93(0.44,1.97)	0.98(0.46,2.07)	0.05	1	1.49(0.70,3.16)	1.88(0.60,5.92)	2.34(0.41,13.39)	0.26
Model 2[b]	1	1.16(0.45,2.98)	0.95(0.38,2.38)	1.40(0.56,3.51)	0.45	1	2.43(0.96,6.17)	4.15(1.01,17.01)	5.73(0.69,47.31)	0.05
Sleep latency										
Crude	1	1.05(0.49.2.22)	1.64(0.76,3.54)	0.78(0.37,1.62)	0.77	1	0.90(0.47,1.72)	0.69(0.32,1.45)	0.42(0.18,0.97)	0.04
Model 1	1	0.98(0.46,2.11)	1.65(0.75,3.64)	0.76(0.36,1.61)	0.75	1	0.90(0.41,1.970	0.66(0.21,2.10)	0.42(0.07,2.42)	0.39
Model 2	1	0.74(0.30,1.84)	1.90(0.74,4.89)	0.91(0.37,2.23)	0.69	1	1.35(0.55,3.36)	0.86(0.23,3.27)	0.61(0.08,4.58)	0.75
Sleep duration										
Crude	1	0.54(0.21,1.40)	1.21(0.54,2.74)	0.67(0.27,1.66)	0.80	1	0.56(0.25,1.26)	1.34(0.59,3.03)	0.69(0.24,2.02)	0.88
Model 1	1	0.52(0.19,1.43)	1.40(0.60,3.27)	0.74(0.30,1.86)	0.98	1	0.49(0.18,1.32)	0.97(0.25,3.76)	0.36(0.04,3.40)	0.62
Model 2	1	0.75(0.23,2.44)	1.83(0.65,5.19)	1.05(0.35,3.14)	0.57	1	0.37(0.11,1.20)	1.30(0.27,6.33)	0.21(0.02,2.72)	0.65
Sleep efficiency										
Crude	1	1.11(0.52,2.37)	0.82(0.39,1.76)	0.71(0.32,1.56)	0.30	1	0.72(0.37,1.41)	1.19(0.56,2.51)	0.86(0.35,2.09)	0.98
Model 1	1	1.05(0.48,2.28)	0.82(0.38,1.80)	0.69(0.31,1.53)	0.29	1	0.66(0.29,1.48)	0.99(0.31,3.23)	0.63(0.10,4.00)	0.75
Model 2	1	0.90(0.32,2.50)	1.17(0.44,3.10)	0.90(0.33,2.46)	0.98	1	0.77(0.28,2.11)	1.39(0.32,5.99)	0.93(0.09,9.36)	0.84
Sleep disorders										
Crude	1	0.69(0.33,1.44)	1.39(0.68,2.83)	0.77(0.37,1.61)	0.97	1	1.19(0.64,2.20)	1.14(0.55,2.40)	1.08(0.47,2.49)	0.77
Model 1	1	0.69(0.32,1.48)	1.66(0.79,3.49)	0.85(0.40,1.79)	0.77	1	1.15(0.54,2.41)	0.95(0.30,2.96)	0.84(0.15,4.85)	0.92
Model 2	1	1.02(0.38,2.73)	3.12(1.19,8.20)	1.18(0.45,3.13)	0.31	1	1.04(0.42,2.60)	0.90(0.23,3.59)	0.62(0.07,5.40)	0.79
Use of sleep medicine										
Crude	1	0.84(0.37,1.91)	0.49(0.20,1.18)	1.11(0.51,2.43)	0.91	1	1.20(0.61,2.34)	0.36(0.13,1.03)	0.67(0.25,1.80)	0.13
Model 1	1	0.81(0.35,1.89)	0.46(0.19,1.16)	1.10(0.49,2.48)	0.94	1	1.37(0.60,3.13)	0.44(0.10,1.85)	1.03(0.13,7.91)	0.69
Model 2	1	0.79(0.29,2.15)	0.43(0.15,1.22)	1.08(0.41,2.88)	0.89	1	1.44(0.55,3.82)	0.47(0.09,2.48)	0.58(0.05,7.17)	0.63
Daytime dysfunction										
Crude	1	1.35(0.63,2.88)	1.33(0.63,2.78)	1.25(0.59,2.65)	0.60	1	1.22(0.64,2.32)	1.41(0.67,2.98)	1.56(0.68,3.58)	0.22
Model 1	1	1.28(0.58,2.80)	1.42(0.65,3.08)	1.36(0.62,2.95)	0.42	1	1.35(0.62,2.91)	1.54(0.49,4.89)	1.85(0.32,10.89)	0.43
Model 2	1	1.05(0.39,2.79)	1.47(0.57,3.83)	1.74(0.67,4.55)	0.19	1	1.06(0.42,2.62)	0.82(0.213.26)	0.92(0.11,7.71)	0.86
Total sleep quality										
Crude	1	1.05(0.44,2.53)	0.99(0.42,2.33)	0.95(0.40,2.27)	0.88	1	0.67(0.32,1.43)	0.72(0.30,1.75)	0.40(0.15,1.02)	0.78
Model 1	1	0.94(0.38,2.30)	0.88(0.37,2.12)	0.92(0.38,2.21)	0.82	1	0.70(0.28,1.70)	0.71(0.19,2.72)	0.38(0.05,2.72)	0.43
Model 2	1	0.78(0.27,2.26)	0.94(0.32,2.76)	0.90(0.31,2.62)	0.97	1	0.57(0.20,1.63)	0.69(0.14,3.40)	0.20(0.02,1.97)	0.30
	Dietary glycemic index					**Dietary glycemic load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.13(0.56,2.31)	2.47(1.18,5.16)	0.66(0.27,1.61)	0.78	1	1.16(0.58,2.32)	1.54(0.79,2.98)	0.97(0.42,2.24)	0.56
Model 1	1	1.08(0.49,2.38)	2.57(1.17,5.65)	0.65(0.26,1.63)	0.81	1	1.34(0.63,2.86)	1.71(0.85,3.45)	1.14(0.44,2.92)	0.38
Model 2	1	1.42(0.54,3.71)	3.24(1.19,8.79)	0.50(0.15,1.67)	0.85	1	1.34(0.54,3.31)	1.97(0.84,4.58)	1.00(0.33,3.01)	0.48
Sleep latency										
Crude	1	1.80(0.90,3.60)	2.92(1.35,6.36)	1.52(0.68,3.40)	0.11	1	0.42(0.21,0.83)	0.93(0.46,1.88)	0.86(0.37,2.01)	0.88
Model 1	1	1.52(0.71,3.26)	2.88(1.26,6.59)	1.43(0.62,3.31)	0.15	1	0.50(0.24,1.07)	1.08(0.51,2.27)	1.17(0.45,3.05)	0.47
Model 2	1	1.62(0.68,3.88)	2.74(1.04,7.20)	1.35(0.51,3.63)	0.33	1	0.39(0.16,0.95)	0.88(0.38,2.05)	1.22(0.41,3.65)	0.56
Sleep duration										
Crude	1	1.15(0.49,2.69)	0.82(0.32,2.11)	1.47(0.57,3.79)	0.66	1	0.83(0.34,1.99)	1.29(0.58,2.83)	1.30(0.51,3.34)	0.45
Model 1	1	1.12(0.44,2.89)	0.92(0.34,2.48)	1.58(0.59,4.23)	0.47	1	0.90(0.34,2.38)	1.44(0.61,3.38)	1.53(0.52,4.53)	0.28
Model 2	1	1.09(0.37,3.24)	0.94(0.28,3.10)	1.56(0.48,5.08)	0.54	1	0.96(0.32,2.93)	1.81(0.68,4.80)	1.36(0.38,4.86)	0.31
Sleep efficiency										
Crude	1	0.99(0.45,2.15)	1.94(0.89,4.21)	1.70(0.72,3.99)	0.07	1	0.95(0.45,2.01)	1.47(0.73,2.94)	1.57(0.69,3.59)	0.17
Model 1	1	1.07(0.46,2.49)	2.24(0.98,5.12)	1.89(0.78,4.57)	0.04	1	1.01(0.45,2.28)	1.58(0.75,3.31)	1.87(0.73,4.80)	0.10

Table 4 (continued)

Model 2	1	0.90(0.33,2.48)	1.78(0.64,4.98)	1.97(0.65,5.98)	0.09	1	1.23(0.46,3.29)	1.74(0.70,4.29)	2.56(0.82,8.02)	0.08
Sleep disorders										
Crude	1	1.47(0.73,2.95)	1.76(0.84,3.69)	0.98(0.43,2.22)	0.78	1	0.81(0.41,1.59)	0.85(0.44,1.66)	0.85(0.38,1.91)	0.62
Model 1	1	1.63(0.75,3.57)	1.98(0.89,4.40)	0.99(0.42,2.33)	0.84	1	0.72(0.34,1.53)	0.76(0.38,1.55)	0.71(0.28,1.78)	0.44
Model 2	1	2.43(0.91,6.51)	1.99(0.70,5.63)	1.16(0.38,3.54)	0.99	1	0.67(0.26,1.72)	0.69(0.28,1.67)	0.71(0.23,2.17)	0.48
Use of sleep medicine										
Crude	1	1.46(0.64,3.33)	1.75(0.74,4.10)	1.32(0.50,3,47)	0.44	1	0.50(0.22,1.17)	1.01(0.49,2.08)	0.68(0.26,1.75)	0.64
Model 1	1	1.06(0.43,2.66)	1.39(0.56,3.44)	1.07(0.40,2.91)	0.70	1	0.60(0.24,1.49)	1.11(0.52,2.40)	0.78(0.27,2.27)	0.98
Model 2	1	0.93(0.32,2.70)	0.95(0.32,2.83)	1.21(0.37,3.94)	0.75	1	0.48(0.17,1.39)	1.06(0.43,2.63)	0.87(0.26,2.85)	0.88
Daytime dysfunction										
Crude	1	0.49(0.23,1.02)	1.42(0.69,2.92)	0.87(0.38,1.97)	0.47	1	1.73(0.86,3.47)	1.40(0.70,2.78)	2.07(0.91,4.69)	0.10
Model 1	1	0.41(0.18,0.92)	1.14(0.52,2.49)	0.68(0.29,2.62)	0.83	1	1.80(0.83,3.90)	1.35(0.65,2.81)	1.64(0.64,4.18)	0.39
Model 2	1	0.45(0.17,1.18)	0.88(0.33,2.38)	0.86(0.30,2.52)	0.74	1	1.73(0.68,4.41)	1.31(0.53,3.21)	1.66(0.56,4.95)	0.45
Total sleep quality										
Crude	1	1.72(0.79,3.73)	2.47(1.03,5.93)	1.77(0.70,4.46)	0.11	1	0.67(0.34,1.34)	1.10(0.56,2.16)	1.20(0.63,2.31)	0.62
Model 1	1	1.31(0.56,3.09)	1.97(0.78,5.00)	1,49(0.57,3.92)	0.25	1	0.47(0.20,1.11)	0.73(0.31,1.73)	0.95(0.30,2.99)	0.95
Model 2	1	1.72(0.64,4.65)	2.14(0.68,6.75)	1.70(0.57,5.08)	0.34	1	0.39(0.14,1.06)	0.71(0.27,1.91)	1.10(0.31,3,95)	0.80

[a] Model 1: Adjusted for age, and energy intake

[b] Model 2: Further adjusted for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/d), depression score, syntax score, diabetes(yes/no) and caffeine intake

quartiles of DGL and DGI ($P \leq 0.05$). Additionally, marital status and physical activity both showed significant variation across DGL quartiles ($P < 0.05$).

Age, sex, and energy-adjusted nutrients and food intake of the participants across quartiles of DII and DIL are reported in Table 2. The adjusted dietary intake of participants across quartiles of DII and DIL is shown in Supplementary Table 3. Participants in the top quartile of DII had lower intakes of fiber, total fat, protein, nuts, dairy, vegetables, riboflavin, vitamin B6, Pantothenic acid, choline, vitamin E, vitamin A, potassium, sodium, calcium, and zinc ($P \leq 0.05$). In contrast, their intake of carbohydrates, whole grains, refined grains, fruits, and niacin was higher than those in the lowest quartile ($P < 0.05$). A significant association was also observed between higher DIL levels and intakes of protein, total fat, carbohydrate, energy, fruits, refined grains, potassium, vitamin E, riboflavin, and thiamin ($P < 0.05$). Subjects in the fourth quartile of DGL had significantly different intakes of energy, carbohydrate, total fat, fiber, fruits, red meat, nuts, zinc, potassium, pantothenic acid, vitamin B6, and niacin compared with those in the first quartile ($P < 0.05$). Conversely, participants in the highest quartiles of DGI had different intakes of energy, carbohydrates, fiber, pantothenic acid, potassium, zinc, fruits, red meat, and nuts than those in the lowest quartile ($P < 0.05$).

Table 3 provides the odds ratios for low sleep quality and abnormalities in its components across the quartile of DII, DIL, DGI, and DGL. In the fully adjusted model, individuals in the highest quartile of DII had 2.42 times higher odds of experiencing sleep disorders than those in the lowest quartile (OR = 2.42; 95% CI: 1.20–4.87; P_{trend} = 0.003). Similarly, a significant positive association was observed between DGI and sleep latency, with those in the highest quartile of DGI being 1.81 times more likely to experience sleep latency compared to individuals in the lowest quartile (OR = 1.81; 95% CI: 1.06–3.10; P_{trend} = 0.04). The relationship between DII, DIL, DGI, and DGL and the likelihood of sleep abnormalities stratified by gender is shown in Tables 4 and 5. A significant trend was identified between DIL and subjective sleep quality in model 2 in women ($P_{trend} \leq 0.05$, Table 4). Among men, those in the highest DII category were 2.61 times more likely to experience insufficient sleep in the final model (OR = 2.61; 95% CI: 1.07–6.41, P_{trend} = 0.03, Table 5). Moreover, there was a positive association between DII and sleep disorders (OR = 4.46; 95% CI: 1.49–13.36, P_{trend} = 0.01). Higher DII levels were also linked to an increased likelihood of sleep medication use among men in both crude and adjusted models ($P < 0.05$). Conversely, there was a significant negative relationship between DII and the likelihood of short sleep duration in men in the fully adjusted model (OR = 0.37; 95% CI: 0.16–0.89, P_{trend} = 0.02). Additionally, men in the highest DGI quartile reported higher chance of low subjective sleep quality than those in the lowest quartile (OR = 2.95; 95% CI: 1.16–7.50, P_{trend} = 0.04).

Tables 6 and 7 provide data on the associations stratified by diabetes status. A positive association was found between DGI and sleep latency in individuals with

Table 5 Association between dietary insulin and glycemic indices and domains of sleep quality among men

	Dietary insulin index					Dietary insulin load				
	Q1	Q2	Q3	Q4	P-trend	Q1	Q2	Q3	Q4	P-trend
Subjective sleep quality										
Crude	1	1.31(0.60,2.87)	1.70(0.80,3.63)	1.16(0.51,2.64)	0.55	1	0.82(0.33,2.05)	0.97(0.42,2.25)	1.11(0.49,2.50)	0.61
Model 1[a]	1	1.20(0.54,2.67)	1.78(0.82,3.84)	1.14(0.50,2.59)	0.40	1	0.98(0.36,2.64)	1.16(0.38,3.51)	1.49(0.30,7.41)	0.64
Model 2[b]	1	0.87(0.34,2.23)	1.52(0.60,3.87)	1.04(0.39,2.73)	0.66	1	0.72(0.21,2.51)	1.16(0.30,4.46)	1.24(0.19,8.20)	0.70
Sleep latency										
Crude	1	1.35(0.76,2.41)	0.95(0.53,1.72)	1.04(0.57,1.90)	0.80	1	0.63(0.32,1.26)	0.80(0.42,1.52)	0.77(0.41,1.45)	0.74
Model 1	1	1.31(0.73,2.35)	0.94(0.51,1.70)	1.01(0.55,1.85)	0.72	1	0.61(0.29,1.30)	0.72(0.31,1.69)	0.55(0.16,1.97)	0.48
Model 2	1	0.78(0.40,1.55)	0.52(0.25,1.07)	0.76(0.37,1.55)	0.28	1	0.63(0.27,1.52)	0.68(0.24,1.89)	0.53(0.12,2.36)	0.45
Sleep duration										
Crude	1	0.99(0.54,1.84)	0.70(0.37,1.33)	0.39(0.17,0.82)	0.008	1	0.96(0.43,2.11)	1.02(0.49,2.14)	1.10(0.54,2.27)	0.71
Model 1	1	1.02(0.54,1.91)	0.70(0.36,1.34)	0.39(0.19,0.83)	0.008	1	0.88(0.37,2.07)	0.81(0.31,2.14)	0.64(0.15,2.71)	0.59
Model 2	1	0.95(0.46,1.96)	0.74(0.35,1.59)	0.37(0.16,0.89)	0.02	1	0.63(0.24,1.67)	0.51(0.17,1.57)	0.33(0.06,1.68)	0.19
Sleep efficiency										
Crude	1	2.05(0.90,4.66)	2.35(1.04,5.28)	2.27(0.99,5.21)	0.06	1	0.88(0.37,2.12)	0.94(0.42,2.13)	1.03(0.47,2.28)	0.82
Model 1	1	2.00(0.88,4.55)	2.18(0.96,4.95)	2.22(0.96,5.11)	0.07	1	0.62(0.24,1.61)	0.55(0.19,1.59)	0.36(0.07,1.78)	0.24
Model 2	1	1.69(0.69,4.15)	2.30(0.94,5.64)	2.61(1.07,6.41)	0.03	1	0.70(0.25,1.98)	0.86(0.26,2.87)	0.52(0.09,3.04)	0.63
Sleep disorders										
Crude	1	2.16(0.87,5.33)	2.00(0.80,4.97)	2.95(1.22,7.17)	0.03	1	1.09(0.41,2.86)	0.56(0.20,1.54)	1.81(0.77,4.27)	0.13
Model 1	1	2.18(0.87,5.45)	2.16(0.85,5.48)	3.00(1.21,7.39)	0.03	1	0.98(0.35,2.74)	0.39(0.11,1.35)	0.96(0.19,4.95)	0.49
Model 2	1	2.61(0.85,8.01)	2.45(0.77,7.92)	4.46(1.49,13.36)	0.01	1	0.60(0.16,2.27)	0.45(0.10,1.98)	1.03(0.15,7.00)	0.90
Use of sleep medicine										
Crude	1	6.36(1,38,29.22)	8.23(1.83,37.09)	7.80(1.71,35.66)	0.006	1	2.34(0.71,7.67)	1.17(0.34,3.98)	2.07(0.66,6.45)	0.48
Model 1	1	5.64(1.21,26.21)	8.11(1.80,36.59)	7.65(1.67,35.03)	0.005	1	3.50(0.89,13,75)	2.00(0.42,9.56)	4.60(0.60,35.38)	0.36
Model 2	1	3.90(0.75,20.28)	6.56(1.30,33.09)	6.78(1.31,35.19)	0.01	1	1.51(0.32,7.21)	1.20(0.20,7.19)	2.26(0.20,25.27)	0.66
Daytime dysfunction										
Crude	1	2.22(1.01,4.88)	1.47(0.64,3.37)	1.66(0.72,3.80)	0.48	1	1.63(0.58,4.57)	1.87(0.71,4.95)	2.23(0.86,5.77)	0.09
Model 1	1	2.20(0.99,4.87)	1.51(0.66,3.49)	1.62(0.70,3.73)	0.51	1	1.50(0.51,4.42)	1.50(0.46,4.88)	1.51(0.29,7.83)	0.64
Model 2	1	2.11(0.84,5.29)	0.86(0.31,2.38)	1.34(0.50,3.61)	0.92	1	2.04(0.54,7.71)	2.07(0.47,9.15)	1.66(0.22,12.30)	0.62
Total sleep quality										
Crude	1	1.87(1.02,3.43)	1.31(0.71,2.42)	1.61(0.86,2.99)	0.30	1	0.88(0.43,1.82)	1.25(0.64,2.44)	1.22(0.63,2.35)	0.33
Model 1	1	1.78(0.97,3.28)	1.23(0.66,2.30)	1.55(0.83,2.91)	0.37	1	0.74(0.34,1.59)	0.92(0.38,2.18)	0.67(0.19,2.43)	0.75
Model 2	1	1.55(0.77,3.14)	0.96(0.46,2.02)	1.27(0.61,2.65)	0.86	1	0.71(0.28,1.76)	1.00(0.35,2.85)	0.58(0.13,2.60)	0.73
	Dietary glycemic index					**Dietary glycemic load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	2.15(0.91,5.11)	1.38(0.57,3.32)	2.80(1.28,6.14)	0.03	1	0.45(0.18,1.16)	1.09(0.48,2.47)	1.23(0.56,2.70)	0.13
Model 1	1	1.98(0.81,4.82)	1.33(0.55,3.21)	2.58(1.16,5.72)	0.04	1	0.46(0.17,1.29)	1.05(0.42,2.65)	1.20(0.45,3.16)	0.14
Model 2	1	1.89(0.66,5.39)	1.24(0.44,3.53)	2.95(1.16,7.50)	0.04	1	0.68(0.20,2.32)	1.18(0.36,3.84)	1.53(0.46,5.13)	0.17
Sleep latency										
Crude	1	1.38(0.74,2.56)	0.87(0.48,1.59)	1.69(0.96,2.96)	0.17	1	0.70(0.36,1.36)	1.07(0.56,2.05)	0.95(0.50,1.78)	0.66
Model 1	1	1.38(0.73,2.61)	0.83(0.45,1.53)	1.79(1.01,3.18)	0.13	1	0.65(0.32,1.35)	1.01(0.49,2.07)	0.90(0.42,1.92)	0.64
Model 2	1	1.37(0.65,2.91)	0.98(0.47,2.02)	1.87(0.95,3.68)	0.13	1	0.66(0.29,1.54)	0.99(0.43,2.29)	0.87(0.36,2.10)	0.80
Sleep duration										
Crude	1	0.64(0.31,1.33)	0.74(0.38,1.44)	1.24(0.68,2.27)	0.41	1	1.32(0.61,2.89)	1.59(0.74,3.44)	1.26(0.59,2.70)	0.61
Model 1	1	0.72(0.34,1.53)	0.84(0.42,1.66)	1.48(0.79,2.77)	0.21	1	1.14(0.49,2.64)	1.60(0.69,3.72)	1.23(0.50,3.03)	0.55
Model 2	1	1.01(0.44,2.30)	0.78(0.35,1.74)	1.44(0.70,2.97)	0.42	1	0.88(0.34,2.25)	1.19(0.46,3.07)	0.90(0.33,2.45)	0.98
Sleep efficiency										
Crude	1	1.56(0.72,3.41)	1.22(0.57,2.62)	1.46(0.71,3.00)	0.43	1	0.67(0.29,1.55)	0.80(0.35,1.82)	1.11(0.52,2.40)	0.44
Model 1	1	1.71(0.77,3.81)	1.16(0.54,2.53)	1.48(0.71,3.07)	0.46	1	0.55(0.22,1.37)	0.62(0.25,1.56)	0.87(0.35,2.25)	0.68
Model 2	1	1.38(0.59,3.23)	1.10(0.48,2.56)	1.31(0.59,2.88)	0.62	1	0.78(0.30,2.06)	0.75(0.28,2.06)	1.11(0.40,3.10)	0.66

Table 5 (continued)

Sleep disorders										
Crude	1	1.02(0.40,2.62)	1.01(0.42,2.47)	2.52(1.17,5.42)	0.01	1	0.76(0.28,2.06)	1.08(0.42,2.76)	1.85(0.78,4.39)	0.04
Model 1	1	1.09(0.42,2.83)	0.94(0.38,2.33)	2.18(0.99,4.78)	0.05	1	0.53(0.18,1.56)	0.70(0.25,1.96)	1.04(0.37,2.97)	0.36
Model 2	1	0.49(0.15,1.62)	0.68(0.24,1.93)	1.61(0.66,3.92)	0.19	1	0.72(0.20,2.67)	0.58(0.15,2.22)	1.02(0.27,3.84)	0.70
Use of sleep medicine										
Crude	1	1.96(0.71,5.41)	1.71(0.63,4.61)	1.85(0.72,4.80)	0.28	1	0.31(0.10,0.96)	0.89(0.35,2.22)	0.81(0.33,1.97)	0.65
Model 1	1	1.86(0.65,5.35)	1.77(0.65,4.80)	1.93(0.73,5.07)	0.23	1	0.29(0.08,1.02)	0.89(0.31,2.57)	0.77(0.25,2.38)	0.53
Model 2	1	2.41(0.62,9.45)	2.51(0.71,8.93)	2.46(0.75,8.11)	0.16	1	0.28(0.06,1.36)	0.88(0.22,3.58)	0.83(0.20,3.57)	0.44
Daytime dysfunction										
Crude	1	1.15(0.52,2.53)	0.54(0.22,1.28)	1.55(0.77,3.10)	0.32	1	1.02(0.42,2.51)	0.88(0.35,2.20)	1.74(0.76,3.98)	0.12
Model 1	1	1.26(0.56,2.83)	0.52(0.22,1.25)	1.42(0.70,2.88)	0.61	1	0.81(0.31,2.13)	0.66(0.25,1.80)	1.23(0.46,3.30)	0.45
Model 2	1	0.98(0.38,2.56)	0.53(0.20,1.43)	0.98(0.42,2.29)	0.76	1	0.84(0.27,2.62)	0.59(0.18,1.96)	0.83(0.25,2.72)	0.77
Total sleep quality										
Crude	1	1.30(0.69,2.48)	1.05(0.57,1.94)	1.95(1.10,3.49)	0.04	1	0.39(0.18,0.86)	0.66(0.29,1.48)	0.88(0.31,2.49)	0.18
Model 1	1	1.37(0.71,2.64)	1.02(0.55,1.90)	1.97(1.09,3.56)	0.06	1	0.56(0.27,1.18)	0.89(0.43,1.86)	0.97(0.44,2.11)	0.38
Model 2	1	1.07(0.50,2.30)	0.91(0.44,1.89)	1.62(0.82,3.21)	0.22	1	0.68(0.29,1.61)	0.74(0.32,1.85)	0.95(0.38,2.37)	0.75

[a] Model 1: Adjusted for age, and energy intake

[b] Model 2: Further adjusted for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/wk), depression score, syntax score, diabetes(yes/no) and caffeine intake

diabetes after adjusting for all potential confounders (OR =3.37; 95% CI: 1.23–9.18; P_{trend}= 0.02, Table 6). In patients without diabetes, a significant association was reported between DII and sleep efficiency (OR =2.39; 95% CI: 1.03–5.55; P_{trend}= 0.06) and sleep disorders (OR =3.16; 95% CI: 1.24–8.05; P_{trend}= 0.009). Also, there was a significant association between DII and the likelihood of use of sleep medicine (OR =3.08; 95% CI: 1.13–8.36; P_{trend}= 0.02). An increasing trend but non-significant relationship was observed between DIL and subjective sleep quality among patients without diabetes (P_{trend}= 0.04). In addition, Higher DGI was associated with higher odds of sleep medication (OR =2.66; 95% CI: 1.04–6.78; P_{trend}= 0.05) in this subgroup (Table 7).

Discussion

The present study revealed that a higher DII was related to an increased likelihood of sleep disorders. In addition, a positive relationship was found between DGI and odds of sleep latency. However, no significant association was found between DGL and DIL and sleep quality and duration. A few studies have examined the relationship between dietary glycemic or insulin indices and sleep quality or duration, with inconsistent findings. Mohammadi et al. [30] performed a cross-sectional study on a general population of Yazd, Iran, and found an association between DGL and sleep duration. This study reported no significant relation between DGI and sleep duration. In contrast, we found no significant association between either DGI or DGL and sleep duration among all participants. Our analyses only show an inverse association between DII and odds of low sleep duration in men and patients without diabetes. In another population-based cross-sectional study that used the short form PSQI to assess sleep quality and quantity, an inverse relationship was shown between DIL and DII and sleep disturbance [29]. The results of our study using the complete form of PSQI showed that people with higher DII had a higher chance of having sleep disorders, and no significant relationship was found between DIL and sleep disorders. In a cross-over clinical trial on nine male basketball players, consuming meals with different GI did not significantly change sleep parameters [31]. Gangwisch et al. indicated that a diet with a high GI might contribute to the risk of insomnia in postmenopausal women [32]. A cross-over trial involving 12 healthy male participants showed that consuming a high-GI meal 4 h before bedtime significantly decreased sleep onset latency (SOL) compared to a low-GI meal. This research used recording polysomnography to assess SOL [61].

Recently, research indicated a mutual connection between sleep quality and quantity and dietary intake. These aspects of sleep, along with how they interact with one's diet, affect the likelihood of developing chronic diseases [62]. Limited sleep has been shown to lead to a higher intake of calories, with a tendency towards consuming foods high in carbohydrates and fats, which are known to be linked with a negative impact on cardiometabolic health [63–65]. Diets rich in plant foods, such as the Mediterranean diet, have the potential to lower the risk of cardiovascular disease (CVD) by enhancing sleep quality through the intake of tryptophan [66].

High-glycemic-index carbohydrates have been recognized for their role in enhancing tryptophan turnover,

Table 6 The likelihood for sleep characteristics based on quartiles of dietary insulin and glycemic indices in patients with diabetes

	Dietary insulin index					Dietary insulin load				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.55(0.67,3.60)	1.62(0.71,3.68)	1.70(0.71,4.10)	0.23	1	0.81(0.37,1.77)	0.81(0.35,1.90)	0.92(0.42,2.03)	0.80
Model 1[a]	1	1.75(0.71,4.34)	1.91(0.79,4.67)	2.05(0.81,5.21)	0.12	1	1.05(0.41,2.67)	1.37(0.39,4.84)	2.83(0.41,19.37)	0.43
Model 2[b]	1	1.07(0.35,3.26)	1.61(0.55,4.68)	1.34(0.44,4.07)	0.46	1	0.82(0.26,2.61)	0.94(0.20,4.52)	1.55(0.17,14.23)	0.85
Sleep latency										
Crude	1	0.74(0.36,1.54)	0.68(0.33,1.38)	1.02(0.47,2.21)	0.83	1	0.43(0.21,0.89)	0.57(0.26,1.22)	0.39(0.19,0.82)	0.02
Model 1	1	0.74(0.34,1.61)	0.64(0.30,1.38)	1.01(0.45,2.31)	0.82	1	0.37(0.16,0.88)	0.42(0.13,1.31)	0.19(0.03,1.14)	0.08
Model 2	1	0.52(0.21,1.30)	0.73(0.30,1.77)	0.97(0.37,2.55)	0.94	1	0.41(0.16,1.10)	0.59(0.15,2.30)	0.38(0.05,2.88)	0.32
Sleep duration										
Crude	1	1.50(0.66,3.43)	1.81(0.81,4.02)	0.86(0.34,2.22)	0.90	1	0.78(0.36,1.70)	0.76(0.33,1.77)	0.80(0.36,1.79)	0.55
Model 1	1	1.43(0.61,3.37)	1.75(0.76,4.01)	0.90(0.34,2.37)	0.88	1	0.94(0.37,2.38)	0.95(0.27,3.27)	1.26(0.19,8.32)	0.94
Model 2	1	1.33(0.49,3.66)	1.82(0.69,4.83)	1.02(0.34,3.02)	0.77	1	0.77(0.27,2.15)	0.91(0.22,3.84)	0.68(0.08,5.83)	0.77
Sleep efficiency										
Crude	1	1.10(0.48,2.53)	1.16(0.52,2.61)	0.86(0.35,2.16)	0.86	1	0.51(0.22,1.16)	0.61(0.26,1.43)	0.65(0.29,1.47)	0.28
Model 1	1	1.02(0.43,2.42)	1.10(0.48,2.55)	0.87(0.34,2.19)	0.85	1	0.42(0.16,1.09)	0.39(0.11,1.38)	0.28(0.04,2.10)	0.14
Model 2	1	1.17(0.41,3.30)	1.43(0.54,3.81)	0.68(0.23,2.04)	0.64	1	0.36(0.12,1.06)	0.39(0.09,1.67)	0.29(0.03,2.72)	0.17
Sleep disorders										
Crude	1	0.84(0.36,1.96)	1.55(0.71,3.35)	1.13(0.48,2.69)	0.43	1	1.12(0.53,2.40)	0.73(0.30,1.75)	0.96(0.44,2.12)	0.71
Model 1	1	0.89(0.36,2.23)	1.70(0.73,3.98)	1.35(0.54,3.39)	0.28	1	0.89(0.35,2.25)	0.43(0.12,1.57)	0.43(0.06,3.12)	0.25
Model 2	1	1.30(0.40,4.24)	3.45(1.14,10.45)	1.60(0.49,5.22)	0.17	1	0.65(0.20,2.11)	0.45(0.09,2.38)	0.54(0.05,6.26)	0.43
Use of sleep medicine										
Crude	1	1.15(0.40,3.30)	0.75(0.24,2.31)	1.46(0.50,4.24)	0.71	1	1.29(0.52,3.19)	0.39(0.10,1.46)	0.45(0.14,1.48)	0.08
Model 1	1	1.12(0.37,3.34)	0.61(0.19,1.99)	1.39(0.46,4.22)	0.85	1	1.83(0.60,5.64)	0.76(0.12,4.78)	1.88(0.14,26.12)	0.86
Model 2	1	1.03(0.28,3.82)	0.51(0.13,2.00)	0.83(0.21,2.28)	0.55	1	1.59(0.42,6.03)	0.58(0.06,5.59)	0.76(0.03,18.13)	0.85
Daytime dysfunction										
Crude	1	1.29(0.54,3.05)	1.26(0.54,2.93)	1.22(0.49,3.04)	0.67	1	0.63(0.28,1.45)	0.67(0.27,1.63)	0.80(0.35,1.81)	0.54
Model 1	1	1.39(0.55,3.48)	1.32(0.54,3.26)	1.36(0.52,3.55)	0.55	1	0.55(0.21,1.47)	0.52(0.14,1.90)	0.55(0.07,4.19)	0.37
Model 2	1	0.97(0.30,3.14)	1.18(0.39,3.57)	1.29(0.40,4.13)	0.61	1	0.46(0.14,1.51)	0.24(0.04,1.33)	0.22(0.02,2.45)	0.12
Total sleep quality										
Crude	1	1.44(0.67,3.09)	1.47(0.70,3.10)	1.04(0.47,2.33)	0.79	1	0.60(0.28,1.25)	0.85(0.38,1.92)	0.43(0.20,0.92)	0.07
Model 1	1	1.51(0.65,3.49)	1.40(0.61,3.19)	1.15(0.48,2.78)	0.74	1	0.47(0.19,1.18)	0.60(0.18,2.04)	0.22(0.03,1.43)	0.21
Model 2	1	1.15(0.43,3.08)	1.50(0.56,4.00)	0.79(0.28,2.21)	0.83	1	0.34(0.12,0.99)	0.53(0.13,2.19)	0.13(0.02,1.09)	0.12
	Dietary glycemic index					**Dietary glycemic load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.66(0.70,3.96)	2.38(0.99,5.68)	1.27(0.52,3.11)	0.49	1	0.83(0.36,1.90)	1.14(0.52,2.52)	0.90(0.39,2.07)	1.00
Model 1	1	1.42(0.53,3.75)	2.43(0.95,6.24)	1.23(0.47,3.25)	0.47	1	0.96(0.38,2.44)	1.23(0.52,2.94)	1.19(0.41,3.44)	0.60
Model 2	1	2.05(0.56,7.60)	3.65(1.05,12.72)	1.76(0.49,6.36)	0.30	1	1.34(0.42,4.26)	1.67(0.53,5.23)	1.57(0.42,5.78)	0.44
Sleep latency										
Crude	1	2.14(1.01,4.54)	2.06(0.95,4.49)	2.14(1.01,4.54)	0.07	1	0.48(0.23,1.01)	0.91(0.44,1.90)	0.86(0.41,1.81)	0.98
Model 1	1	1.72(0.74,3.98)	1.92(0.83,4.43)	2.39(1.05,5.41)	0.04	1	0.56(0.24,1.28)	1.09(0.49,2.46)	1.37(0.52,3.60)	0.27
Model 2	1	2.14(0.77,5.94)	2.80(1.02,7.68)	3.37(1.23,9.18)	0.02	1	0.46(0.17,1.25)	1.15(0.44,3.00)	1.69(0.52,5.44)	0.15
Sleep duration										
Crude	1	0.93(0.41,2.11)	0.86(0.36,2.02)	0.95(0.42,2.16)	0.87	1	1.20(0.53,2.68)	1.06(0.47,2.40)	1.00(0.43,2.32)	0.96
Model 1	1	0.94(0.38,2.30)	0.97(0.40,2.35)	1.13(0.48,2.67)	0.77	1	1.26(0.51,3.07)	1.25(0.52,2.98)	1.37(0.48,3.91)	0.57
Model 2	1	0.97(0.34,2.81)	1.06(0.38,2.98)	1.31(0.47,3.67)	0.59	1	1.51(0.53,4.29)	1.81(0.65,5.00)	1.31(0.37,4.60)	0.54
Sleep efficiency										
Crude	1	1.60(0.66,3.85)	1.56(0.63,3.84)	1.56(0.65,3.76)	0.38	1	0.53(0.22,1.26)	0.79(0.35,1.79)	0.91(0.40,2.06)	0.94
Model 1	1	1.42(0.55,3.65)	1.55(0.61,3.93)	1.61(0.65,3.99)	0.31	1	0.57(0.22,1.48)	0.85(0.36,2.02)	1.12(0.40,3.12)	0.70
Model 2	1	0.97(0.33,2.88)	1.38(0.48,4.02)	1.30(0.45,3.75)	0.49	1	0.89(0.31,2.58)	0.87(0.31,2.45)	1.69(0.50,5.77)	0.50

Table 6 (continued)

Sleep disorders										
Crude	1	2.26(0.98,5.19)	1.41(0.58,3.47)	1.33(0.56,3.17)	0.88	1	0.53(0.24,1.20)	0.62(0.28,1.35)	0.52(0.23,1.19)	0.13
Model 1	1	2.71(1.03,7.15)	1.69(0.63,4.53)	1.64(0.62,4.30)	0.62	1	0.42(0.16,1.09)	0.50(0.20,1.21)	0.43(0.14,1.28)	0.15
Model 2	1	2.31(0.68,7.86)	1.20(0.33,4.37)	1.36(0.39,4.74)	0.99	1	0.50(0.16,1.64)	0.35(0.11,1.12)	0.43(0.11,1.67)	0.15
Use of sleep medicine										
Crude	1	2.34(0.76,7.24)	1.86(0.57,6.11)	1.15(0.33,4.02)	0.98	1	0.29(0.09,0.95)	0.52(0.19,1.40)	0.40(0.13,1.19)	0.11
Model 1	1	1.66(0.48,5.72)	1.55(0.44,5.43)	1.12(0.30,4.13)	0.97	1	0.36(0.10,1.28)	0.59(0.21,1.67)	0.65(0.17,2.54)	0.50
Model 2	1	1.11(0.25,4.96)	1.44(0.32,6.55)	0.79(0.16,3.86)	0.90	1	0.43(0.10,1.80)	0.56(0.15,2.11)	0.73(0.14,3.73)	0.66
Daytime dysfunction										
Crude	1	1.87(0.77,4.54)	1.70(0.68,4.28)	1.17(0.46,2.99)	0.86	1	0.90(0.39,2.07)	0.69(0.29,1.64)	0.87(0.37,2.05)	0.60
Model 1	1	1.92(0.71,5.21)	1.93(0.72,5.18)	1.34(0.49,3.67)	0.63	1	0.98(0.38,2.53)	0.72(0.28,1.85)	1.18(0.39,3.53)	0.96
Model 2	1	1.86(0.51,6.71)	1.61(0.45,5.70)	1.57(0.43,5.76)	0.62	1	0.81(0.25,2.64)	0.54(0.16,1.83)	1.10(0.26,3.90)	0.80
Total sleep quality										
Crude	1	2.61(1.18,5.75)	1.66(0.74,3.69)	1.50(0.70,3.23)	0.54	1	0.36(0.16,0.78)	0.60(0.27,1.31)	0.46(0.21,1.02)	0.13
Model 1	1	2.19(0.89,5.42)	1.56(0.64,3.78)	1.56(0.66,3.66)	0.48	1	0.35(0.14,0.87)	0.56(0.23,1.38)	0.55(0.19,1.57)	0.48
Model 2	1	2.42(0.84,6.94)	1.87(0.66,5.27)	1.40(0.52,1.81)	0.65	1	0.32(0.11,0.91)	0.50(0.17,1.47)	0.50(0.15,1.73)	0.51

[a] Model 1: Adjusted for age, sex, and energy intake

[b] Model 2: Further adjusted for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/wk), depression score, syntax score, and caffeine intake

leading to increased levels of tryptophan and serotonin in the brain, which supports sleep [67]. Following the consumption of carbohydrate-rich foods, insulin release promotes the uptake of long-chain neutral amino acids (LNAA) by muscles, leaving more circulating tryptophan available to enter the brain, where it enhances serotonin and melatonin production and improves sleep [68]. Moreover, the rise in plasma tryptophan levels due to insulin release supports mental health and cognitive functions [69]. Diets with a high glycemic index may also alleviate stress by reducing the activity of the hypothalamic–pituitary–adrenal (HPA) axis [70, 71].

High-glycemic load diets may also contribute to depression through frequent blood sugar fluctuations [72]. Elevated postprandial glucose levels, followed by excessive insulin release, can reduce plasma glucose to approximately ~70 mg/dL (3.8 mmol/L), potentially impairing brain glucose availability [73]. This disruption stimulates the release of counterregulatory hormones such as cortisol, adrenaline, glucagon, and growth hormone [74]. The physiological effects of these hormonal responses may include symptoms such as heart palpitations, tremors, cold sweats, paresthesia, anxiety, irritability, and intensified hunger [75].

The variation in research outcomes may be attributed to the distinct characteristics of the disease. Based on previous evidence, patients with coronary artery disease commonly experience a range of symptoms, including difficulties with sleep, persistent tiredness, angina, perspiration, a sense of frailty, and breathing difficulties [76, 77]. Poor sleep quality is prevalent among cardiovascular disease patients [78]. Moreover, it was found that patients who underwent coronary angiography had low sleep quality and high levels of fatigue [79]. Previous studies have focused on the general population, athletes, and postmenopausal women, and none have examined individuals with cardiovascular problems [29, 31, 32]. Additionally, it is essential to consider the differences in dietary habits observed among the studied groups. Traditionally, the diet of Iranian individuals, along with that of many in the Middle East and North Africa (MENA) region, is characterized by high carbohydrate-rich foods such as cereals, rice, and potatoes, which serve as their primary energy sources [80]. Over recent decades, there has been a notable rise in the intake of simple sugars, refined grains, and desserts within the Iranian community [81]. In this regard, evaluating the relationship between glycemic indices and diseases in the Iranian population is highlighted.

In the stratified analysis based on diabetes status, the relationship between DII and sleep disturbance, sleep medication use, and sleep efficiency was significant and positive in patients without diabetes, suggesting the possibility of reverse causality. The unexpected results of stratified analysis may be referred to the dietary modifications that individuals with diabetes might have adopted in response to their condition. In addition, the stratified analysis based on gender showed a positive significant association between DII and sleep efficiency, sleep disorders, and sleep medication among men, probably due to the more substantial number of male participants than female participants.

Table 7 The likelihood for sleep characteristics based on quartiles of dietary insulin and glycemic indices in patients without diabetes

	Dietary insulin index					**Dietary insulin load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.00(0.52,1.92)	0.99(0.51,1.90)	0.83(0.42,1.61)	0.58	1	0.91(0.47,1.76)	0.74(0.38,1.43)	0.62(0.22,1.23)	0.13
Model 1[a]	1	0.98(0.49,1.93)	1.08(0.55,2.12)	0.81(0.41,1.62)	0.63	1	1.36(0.64,2.90)	1.53(0.57,4.07)	1.75(0.40,7.66)	0.41
Model 2[b]	1	1.26(0.55,2.90)	1.28(0.56,2.94)	1.37(0.59,3.18)	0.48	1	2.19(0.87,5.51)	3.79(1.16,12.45)	5.25(0.89,30.99)	0.04
Sleep latency										
Crude	1	1.65(0.93,2.92)	1.68(0.95,2.99)	1.04(0.59,1.86)	0.95	1	0.86(0.48,1.56)	0.62(0.34,1.10)	0.54(0.30,0.97)	0.02
Model 1	1	1.66(0.91,3.00)	1.78(0.98,3.24)	0.98(0.54,1.78)	0.91	1	1.01(0.52,1.96)	0.90(0.39,2.06)	0.82(0.23,2.87)	0.75
Model 2	1	1.12(0.57,2.22)	1.24(0.62,2.46)	0.90(0.45,1.80)	0.82	1	1.43(0.67,3.07)	1.05(0.40,2.78)	0.87(0.20,3.81)	0.93
Sleep duration										
Crude	1	0.59(0.31,1.14)	0.52(0.27,1.02)	0.36(0.18,0.73)	0.005	1	0.95(0.42,2.12)	1.85(0.89,3.83)	1.64(0.78,3.44)	0.07
Model 1	1	0.60(0.31,1.18)	0.55(0.28,1.09)	0.37(0.18,0.76)	0.008	1	0.69(0.28,1.68)	0.90(0.32,2.49)	0.38(0.08,1.83)	0.52
Model 2	1	0.66(0.31,1.43)	0.63(0.29,1.37)	0.38(0.16,0.90)	0.03	1	0.52(0.19,1.41)	0.66(0.21,2.09)	0.22(0.04,1.31)	0.24
Sleep efficiency										
Crude	1	1.73(0.85,3.53)	1.56(0.76,3.20)	1.67(0.82,3.41)	0.25	1	0.94(0.47,1.90)	1.03(0.53,2.02)	0.86(0.43,1.73)	0.75
Model 1	1	1.77(0.86,3.64)	1.57(0.75,3.27)	1.59(0.77,3.29)	0.33	1	0.85(0.39,1.86)	1.05(0.40,2.77)	0.66(0.15,2.94)	0.85
Model 2	1	1.83(0.78,4.30)	1.89(0.81,4.39)	2.39(1.03,5.55)	0.06	1	0.98(0.41,2.34)	1.56(0.52,4.67)	0.94(0.17,5.04)	0.67
Sleep disorders										
Crude	1	1.25(0.63,2.47)	1.46(0.75,2.87)	1.42(0.73,2.79)	0.27	1	0.82(0.43,1.57)	0.39(0.19,0.79)	0.68(0.36,1.31)	0.09
Model 1	1	1.36(0.64,2.89)	1.87(0.89,3.95)	1.57(0.75,3.30)	0.18	1	1.15(0.53,2.49)	0.68(0.24,1.94)	1.49(0.33,6.87)	0.94
Model 2	1	1.77(0.68,4.58)	2.80(1.10,7.14)	3.16(1.24,8.05)	0.009	1	1.27(0.50,3.20)	1.21(0.36,4.07)	2.90(0.49,17.33)	0.43
Use of sleep medicine										
Crude	1	1.62(0.72,3.64)	1.71(0.86,3.81)	2.14(0.98,4.69)	0.07	1	1.07(0.53,2.17)	0.39(0.17,0.88)	0.76(0.37,1.57)	0.14
Model 1	1	1.69(0.72,3.96)	2.02(0.87,4.68)	2.32(1.03,5.26)	0.04	1	1.43(0.64,3.21)	0.62(0.20,1.91)	1.33(0.27,6.61)	0.81
Model 2	1	1.65(0.60,4.55)	2.14(0.79,5.76)	3.08(1.13,8.36)	0.02	1	1.18(0.46,3.01)	0.62(0.17,2.28)	0.92(0.13,6.40)	0.66
Daytime dysfunction										
Crude	1	1.92(0.97,3.78)	1.45(0.73,2.90)	1.43(0.72,2.87)	0.56	1	1.63(0.81,3.28)	1.32(0.66,2.66)	1.34(0.66,2.70)	0.66
Model 1	1	2.00(0.99,4.06)	1.53(0.74,3.18)	1.46(0.71,3.02)	0.54	1	2.12(0.96,4.68)	2.04(0.75,5.55)	2.25(0.52,9.81)	0.23
Model 2	1	2.18(0.95,5.00)	1.22(0.52,2.85)	1.66(0.71,3.86)	0.60	1	2.43(0.97,6.07)	2.27(0.70,7.38)	1.92(0.34,10.92)	0.31
Total sleep quality										
Crude	1	1.51(0.84,2.73)	1.08(0.60,1.94)	1.48(0.82,2.66)	0.40	1	0.67(0.36,1.25)	0.53(0.29,0.97)	0.50(0.27,0.92)	0.02
Model 1	1	1.54(0.82,2.87)	1.05(0.56,1.97)	1.38(0.74,2.58)	0.59	1	0.75(0.37,1.53)	0.78(0.32,1.88)	0.69(0.18,2.60)	0.59
Model 2	1	1.38(0.66,2.89)	0.86(0.40,1.82)	1.59(0.75,3.35)	0.46	1	0.87(0.38,2.02)	1.24(0.42,3.61)	0.88(0.18,4.33)	0.89
	Dietary glycemic index					**Dietary glycemic load**				
	Q1	**Q2**	**Q3**	**Q4**	**P-trend**	**Q1**	**Q2**	**Q3**	**Q4**	**P-trend**
Subjective sleep quality										
Crude	1	1.67(0.85,3.29)	1.66(0.85,3.23)	1.50(0.75,3.00)	0.29	1	0.53(0.26,1.06)	1.03(0.55,1.94)	0.80(0.42,1.53)	1.00
Model 1	1	1.36(0.66,2.81)	1.66(0.83,3.22)	1.69(0.82,3.50)	0.12	1	0.82(0.37,1.80)	1.61(0.78,3.34)	1.50(0.66,3.42)	0.10
Model 2	1	1.65(0.70,3.87)	1.62(0.71,3.68)	1.71(0.74,3.96)	0.23	1	0.76(0.30,1.94)	1.57(0.66,3.73)	1.50(0.57,3.96)	0.15
Sleep latency										
Crude	1	1.50(0.86,2.64)	1.16(0.67,2.01)	1.27(0.72,2.24)	0.61	1	0.43(0.24,0.77)	0.74(0.41,1.31)	0.50(0.28,0.90)	0.12
Model 1	1	1.31(0.72,2.40)	1.17(0.66,2.09)	1.54(0.85,2.81)	0.22	1	0.56(0.29,1.08)	0.96(0.50,1.84)	0.78(0.38,1.59)	0.88
Model 2	1	1.20(0.60,2.40)	1.07(0.55,2.10)	1.48(0.75,2.91)	0.33	1	0.55(0.26,1.19)	0.88(0.42,1.85)	0.78(0.35,1.75)	0.95
Sleep duration										
Crude	1	0.70(0.34,1.45)	0.73(0.36,1.48)	1.68(0.88,3.22)	0.12	1	1.27(0.58,2.76)	2.11(1.01,4.39)	1.78(0.84,3.74)	0.06
Model 1	1	0.82(0.38,1.76)	0.82(0.40,1.69)	1.84(0.94,3.62)	0.10	1	0.95(0.40,2.28)	1.75(0.76,4.03)	1.31(0.53,3.26)	0.27
Model 2	1	1.22(0.53,2.86)	0.69(0.30,1.63)	1.60(0.75,3.44)	0.41	1	0.63(0.23,1.69)	1.24(0.50,3.11)	0.81(0.29,2.25)	0.77
Sleep efficiency										
Crude	1	1.15(0.57,3.33)	1.57(0.81,3.04)	1.38(0.70,2.74)	0.24	1	0.88(0.44,1.79)	1.16(0.59,2.29)	1.22(0.62,2.41)	0.40
Model 1	1	1.22(0.58,2.54)	1.68(0.85,3.35)	1.70(0.83,3.48)	0.09	1	1.07(0.49,2.34)	1.40(0.65,3.01)	1.75(0.76,4.03)	0.12
Model 2	1	1.30(0.57,2.92)	1.66(0.77,3.58)	1.66(0.76,3.63)	0.16	1	1.11(0.46,2.66)	1.43(0.61,3.32)	1.70(0.67,4.30)	0.19

Table 7 (continued)

Sleep disorders										
Crude	1	1.17(0.60,2.31)	1.30(0.68,2.51)	1.45(0.75,2.82)	0.25	1	0.59(0.30,1.14)	0.67(0.35,1.29)	0.85(0.45,1.59)	0.74
Model 1	1	0.98(0.46,2.09)	1.33(0.65,2.75)	1.76(0.84,3.69)	0.10	1	0.83(0.37,1.86)	0.97(0.44,2.11)	1.51(0.64,3.57)	0.26
Model 2	1	0.84(0.34,2.09)	1.24(0.52,2.91)	1.86(0.79,4.42)	0.11	1	1.01(0.38,2.66)	1.00(0.39,2.53)	1.88(0.69,5.17)	0.22
Use of sleep medicine										
Crude	1	1.63(0.76,3.52)	1.69(0.80,3.60)	1.59(0.73,3.45)	0.26	1	0.36(0.16,0.82)	0.97(0.49,1.90)	0.65(0.32,1.33)	0.72
Model 1	1	1.38(0.61,3.13)	1.80(0.83,3.91)	1.90(0.85,4.27)	0.09	1	0.49(0.20,1.21)	1.36(0.62,2.98)	1.01(0.41,2.49)	0.32
Model 2	1	1.88(0.70,5.07)	1.94(0.76,4.94)	2.66(1.04,6.78)	0.05	1	0.37(0.12,1.10)	1.21(0.48,3.06)	1.23(0.42,3.54)	0.17
Daytime dysfunction										
Crude	1	0.48(0.24,0.96)	0.73(0.39,1.38)	1.06(0.57,1.96)	0.66	1	1.23(0.62,2.42)	1.09(0.55,2.16)	1.58(0.81,3.06)	0.23
Model 1	1	0.41(0.19,0.86)	0.63(0.32,1.23)	1.08(0.56,2.09)	0.69	1	1.59(0.73,3.47)	1.31(0.60,2.86)	2.12(0.91,4.91)	0.15
Model 2	1	0.40(0.17,0.95)	0.66(0.30,1.45)	0.92(0.43,1.96)	0.99	1	1.63(0.66,4.01)	1.45(0.60,3.50)	1.71(0.65,4.50)	0.40
Total sleep quality										
Crude	1	1.30(0.73,2.32)	1.23(0.70,2.16)	1.65(0.92,2.97)	0.13	1	0.43(0.24,0.79)	0.65(0.36,1.19)	0.66(0.36,1.21)	0.47
Model 1	1	1.17(0.61,2.21)	1.25(0.68,2.31)	2.29(1.20,4.36)	0.02	1	0.60(0.30,1.21)	0.95(0.47,1.92)	1.16(0.54,2.52)	0.25
Model 2	1	1.01(0.48,2.15)	1.05(0.51,2.17)	1.93(0.93,4.03)	0.10	1	0.66(0.29,1.52)	0.88(0.39,1.97)	1.20(0.50,2.89)	0.39

[a] Model 1: Adjusted for age, sex, and energy intake

[b] Model 2: Further adjusted for marital status, education level, occupation, economic condition, BMI, smoking status, drug addiction, physical activity (METs/wk), depression score, syntax score, and caffeine intake

This study had several strengths, including using validated food frequency questionnaires (FFQ) and standardized tools for data collection and incorporating adjustments for a wide range of possible confounding factors that could influence the findings. However, certain limitations were identified. The reliance on validated FFQ for dietary assessment does not exclude the risk of misclassification and recall bias among participants. While the study accounted for numerous confounding factors, it remains possible that unmeasured confounding variables could affect the findings. Additionally, although stratified analyses provided valuable subgroup-specific insights, multiple statistical tests might have increased the likelihood of false-positive results. Moreover, the study's cross-sectional nature limits its ability to establish definitive causal relationships. To address these concerns, future research employing robust interventional or cohort designs is necessary to validate the findings.

Conclusion

The findings of this study indicate that diets with a higher insulin index are associated with increased odds of sleep disturbances. Moreover, diets with a higher glycemic index are linked to a greater likelihood of delayed sleep onset. However, no substantial links were observed between the DGL and DIL with sleep quality and duration. These results highlight that dietary interventions emphasizing lower glycemic and insulin indices could benefit patients undergoing coronary angiography. Such targeted strategies may enhance sleep quality within this group of participants. It should be noted that prospective studies are required to confirm and strengthen the findings of this research.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40795-025-01082-6.

Supplementary Material 1

Acknowledgements
We are very grateful to the participants of this study. We also thank the researchers for their contribution to the data.

Clinical trial number
Not applicable.

Authors' contributions
ASA, MTSH, SMSH were responsible for the conceptualization and design of the study. FSM, MM, AAV participated in data collection, ASA, MTSH, SMSH managed the project, KR, ASA provided data analyses. RB Performed data interpretation. KR wrote the first draft of the manuscript. all authors conducted a critical review of the manuscript. The final version of manuscript has been read and approved by all contributing authors.

Funding
The present study has received financial support from Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Data availability
The datasets utilized in this study can be obtained from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Informed consent was obtained from all participants. The present study was conducted based on the Declaration of Helsinki and has been approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Iran (ethics approval code: IR.SSU.SPH.REC.1402.201).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 15 December 2024 Accepted: 5 May 2025
Published online: 23 May 2025

References

1. Wang Q, Xi B, Liu M, Zhang Y, Fu M. Short sleep duration is associated with hypertension risk among adults: a systematic review and meta-analysis. Hypertens Res. 2012;35(10):1012–8.
2. Spiegel K, Sheridan JF, Van Cauter E. Effect of sleep deprivation on response to immunization. JAMA. 2002;288(12):1471–2.
3. Spiegel K, Leproult R, L'Hermite-Balériaux M, Copinschi G, Penev PD, Van Cauter E. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. J Clin Endocrinol Metab. 2004;89(11):5762–71.
4. Gómez-González B, Domínguez-Salazar E, Hurtado-Alvarado G, Esqueda-Leon E, Santana-Miranda R, Rojas-Zamorano JA, et al. Role of sleep in the regulation of the immune system and the pituitary hormones. Ann N Y Acad Sci. 2012;1261:97–106.
5. Di Milia L, Vandelanotte C, Duncan MJ. The association between short sleep and obesity after controlling for demographic, lifestyle, work and health related factors. Sleep Med. 2013;14(4):319–23.
6. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann Intern Med. 2004;141(11):846–50.
7. Lim J, Dinges DF. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. Psychol Bull. 2010;136(3):375–89.
8. Hale L, Troxel W, Buysse DJ. Sleep health: an opportunity for public health to address health equity. Annu Rev Public Health. 2020;41:81–99.
9. Chen Y, Tan F, Wei L, Li X, Lyu Z, Feng X, et al. Sleep duration and the risk of cancer: a systematic review and meta-analysis including dose–response relationship. BMC Cancer. 2018;18:1–13.
10. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. Eur Heart J. 2011;32(12):1484–92.
11. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. Diabetes Care. 2010;33(2):414–20.
12. Grandner MA. Addressing sleep disturbances: an opportunity to prevent cardiometabolic disease? Int Rev Psychiatry. 2014;26(2):155–76.
13. Binks HE, Vincent G, Gupta C, Irwin C, Khalesi S. Effects of diet on sleep: a narrative review. Nutrients. 2020;12(4):936.
14. Peuhkuri K, Sihvola N, Korpela R. Diet promotes sleep duration and quality. Nutr Res. 2012;32(5):309–19.
15. Wilson K, St-Onge M-P, Tasali E. Diet composition and objectively assessed sleep quality: a narrative review. J Acad Nutr Diet. 2022;122(6):1182–95.
16. Mossavar-Rahmani Y, Weng J, Wang R, Shaw PA, Jung M, Sotres-Alvarez D, et al. Actigraphic sleep measures and diet quality in the hispanic community health study/study of Latinos Sueno ancillary study. J Sleep Res. 2017;26(6):739–46.
17. Komada Y, Okajima I, Kuwata T. The effects of milk and dairy products on sleep: a systematic review. Int J Environ Res Public Health. 2020;17(24):9440.
18. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Dietary nutrients associated with short and long sleep duration. Data from a nationally representative sample. Appetite. 2013;64:71–80.
19. Kakutani-Hatayama M, Kadoya M, Morimoto A, Miyoshi A, Kosaka-Hamamoto K, Kusunoki Y, et al. Associations of sleep quality, sleep apnea and autonomic function with insulin secretion and sensitivity: HSCAA study. Metabolism open. 2020;6:100033.
20. Sondrup N, Termannsen A-D, Eriksen JN, Hjorth MF, Færch K, Klingenberg L, et al. Effects of sleep manipulation on markers of insulin sensitivity: a systematic review and meta-analysis of randomized controlled trials. Sleep Med Rev. 2022;62:101594.
21. Ang M, Müller AS, Wagenlehner F, Pilatz A, Linn T. Combining protein and carbohydrate increases postprandial insulin levels but does not improve glucose response in patients with type 2 diabetes. Metabolism. 2012;61(12):1696–702.
22. Hosseinpour-Niazi S, Sohrab G, Asghari G, Mirmiran P, Moslehi N, Azizi F. Dietary glycemic index, glycemic load, and cardiovascular disease risk factors: Tehran lipid and glucose study. Arch Iran Med. 2013;16(7):0-.
23. Anderson C, Milne GL, Park Y-MM, Sandler DP, Nichols HB. Dietary glycemic index and glycemic load are positively associated with oxidative stress among premenopausal women. J Nutr. 2018;148(1):125–30.
24. Liu S, Willett WC, Stampfer MJ, Hu FB, Franz M, Sampson L, et al. A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. Am J Clin Nutr. 2000;71(6):1455–61.
25. Nuttall FQ, Gannon MC. Plasma glucose and insulin response to macronutrients in nondiabetic and NIDDM subjects. Diabetes Care. 1991;14(9):824–38.
26. Moghaddam E, Vogt JA, Wolever TM. The effects of fat and protein on glycemic responses in nondiabetic humans vary with waist circumference, fasting plasma insulin, and dietary fiber intake. J Nutr. 2006;136(10):2506–11.
27. Holt S, Miller J, Petocz P. An insulin index of foods: the insulin demand generated by 1000-kJ portions of common foods. Am J Clin Nutr. 1997;66(5):1264–76.
28. Bao J, De Jong V, Atkinson F, Petocz P, Brand-Miller JC. Food insulin index: physiologic basis for predicting insulin demand evoked by composite meals. Am J Clin Nutr. 2009;90(4):986–92.
29. Sarsangi P, Mohammadi M, Salehi-Abargouei A, Esmaillzadeh A, Mirzaei M. Dietary insulinemic potential, sleep quality and quantity in Iranian adults: Yazd Health Study and TAMYZ study. 2022.
30. Mohammadi M, Nadjarzadeh A, Mirzaei M, Fallahzadeh H, Haghighatdoost F, Sakhaei R, et al. Dietary glycemic index and glycemic load in association with sleep duration: YaHS-TAMYZ and Shahedieh observational studies. Clin Nutr ESPEN. 2021;46:471–6.
31. Daniel NV, Zimberg IZ, Estadella D, Garcia MC, Padovani RC, Juzwiak CR. Effect of the intake of high or low glycemic index high carbohydrate-meals on athletes' sleep quality in pre-game nights. Anais da Academia Brasileira de Ciências. 2019;91.
32. Gangwisch JE, Hale L, St-Onge M-P, Choi L, LeBlanc ES, Malaspina D, et al. High glycemic index and glycemic load diets as risk factors for insomnia: analyses from the Women's Health Initiative. Am J Clin Nutr. 2020;111(2):429–39.
33. Motallaei M, Darand M, Taftian M, Beigrezaei S, Golvardi-Yazdi F, Mohyadini M, et al. A cross-sectional study on the association between lifestyle factors and coronary artery stenosis severity among adults living in central Iran: a protocol for the Iranian-CARDIO study. ARYA atherosclerosis. 2024;20(1):51–61.
34. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. J Am Coll Cardiol. 2020;76(25):2982–3021.
35. Khera AV, Chaffin M, Aragam KG, Haas ME, Roselli C, Choi SH, et al. Genome-wide polygenic scores for common diseases identify individuals with risk equivalent to monogenic mutations. Nat Genet. 2018;50(9):1219–24.
36. Andrews FM, Herzog AR. The quality of survey data as related to age of respondent. J Am Stat Assoc. 1986;81(394):403–10.
37. Zimorovat A, Moghtaderi F, Amiri M, Raeisi-Dehkordi H, Mohyadini M, Mohammadi M, et al. Validity and reproducibility of a semi-quantitative multiple-choice food frequency questionnaire in adults living in central Iran. 2020.
38. Atkinson FS, Foster-Powell K, Brand-Miller JC. International tables of glycemic index and glycemic load values: 2008. Diabetes Care. 2008;31(12):2281–3.
39. Foster-Powell K, Holt SH, Brand-Miller JC. International table of glycemic index and glycemic load values: 2002. Am J Clin Nutr. 2002;76(1):5–56.
40. Bao J, Atkinson F, Petocz P, Willett WC, Brand-Miller JC. Prediction of postprandial glycemia and insulinemia in lean, young, healthy adults:

glycemic load compared with carbohydrate content alone. Am J Clin Nutr. 2011;93(5):984–96.
41. Anderson GH, Soeandy CD, Smith CE. White vegetables: glycemia and satiety. Adv Nutr. 2013;4(3):356s-s367.
42. Arcot J, Miller JB, Research RI, Corporation D, Research RI, Research DCH, et al. A preliminary assessment of the glycemic index of honey: a report for the rural industries research and development corporation: rural industries research and development corporation; 2005.
43. 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. Am J Clin Nutr. 2021;114(5):1625–32.
44. Taleban F, Esmaeili M. Glycemic index of Iranian foods. National Nutrition and Food Technology Research Institute publication. 1999.
45. Haytowitz DB, Ahuja JKC, Wu X, Somanchi M, Nickle M, Nguyen QA, et al. USDA National Nutrient Database for Standard Reference, Legacy Release. Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, ARS, USDA; 2023.
46. 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. Am J Clin Nutr. 2006;83(6):1306–12.
47. Bell KJ, Petocz P, Colagiuri S, Brand-Miller JC. Algorithms to improve the prediction of postprandial insulinaemia in response to common foods. Nutrients. 2016;8(4):210.
48. Brand-Miller J, Holt SH, de Jong V, Petocz P. Cocoa powder increases postprandial insulinemia in lean young adults. J Nutr. 2003;133(10):3149–52.
49. Ryu J-H, Yim J-E, Suk W-H, Lee H, Ahn H, Kim Y-S, et al. Sugar composition and glycemic indices of frequently consumed fruits in Korea. Korean J Nutr. 2012;45(2):192–200.
50. Nimptsch K, Brand-Miller JC, Franz M, Sampson L, Willett WC, Giovannucci E. Dietary insulin index and insulin load in relation to biomarkers of glycemic control, plasma lipids, and inflammation markers. Am J Clin Nutr. 2011;94(1):182–90.
51. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213.
52. Farrahi Moghaddam J, Nakhaee N, Sheibani V, Garrusi B, Amirkafi A. Reliability and validity of the Persian version of the Pittsburgh Sleep Quality Index (PSQI-P). Sleep and Breathing. 2012;16:79–82.
53. Kroenke K, Spitzer RL. The PHQ-9: a new depression diagnostic and severity measure. Slack Incorporated Thorofare, NJ; 2002. p. 509–15.
54. Dadfar M, Kalibatseva Z, Lester D. Reliability and validity of the Farsi version of the Patient Health Questionnaire-9 (PHQ-9) with Iranian psychiatric outpatients. Trends Psychiatry Psychother. 2018;40(2):144–51.
55. Zhong Q, Gelaye B, Rondon M, Sánchez SE, García PJ, Sánchez E, et al. Comparative performance of patient health questionnaire-9 and Edinburgh Postnatal Depression Scale for screening antepartum depression. J Affect Disord. 2014;162:1–7.
56. Ryan TJ. Guidelines for percutaneous transluminal coronary angioplasty: a report of the American College of Cardiology/American Heart Association Task Force on assessment of diagnostic and therapeutic cardiovascular procedures (subcommittee on percutaneous transluminal coronary angioplasty). J Am Coll Cardiol. 1988;12(2):529–45.
57. Neeland IJ, Patel RS, Eshtehardi P, Dhawan S, McDaniel MC, Rab ST, et al. Coronary angiographic scoring systems: an evaluation of their equivalence and validity. Am Heart J. 2012;164(4):547-52. e1.
58. Gensini GG. A more meaningful scoring system for determining the severity of coronary heart disease. Am J cardiol. 1983;51:606.
59. İpek E, Ermiş E, Uysal H, Kızılet H, Demirelli S, Yıldırım E, et al. The relationship of micronucleus frequency and nuclear division index with coronary artery disease SYNTAX and Gensini scores. Anatolian Journal of Cardiology/Anadolu Kardiyoloji Dergisi. 2017;17(6).
60. Kundu A, Sardar P, O'Day K, Chatterjee S, Owan T, Dawn AJ. SYNTAX score and outcomes of coronary revascularization in diabetic patients. Curr Cardiol Rep. 2018;20:1–9.
61. Afaghi A, O'Connor H, Chow CM. High-glycemic-index carbohydrate meals shorten sleep onset. Am J Clin Nutr. 2007;85(2):426–30.
62. Frank S, Gonzalez K, Lee-Ang L, Young MC, Tamez M, Mattei J. Diet and sleep physiology: public health and clinical implications. Front Neurol. 2017;8:393.
63. Abdesselam I, Pepino P, Troalen T, Macia M, Ancel P, Masi B, et al. Time course of cardiometabolic alterations in a high fat high sucrose diet mice model and improvement after GLP-1 analog treatment using multimodal cardiovascular magnetic resonance. J Cardiovasc Magn Reson. 2015;17(1):95.
64. Drake I, Sonestedt E, Ericson U, Wallström P, Orho-Melander M. A Western dietary pattern is prospectively associated with cardiometabolic traits and incidence of the metabolic syndrome. Br J Nutr. 2018;119(10):1168–76.
65. Heidemann C, Scheidt-Nave C, Richter A, Mensink GB. Dietary patterns are associated with cardiometabolic risk factors in a representative study population of German adults. Br J Nutr. 2011;106(8):1253–62.
66. St-Onge M-P, Crawford A, Aggarwal B. Plant-based diets: reducing cardiovascular risk by improving sleep quality? Curr Sleep Med Rep. 2018;4:74–8.
67. Alruwaili NW, Alqahtani N, Alanazi MH, Alanazi BS, Aljrbua MS, Gatar OM. The effect of nutrition and physical activity on sleep quality among adults: a scoping review. Sleep Sci Pract. 2023;7(1):8.
68. Chauffard-Alboucq FA, Leathwood PD, Dormond CA. Changes in plasma amino acid and subjective sleepiness ratings in humans after consumingL-tryptophan/maltodextrin mixes. Amino Acids. 1991;1(1):37–45.
69. Markus C. Effects of carbohydrates on brain tryptophan availability and stress performance. Biol Psychol. 2007;76(1–2):83–90.
70. Ulrich-Lai YM, Ostrander MM, Herman JP. HPA axis dampening by limited sucrose intake: reward frequency vs. caloric consumption. Physiol Behav. 2011;103(1):104–10.
71. Adam TC, Epel ES. Stress, eating and the reward system. Physiol Behav. 2007;91(4):449–58.
72. Gangwisch JE, Hale L, Garcia L, Malaspina D, Opler MG, Payne ME, et al. High glycemic index diet as a risk factor for depression: analyses from the Women's Health Initiative. Am J Clin Nutr. 2015;102(2):454–63.
73. Seaquist E, Anderson J, Child B, Cryer P, Dagogo-Jack S. Fish. L., Heller. SR, Rodriguez H., Rosenzweig J., Vigersky R. Hypoglycemia and diabetes: a report of a workgroup of the American diabetes association and the endocrine society. Diabetes Care. 2013;36:1384–95.
74. Ludwig DS. The glycemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. JAMA. 2002;287(18):2414–23.
75. Alsahli M, Gerich JE. Hypoglycemia in patients with diabetes and renal disease. J Clin Med. 2015;4(5):948–64.
76. Moore SM. Effects of interventions to promote recovery in coronary artery bypass surgical patients. J Cardiovasc Nurs. 1997;12(1):59–70.
77. Williams MC, Hunter A, Shah A, Assi V, Lewis S, Mangion K, et al. Symptoms and quality of life in patients with suspected angina undergoing CT coronary angiography: a randomised controlled trial. Heart. 2017;103(13):995–1001.
78. Norra C, Kummer J, Boecker M, Skobel E, Schauerte P, Wirtz M, et al. Poor sleep quality is associated with depressive symptoms in patients with heart disease. Int J Behav Med. 2012;19:526–34.
79. ÖNEĞİ T, Arslan DE. Sleep quality and fatigue level of patients with coronary angiography. Clin Exp Health Sci. 2021;11(3):449–56.
80. Golzarand M, Mirmiran P, Jessri M, Toolabi K, Mojarrad M, Azizi F. Dietary trends in the Middle East and North Africa: an ecological study (1961 to 2007). Public Health Nutr. 2012;15(10):1835–44.
81. Aghayan M, Asghari G, Yuzbashian E, Mahdavi M, Mirmiran P, Azizi F. Secular trend in dietary patterns of Iranian adults from 2006 to 2017: Tehran lipid and glucose study. Nutr J. 2020;19:1–8.

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