Original Article

Dietary Patterns in Association with Sleep Duration in Iranian Adults: Results from YaHS-TAMYZ and Shahadieh Cohort Studies

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Abstract

Background: Little observational studies have been conducted on the association between diet and sleep. We conducted a cross-sectional study to evaluate the associations of dietary patterns with sleep duration in an Iranian population. **Methods:** This study was conducted on the baseline data of two population-based Iranian cohorts: the YaHS-TAMYS and Shahedieh studies. Dietary intakes were assessed in 10451 Yazdi people aged 20–75 years. Dietary habits were derived from answers to a food frequency questionnaire, and a factor analysis using principal component analysis (PCA) was used to identify dietary patterns. The reported sleep duration was categorized as short (<6 h), normal (6–8 h) or long (>8 h). Multivariable logistic regression was used to determine the relationship between dietary patterns and the odds of short and long sleep duration. **Results:** Four major dietary patterns were identified: "healthy," "western," "traditional," and "high-carbohydrate, high-fat." In the Shahedieh study, participants in the top quartile of the western dietary pattern had greater odds of short (<6 h) and long (>8 h) sleep duration (OR = 1.49; 95% CI: 1.17, 1.90; *P* trend <0.001 and OR = 1.46; 95% CI: 1.12, 1.90; *P* trend = 0.014, respectively) than those in the bottom quartile. Also, participants in the highest quartile of the high-carbohydrate, high-fat pattern had higher odds of long sleep duration compared with those in the lowest quartile (OR = 1.36; 95% CI: 1.05, 1.75; *P* trend = 0.005). Pooling the two studies revealed that the western dietary pattern was significantly associated with short sleep duration (OR = 1.31; 95% CI: 1.08, 1.59). **Conclusions:** The western dietary pattern might inversely be associated with sleep duration. Future prospective studies are recommended to confirm these results.

Keywords: *Adult, diet, principal component analysis, sleep*

Introduction

Sleep is recognized as one of the lifestyle behaviors closely related to health outcomes.[1] Sleep duration has declined in recent years, and it has been reported that approximately 10 to 29.2% of adults are usually sleeping 6 hours or less in many countries.[2] Multiple studies provide evidence that short sleep duration (generally <6 h per night) and long sleep duration (generally >8 h per night) are associated with increased risk of mortality, as well as obesity, diabetes, hypertension, and cardiometabolic disease.[3-6] Sleep duration has been also considered an independent and valid indicator of total mortality.[7,8] Links between inadequate sleep and metabolic dysfunctions may be mediated through the interaction between the circadian clock with food intake and possible health outcomes.[1] Indeed, changes in food intake like increasing energy intake can be influenced by hormonal, metabolic, and behavioral changes associated with inadequate sleep.[9]

There is probably a bidirectional relationship between food intake and sleep duration; as numerous cross-sectional surveys have revealed that short or long duration of sleep is associated with poorer nutritional status.[10,11] The cross-sectional studies showed a relationship between shorter sleep durations and less healthy dietary habits, such as higher intake of energy, sugar, caffeine, confectionary foods, snacks, beverages, and energy-dense foods, as well as lower intake of fiber, fish, vegetables, whole-grain, and beans.[12-14] It has been proposed that food items may affect the release of gastrointestinal tract hormones [for instance peptide YY (PYY), cholecystokinin (CCK), and ghrelin], resulting in a change in the availability of tryptophan, stimulating the production of serotonin and melatonin, and acting on serotonergic and GABAergic

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neurons which have a significant effect on sleep.[15-17] As mentioned, foods can be related to the sleep process; however, it is important to mention that people consume a combination of various foods in their meals. Indeed, instead of looking at individual foods, a dietary pattern analysis is might help to our understanding of the complex role of diet and likely provide new insight into the effects described for single foods.[18]

Although the relationship between dietary patterns and chronic diseases such as cardiovascular diseases, diabetes, neurological disease, etc., has been widely investigated so far,[19-21] there are few available epidemiological studies about the association between dietary patterns and sleep duration. We are aware of only one study that has directly examined the cross-sectional association between dietary patterns and sleep status.[22] This study has assessed the association between dietary patterns and sleep duration in developed country settings, where the demographic and socioeconomic factors as important factors for sleep disturbances are different from developing countries. Moreover, dietary habits in the Middle Eastern countries seem to be different from those in other nations. Indeed, it has been stated that more than 60% of total energy intake in the Middle Eastern countries is taken from carbohydrates, mostly from refined grains as one of the effective factors in sleep disorders.[23] Because we found no study that addressed these relationships in developing countries such as Iran, we thus aimed to examine the possible cross-sectional associations between dietary patterns and short and long sleep duration among a large sample of Iranian adults living in urban and municipal areas of central Iran.

Methods

Study design and population

The present cross-sectional study was conducted on adults who participated in the baseline survey of two population-based prospective cohort studies, the YaHS (Yazd Health Study) and Shahedieh studies. The detailed information of dietary intakes of adults who participated in the YaHS study was separately collected in the Yazd nutrition survey [called Taghzieh Mardom Yazd (TAMYZ) in Persian] using a semi-quantitative food frequency questionnaire (FFQ) which its validity and reproducibility have been previously reported.[24] The methodology of the YaHS-TAMYZ study has been published in detail elsewhere.[25] The Shahedieh study is a subset of the nationwide population-based cohort study (Persian cohort) that including 180,000 persons from 18 geographically distinct areas of Iran,[26] and Shahedieh is one part of those areas in which 9977 adults were included. The Shahedieh study was started in December 2014 with the enrollment of residents who were living in Shahedieh city annexed to Yazd city, in Iran. The questionnaires were completed in three different sections including general, medical, and dietary intakes were completed by trained interviewers. These two cohorts were approved by the research council and ethics committees of Shahid Sadoughi University of Medical Sciences. Written informed consent was obtained from each participant. The present study was also approved by the ethics committee of Shahid Sadoughi University of Medical Sciences' ethics committee (Approval code: IR.SSU.SPH.REC.1397.143).

For this study, subjects were excluded if they met any of the following criteria: participants who had missing or incomplete sleep or dietary data (850 in YaHS-TAMYZ and 23 in Shahedieh), participants with a history of diabetes, cancer, and cardiovascular disease (CVD) at the baseline examination (1908 in YaHS-TAMYZ and 2632 in Shahedieh studies), participants who were night shift workers (590 in Shahedieh), participants who had a high frequency of sedative medications use (475 in YaHS-TAMYZ and 363 in Shahedieh), participants with sleep deprivation (less than 3 hours) or sleep extension (more than 12 hours) (250 in YaHS-TAMYZ and 114 in Shahedieh studies), also with low (<800 kcal/day) or high (>6000 kcal/day) energy intake (864 in YaHS-TAMYZ and 1328 in Shahedieh), and finally, subjects who reported to have major depression (91 in YaHS-TAMYZ) were excluded. In total, 10451 individuals (5524 in YaHS and 4927 in Shahedieh) were eligible to be included in our analysis.

Dietary intakes

In the YaHS-TAMYZ study, the usual dietary intakes of participants were assessed using a 178-item semi-quantitative food-based multiple-choice FFQ by trained interviewers. This FFQ consisted of a list of food items with standard serving sizes that are routinely consumed by people living in central Iran. Respondents were asked how frequently they consumed each food item during the preceding 12 months by using a ten-point frequency scale ranging from "never or less than once a month" to "10 or more times per day". For each food item in the questionnaire, there were additional questions about the number of serves consumed each time and five choices were used from one to more than 11 times a general portion size. However, this structure was not used for all foods. A commonly consumed portion size was defined for each food item. Intraclass correlation coefficients values for the intake of energy, macronutrients, and micronutrients ranged from 0.43 (thiamin) to 0.73 (vitamin D) in this study. In the Shahedieh study, usual dietary intakes of participants were assessed using a 121-item semi-quantitative FFQ by trained interviewers. For each food item on the FFQ, the frequency of food intake during the past year on a daily, weekly, or monthly, and the normal portion size commonly consumed by the respondent was ascertained. In both studies, the reported daily intake of all food items were converted to grams per day using household measures.[27] A total of 30 food groups were defined based on the similarity of nutrients profile of the typical culinary use for each of the food items. The food items used to define each food group in each cohort are provided in Supplementary Table 1. Finally, the daily nutrient intake of each participant was calculated by the sum of the nutrient intakes of each food item.

Sleep duration

In both studies, data on habitual sleep duration were extracted from a self-reported nocturnal sleep questionnaire. Total sleep time was defined as the time between falling asleep and finally waking up except awakening periods. According to an earlier study[28] that assessed the association between sleep and diet, we also considered sleeping 6 to 8 hours as an adequate sleep duration. Besides, in both YaHS-TAMYS and Shahedieh studies, subjects in the lowest quintile of sleep duration reported sleeping less than 6 h per night and those in the highest quintile of sleep duration reported sleeping more than 8 h per night. Therefore, sleep duration was categorized in three groups from <6 h, 6 to 8 h, and >8 h.

Other variables

Other variables including age, sex, BMI, education, physical activity, occupation, history of other chronic diseases as having at least one of the health disorders, marital status, smoking status, depression, average duration of mobile use, and average duration of watching television were adjusted in both YaHS-TAMYZ and Shahedieh studies. Moreover, further adjustments were also conducted for economic status and being menopause in the Shahedieh study and use of sleeping pills (less than once a week) in the YaHS-TAMYZ study.

Statistical analysis

The principal component analysis with varimax rotation was conducted to identify dietary patterns based on the 30 food groups. Factor solutions were retained based on the eigenvalue (scree plots). General characteristics in categories of sleep duration were reported as mean ± standard deviation (SD) for continuous variables and percentage for categorical variables. For continuous variables, one-way analysis of variance (ANOVA) and for categorical variables, a chi-square test was applied to evaluate their statistical differences between sleep duration categories (<6 h, 6 to 8 h, and >8 h). The age, sex, and energy intake were adjusted for comparing the dietary food groups/nutrients intakes between sleep duration categories using the analysis of covariance (ANCOVA). Logistic regression in crude and multivariable-adjusted models was performed to examine the association between the adherence to the major dietary patterns and likelihood for developing short (<6 h) vs. normal (6–8 h), and long (>8 h) vs. normal (6–8 h) sleep duration. Odds ratios (ORs) and 95% confidence intervals (CIs) for developing short and long sleep duration were calculated with the first quartiles of dietary patterns' scores assigned as reference group. For both YaHS-TAMYZ and Shahedieh studies, age (a categorical variable in the YaHS-TAMYS study and continuous variable in the Shahedieh study), sex, and total energy intake were adjusted in model 1. *P*-value for trend was assessed across quartiles of dietary pattern scores to describe the dose-response association between dietary patterns and sleep duration. The internal consistency of each factor was assessed by Cronbach's alpha coefficients. All analyses were performed separately for the YaHS-TAMYZ and Shahedieh studies because the participants were heterogeneous regarding their lifestyle. If the same dietary patterns were derived in both YaHS-TAMYZ and Shahedieh studies, we pooled their relationship with sleep duration by using a fixed-effect model meta-analysis considering odds ratios and their confidence limits as effect size. The statistical analyses were done with Statistical Package for the Social Sciences (version 16 for Windows, 2006, SPSS, Inc, Chicago, IL, USA). *P*-value <0.05 was considered significant in all statistical analyses.

Results

Study-specific characteristics of participants in the YaHS-TAMYZ and Shahedieh studies across categories of sleep duration are presented in Tables 1 and 2, respectively. In brief, 5524 participants aged 20–69 years from the YaHS-TAMYZ, and 4927 participants aged 29-73 years from Shahedieh studies were included in the analyses. The mean BMI was 26.6 kg/m^2 in the YAHS-TAMYS study and 28.1 kg/m^2 in the Shahedieh study. The gender distributions were 47.8% and 56.1% female, and 52.2% and 43.9% male in the YAHS-TAMYZ and Shahedieh studies, respectively. In both studies, compared with those with short sleep, subjects with the highest sleep time (>8 h) had significantly lower age and were significantly less physically active. Also, participants with lower (<6 h) and higher (>8 h) sleep duration were more depressed than those with sufficient sleep duration. In the YaHS-TAMYZ study, participants with long sleep duration had lower BMI compared to short sleepers. In both studies, there were no significant differences between the categories of sleep duration in terms of other demographic variables.

Table 3 shows the dietary intake of participants across the categories of sleep duration. In pooled data from two studies, subjects in the top quintile of sleep duration had higher intakes of pizza and lower intakes of refined grain compared with those in the bottom quintile.

Four major dietary patterns were identified for both included studies. These dietary patterns explained approximately 26% and 27% of the total variation in the food intake in the YaHS-TAMYZ and Shahedieh studies, respectively. The Cronbach's alpha coefficients ranged from 0.12 to 0.47 in the YaHS-TAMYZ study and 0.15 to 0.49 in the Shahedieh study. The dietary patterns were interpreted and labeled based on the factor loadings that contributed most highly to each dietary pattern. The factor loading matrices for the four identified dietary patterns in

Table 1: Baseline characteristics of 5524 subjects aged 20-70 years who participated in the YaHS-TAMYZ Study

Variable	Sleep duration (h/night)			*P**	Total
	<6	6-8	>8		
Subjects (*n*)	555	4454	515		5524
Male (%)	179 (61.4)	2365 (53.1)	179 (34.8)	<0.001	2886 (52.2)
Age (%)				<0.001	
20-29	116 (20.9)	1074 (24.1)	173 (33.6)		1363 (24.7)
30-39	96 (17.3)	1093 (24.5)	136 (26.4)		1325 (24.0)
40-49	139 (25.0)	1032 (23.2)	82 (15.9)		1253 (22.7)
50-59	133 (24.0)	710 (15.9)	63 (12.3)		906 (16.4)
60-69	71 (12.8)	545 (12.3)	61 (11.8)		677 (12.3)
BMI (kg/m^2)	27.39±5.20	26.57±4.96	26.13±5.46	<0.001	26.61±5.04
Physical activity (MET*h/wk)	17.31±15.76	15.31±15.47	13.46±15.11	<0.001	15.34±15.49
Education (%)				0.943	
Primary school and less	109 (19.6)	886 (19.9)	104 (20.2)		1099 (19.9)
High school	146 (26.3)	1221 (27.4)	137 (26.6)		1504 (27.2)
Diploma and graduate diploma	190 (34.2)	1497 (33.6)	170 (33.0)		1857 (33.6)
Bachelor	86 (15.5)	669 (15.0)	78 (15.1)		833 (15.1)
Master and Doctorate	19 (3.4)	141 (3.2)	17 (3.3)		177 (3.2)
Missing	5 (0.9)	40 (0.9)	9 (1.7)		54 (1.0)
Occupation (%)				<0.001	
Unemployed	110 (19.8)	836 (18.8)	134 (26.0)		1080 (19.6)
Government employee	227 (40.9)	2063 (46.3)	267 (51.8)		2557 (46.3)
Manual worker	30 (5.4)	159 (3.6)	11 (2.1)		200 (3.6)
Self-employed	188 (33.9)	1396 (31.3)	103 (20.0)		1687 (30.5)
Marital status (%)				0.289	
Single	69 (12.4)	589 (13.2)	70 (13.6)		728 (13.2)
Married	464 (836)	3726 (837)	421 (81.7)		4611 (83.5)
Widowed or divorced	14 (2.5)	104 (2.3)	15 (2.9)		133 (2.4)
Missing	8 (1.4)	35 (0.8)	9 (1.7)		52 (0.9)
Smoking status (%)				0.391	
Never smoker	481 (86.7)	3933 (88.3)	463 (89.9)		4877 (88.3)
Current smoker	62 (11.2)	460 (10.3)	46 (8.9)		568 (10.3)
Ex-smoker	12 (2.1)	61 (1.4)	6 (1.2)		79 (1.4)
Depression (%)	71 (12.8)	409 (9.2)	53 (10.3)	0.025	535 (9.7)
Chronic disease (%)	207 (37.4)	1527 (34.3)	176 (34.3)	0.348	1897 (34.3)
Mobile (min)	29.21±54.30	28.64±0.53.64	28.12±55.84	0.944	28.18±54.01
Television (min)	34.47±61.94	30.42±0.58.10	27.84±56.49	0.152	30.33±58.36
Sleeping pills (%)	23 (4.2)	218 (5)	34 (6.7)	0.153	275 (5.0)

BMI, body mass index; MET, metabolic equivalent. **P* are resulted from ANOVA for quantitative variables and from Chi-square for qualitative variables. Values are mean±SD

the YaHS-TAMYZ and Shahedieh studies are shown in Supplementary Tables 2 and 3, respectively.

Table 4 indicates associations between the four identified dietary patterns and sleep duration. There was no significant association between the categorized of dietary patterns and sleep duration in crude and adjusted models in the YaHS-TAMYS study. The analyses revealed that those in the third quartile of the “healthy” dietary pattern had a lower odds to be short sleeper compared to those in the lowest quartile (OR = 0.69, 95% CI: 0.53, 0.89). The association has remained significant even after adjustment for all possible confounding variables in the second model (OR = 0.71, 95% CI: 0.54, 0.93) and the trend was not significant (P > 0.05). No other association was shown between the major dietary patterns and abnormal sleep in the YaHS-TAMYZ study [Table 4].

In the Shahedieh study participants in the top quartile of the “healthy” dietary pattern had 32% higher odds for short sleep compared to those in the lowest quartile (OR = 1.32; 95% CI: 1.06, 1.64). However, this association was not present after adjustment for all potential confounders in model 1 (OR = 1.22; 95% CI: 0.98, 1.53) and model 2 (OR = 1.20; 95% CI: 0.95, 1.51). It was also revealed that the “healthy” dietary pattern is significantly associated with a lower odds for long sleep duration (OR = 0.75, 95% CI: 0.60, 0.95), in the crude model and the linear trend was significant (P < 0.05). However, that association vanished after adjusting the association for all possible confounders.

Table 2: Baseline characteristics of 4927 subjects aged 35-75 years who participated in the Shahedieh Study

Variable	Sleep duration (h/night)			*P**	Total
	<6	6-8	>8		
Subjects (*n*)	847	3307	773		4927
Male (%)	402 (47.5)	1490 (45.1)	271 (35.1)	<0.001	2163 (43.9)
Age (y)	47.85±9.17	46.12±8.92	46.04±9.47	<0.001	46.40±9.07
BMI (kg/m^2)	28.37±5.00	28.21±8.61	27.89±4.95	0.428	28.18±7.61
Physical activity (MET*h/wk)	43.65±6.85	41.34±6.70	39.09±6.06	<0.001	41.38±6.76
Education (%)				<0.001	
Uneducated	118 (13.8)	380 (11.5)	98 (12.7)		595 (12.1)
Elementary	269 (31.8)	945 (28.5)	266 (34.4)		1480 (30.0)
Middle school	146 (17.3)	588 (17.8)	138 (17.9)		872 (17.7)
High School	181 (21.4)	737 (22.3)	185 (23.9)		1103 (22.4)
University or college	111 (13.1)	568 (17.2)	79 (10.2)		758 (15.4)
Postgraduate	22 (2.6)	89 (2.7)	7 (0.9)		118 (2.4)
Occupation (%)				<0.001	
Unemployed	12 (1.4)	91 (2.8)	28 (3.6)		131 (2.7)
retired	93 (11.0)	290 (8.8)	81 (10.5)		464 (9.4)
Government employee	102 (11.9)	430 (13.0)	24 (3.1)		555 (11.3)
Manual worker	60 (7.1)	178 (5.4)	24 (3.1)		262 (5.3)
Housewife	364 (43.0)	1424 (43.1)	426 (55.1)		2214 (44.9)
Self-employed	213 (25.2)	3303 (26.9)	187 (24.2)		1290 (26.2)
Missing	3 (0.4)	4 (0.1)	3 (0.4)		10 (0.2)
Socioeconomic status (%)				0.095	
Low	279 (33.0)	1149 (34.9)	282 (36.5)		1710 (34.7)
Middle	266 (31.4)	1034 (31.3)	264 (34.2)		1564 (31.7)
High	293 (34.6)	1111 (33.6)	224 (29.0)		1628 (33.0)
Missing	8 (0.9)	13 (0.4)	3 (0.4)		24 (0.5)
Marital status (%)				0.027	
Single	3 (0.4)	13 (0.4)	5 (0.6)		21 (0.4)
Married	807 (95.4)	3211 (97.1)	737 (95.3)		4755 (96.5)
Widowed or divorced	37 (4.3)	83 (2.5)	31 (4.0)		150 (3.0)
Smoking status (%)				0.055	
Never smoker	677 (80.0)	2681 (81.1)	633 (81.9)		3991 (81.0)
Current smoker	110 (13.0)	352 (10.6)	91 (11.8)		553 (11.2)
Ex-smoker	50 (6.0)	218 (6.6)	33 (4.3)		302 (6.1)
Depression (%)	105 (12.4)	347 (10.5)	112 (14.5)	0.005	564 (11.4)
Menopause (%)	129 (15.2)	406 (12.3)	114 (14.7)	0.249	649 (13.2)
Chronic disease (%)	438 (51.8)	1612 (48.7)	390 (50.5)	0.249	2440 (49.5)
Mobile (min)	13.44±22.17	12.86±21.45	11.69±38.13	0.343	12.78±24.93
Television (min)	18.78±31.41	17.50±30.76	16.82±32.22	0.557	17.56±31.10

BMI, body mass index; MET, metabolic equivalent. **P* are resulted from ANOVA for quantitative variables and from Chi-square for qualitative variables. Values are mean±SD

The analyses showed that the odds for occurrence of short (OR = 1.49, 95% CI: 1.17, 1.90) and long (OR = 1.46, 95% CI: 1.12, 1.90) sleep duration was higher in those with the highest adherence to the "western" dietary pattern after adjustment for all possible confounders and the linear trend was significant for both associations ($P < 0.05$, Table 4). The participants in the 3rd quartile of the "high-carbohydrate, high-fat" dietary pattern had a higher odds for developing long sleep duration in the crude analysis (OR = 1.33, 95% CI: 1.07, 1.67). In the second model participants in third (OR = 1.49, 95% CI: 1.18, 1.87) and the fourth (OR = 1.37, 95% CI: 1.07, 1.75) quartiles had a significantly higher odds for long sleep duration after adjustment for age, sex, and energy intake and the trend was significant ($P < 0.05$). The associations remained significant after adjustment for all possible confounders in the second model (quartile 4 vs. quartile 1, OR = 1.36, 95% CI: 1.05, 1.75, $P = 0.005$, Table 4). The analyses in the Shahedieh study also revealed that those in the second quartile of the "traditional" dietary pattern had a significantly lower odds of being long sleeper compared to those in the first quartile (OR = 0.69, 95% CI: 0.55, 0.86) and the association remained significant even after adjustment for all possible confounders (OR = 0.73, 95% CI: 0.58, 0.93); however, no linear trend was found

Table 3: Dietary intakes of participants across the tertiles of sleep duration in pooled data from two studies

Variables	Sleep duration (h/night)			*P*
	<6	6-8	>8	
Subjects (*n*)	1401	7762	1288	
Energy intake (kcal/d)	3135.37±1216.52	3025.48±1202.42	3064.30±1169.12	0.999
Macronutrients (% of total energy)				
Carbohydrate (%)	483.40±216.39	453.33±209.61	470.63±210.83	0.387
Fat (%)	99.21±44.27	101.90±51.90	98.44±49.18	0.709
Protein (%)	114.01±48.00	112.79±50.00	110.69±47.05	0.850
Food and Food groups (g/day)				
Cereals (g/day)	37.87±38.24	41.07±48.18	36.82±43.24	
Red, processed and organ meats (g/day)	90.86±167.29	111.25±207.66	93.49±298.22	0.834
Poultry (g/day)	30.48±48.63	37.64±64.79	27.24±39.76	0.123
Dairy products (g/day)	238.99±213.69	234.05±176.36	227.84±203.07	0.442
Refined grains (g/day)	243.85±159.98	234.05±176.36	227.84±203.07	<0.001
Pizza (g/day)	11.84±37.93	15.88±43.88	16.81±70.29	0.003
Snacks (g/day)	5.67±18.73	8.52±23.44	6.63±24.24	0.736
Sweet and dessert (g/day)	45.80±90.73	62.40±119.38	49.41±138.48	0.884
Sugars (g/day)	53.59±56.28	50.00±50.23	51.90±52.76	0.001
Soft drinks (g/day)	114.52±250.87	37.87±38.24	36.82±43.24	0.450
Nutrients				
Vitamin B_1 (mg)	2.90±1.54	2.71±1.43	2.83±1.46	0.182
Vitamin B_2 (mg)	2.44±1.03	2.39±1.03	2.38±1.07	0.887
Vitamin B_3 (mg)	31.68±15.31	30.52±14.92	30.77±14.71	0.170
Vitamin B_6 (mg)	2.48±1.16	2.47±1.26	2.40±1.15	0.138
Vitamin B_9 (µg)	562.40±280.75	506.82±272.89	549.29±270.92	0.294
Vitamin B_{12} (µg)	5.24±4.25	5.28±4.47	5.00±4.14	0.253
Vitamin C (mg)	158.99±137.70	166.82±141.42	152.93±142.37	0.128
Vitamin D (µg)	1.21±1.89	1.26±1.46	1.20±1.77	0.681
Calcium (mg)	1105.71±496.06	1041.36±454.59	1058.74±477.85	0.150
Zinc (mg)	16.74±8.60	15.23±8.19	16.09±8.11	0.193
Sodium (g/day)	5636.64±3637.25	5425.39±3910.56	5313.27±3175.85	0.502
Potassium (g/day)	4407.97±1798.95	4222.14±1818.46	4227.60±1809.25	0.043

The foods and nutrients were adjusted for age, sex, and energy intake (kcal). Total energy intake was adjusted for age and sex. **P* are resulted from ANCOVA. Values are mean±SD

between this dietary pattern and likelihood of long sleep [Table 4].

There were overlaps in terms of food items highly loaded in the "western" and "healthy" dietary patterns in the Shahedieh and YaHS-TAMYZ studies. Due to these similarities, we thus pooled the associations for the "western" and "healthy" dietary patterns by performing a small meta-analysis using fixed-effect model [Figure 1]. The pooled results showed that the third and fourth quartiles of the "western" dietary pattern are significantly associated with short sleep duration (OR = 1.19; 95% CI: 1.00, 1.42) and (OR = 1.31; 95% CI: 1.08, 1.59), respectively. The "healthy" dietary pattern was not associated with sleep duration.

Discussion

This study revealed that the "western" dietary pattern was significantly associated with short and long sleep in those who participated in the Shahedieh study. The pooled results of two studies also revealed that the third and fourth quartiles of the "western" pattern was significantly related to short sleep duration. On the other hand, although in the Shahedieh study the "high-carbohydrate, high-fat" dietary pattern was linked to higher odds of long sleep duration, this association was not observed in the YaHS-TAMYZ study. No significant association was also detected between other dietary patterns and short or long sleep duration.

The "western" dietary pattern was characterized by high consumption of sweets and desserts, pizza, soft drinks, snacks, red, processed, and organ meat, mayonnaise and coffee, and was significantly related to a higher odds of occurrence of short sleep duration. This association is in line with an earlier study suggesting that a higher intake of noodles, confections, fat, and oil, and meat can be associated with short sleep duration.[29] In another cross-sectional study by Weiss *et al.*,[30] there was also a significant association between higher intake of non-alcoholic beverages, carbonated beverages, and coffee

Table 4: Logistic regression analyses of the association between dietary patterns with short and long sleep duration in the YaHS-TAMYZ and Shahedieh studies

Variables	Sleep duration (<6 h versus 6-8 h)					Sleep duration (>8 h versus 6-8 h)				
	Quartiles of dietary pattern				*P* trend	Quartiles of dietary pattern				*P* trend
	Q_1	Q_2	Q_3	Q_4		Q_1	Q_2	Q_3	Q_4	
YaHS-TAMYZ study										
Subjects (*n*)	1247	1256	1258	1248		1274	1243	1231	1248	
Healthy dietary pattern										
Crude	1	0.89 (0.69, 1.14)	0.69 (0.53, 0.89)	1.09 (0.86, 1.39)	0.833	1	0.83 (0.64, 1.08)	1.03 (0.80, 1.32)	0.92 (0.71, 1.19)	0.936
Model I	1	0.88 (0.69, 1.13)	0.71 (0.54, 0.93)	1.22 (0.93, 1.60)	0.550	1	0.86 (0.66, 1.13)	1.00 (0.77, 1.29)	0.85 (0.63, 1.14)	0.506
Model II	1	0.87 (0.67, 1.11)	0.71 (0.54, 0.93)	1.17 (0.89, 1.54)	0.701	1	0.89 (0.68, 1.16)	1.03 (0.80, 1.34)	0.91 (0.68, 1.23)	0.836
Western dietary pattern										
Crude	1	1.02 (0.79, 1.31)	1.12 (0.87, 1.44)	0.99 (0.76, 1.27)	0.865	1	0.92 (0.71, 1.20)	0.92 (0.71, 1.19)	0.99 (0.76, 1.27)	0.933
Model I	1	1.03 (0.80, 1.33)	1.17 (0.90, 1.51)	1.06 (0.77, 1.45)	0.457	1	0.91 (0.70, 1.18)	0.87 (0.66, 1.14)	0.88 (0.64, 1.21)	0.376
Model II	1	1.03 (0.79, 1.32)	1.18 (0.91, 1.53)	1.07 (0.78, 1.47)	0.421	1	0.91 (0.70, 1.18)	0.85 (0.65, 1.12)	0.87 (0.63, 1.20)	0.316
Traditional dietary pattern										
Crude	1	1.02 (.79, 1.32)	1.10 (0.86, 1.41)	1.03 (0.80, 1.33)	0.674	1	0.96 (0.74, 1.24)	0.88 (0.68, 1.15)	0.93 (0.72, 1.20)	0.474
Model I	1	1.02 (.79, 1.32)	1.10 (0.85, 1.42)	1.02 (0.79, 1.32)	0.695	1	0.97 (0.74, 1.26)	0.89 (0.69, 1.17)	0.93 (0.72, 1.20)	0.486
Model II	1	0.99 (0.76, 1.29)	1.07 (0.83, 1.38)	0.98 (0.76, 1.27)	0.909	1	0.96 (0.74, 1.26)	0.90 (0.69, 1.17)	0.93 (0.72, 1.21)	0.521
High-carbohydrate, high-fat dietary pattern										
Crude	1	1.10 (0.86, 1.40)	0.82 (0.63, 1.06)	1.04 (0.81, 1.33)	0.673	1	0.85 (0.66, 1.11)	0.84 (0.64, 1.08)	1.00 (0.78, 1.29)	0.980
Model I	1	1.10 (0.86, 1.41)	0.82 (0.63, 1.07)	1.07 (0.82, 1.40)	0.852	1	0.84 (0.65, 1.10)	0.84 (0.65, 1.09)	0.97 (0.74, 1.26)	0.748
Model II	1	1.12 (0.88, 1.44)	0.85 (0.65, 1.10)	1.12 (0.86, 1.46)	0.912	1	0.84 (0.64, 1.09)	0.85 (0.65, 1.11)	0.94 (0.72, 1.23)	0.655
Shahedieh study										
Subjects (*n*)	1019	1029	1034	1071		979	1032	992	966	
Healthy dietary pattern										
Crude	1	1.40 (1.13, 1.75)	1.14 (0.91, 1.43)	1.32 (1.06, 1.64)	0.082	1	1.01 (0.81, 1.26)	0.94 (0.76, 1.17)	0.75 (0.60, 0.95)	0.016
Model I	1	1.37 (1.10, 1.70)	1.09 (0.87, 1.36)	1.22 (0.98, 1.53)	0.319	1	1.00 (0.81, 1.25)	0.94 (0.76, 1.18)	0.80 (0.63, 1.01)	0.065
Model II	1	1.40 (1.12, 1.76)	1.06 (0.83, 1.34)	1.20 (0.95, 1.51)	0.526	1	1.04 (0.83, 1.30)	1.05 (0.83, 1.32)	0.90 (0.70, 1.16)	0.532
Western dietary pattern										
Crude	1	0.80 (0.64, 1.00)	0.96 (0.77, 1.18)	1.12 (0.91, 1.38)	0.127	1	1.26 (1.01, 1.57)	1.07 (0.85, 1.34)	1.25 (1.00, 1.57)	0.164
Model I	1	0.90 (0.72, 1.12)	1.15 (0.92, 1.44)	1.43 (1.13, 1.81)	0.001	1	1.27 (1.01, 1.59)	1.14 (0.90, 1.45)	1.50 (1.17, 1.93)	0.001
Model II	1	0.95 (0.75, 1.19)	1.21 (0.96, 1.53)	1.49 (1.17, 1.90)	<0.001	1	1.20 (0.95, 1.52)	1.11 (0.87, 1.43)	1.46 (1.12, 1.90)	0.014
High-carbohydrate, high-fat dietary pattern										
Crude	1	1.12 (0.90, 1.39)	1.18 (0.95, 1.46)	1.03 (0.83, 1.28)	0.645	1	1.19 (0.95, 1.49)	1.33 (1.07, 1.67)	1.11 (0.88, 1.39)	0.242
Model I	1	1.14 (0.92, 1.41)	1.18 (0.95, 1.47)	1.03 (0.82, 1.30)	0.666	1	1.24 (0.98, 1.56)	1.49 (1.18, 1.87)	1.37 (1.07, 1.75)	0.003
Model II	1	1.16 (0.93, 1.45)	1.19 (0.95, 1.49)	0.99 (0.78, 1.27)	0.908	1	1.21 (0.95, 1.53)	1.49 (1.18, 1.90)	1.36 (1.05, 1.75)	0.005
Traditional dietary pattern										
Crude	1	0.85 (0.68, 1.06)	0.93 (0.75, 1.15)	1.02 (0.83, 1.27)	0.598	1	0.69 (0.55, 0.86)	0.83 (0.67, 1.03)	0.87 (0.70, 1.08)	0.480
Model I	1	0.87 (0.70, 1.09)	0.99 (0.80, 1.23)	1.09 (0.87, 1.36)	0.282	1	0.70 (0.56, 0.88)	0.87 (0.70, 1.09)	1.00 (0.80, 1.26)	0.628
Model II	1	0.86 (0.69, 1.08)	0.99 (0.79, 1.24)	1.06 (0.84, 1.33)	0.396	1	0.73 (0.58, 0.93)	0.94 (0.74, 1.18)	1.07 (0.84, 1.35)	0.299

Model 1: adjusted for age, sex, and energy (kcal) in both studies. Model 2: adjusted as for model 1 plus BMI (category), physical activity, education (category), occupation (category), chronic disease, marital status (category), smoking status (category), depression, duration of mobile use, duration of watching television, sleeping pills in the YaHS-TAMYZ study and model 1 plus BMI (category), physical activity, education (category), occupation (category), chronic disease, marital status (category), smoking status (category), depression, duration of mobile use, duration of watching television, socioeconomic status (category) in the Shahedieh study

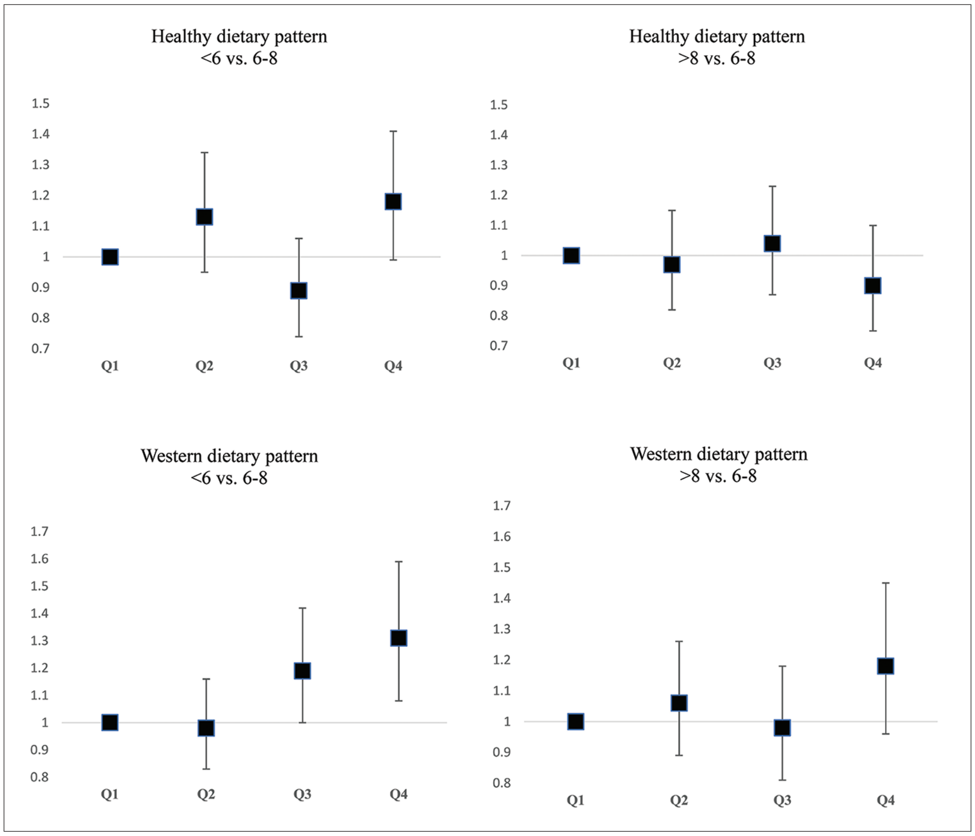

Figure 1: Multivariable-adjusted ORs and corresponding 95% CIs for short (<6 h) vs. normal (6-8 h), and long (>8 h) vs. normal (6-8 h) sleep duration in the pooled data of the YaHS-TAMYS and Shahedieh studies across quartiles of the healthy and western dietary patterns in the fully adjusted model by performing a small meta-analysis (with fixed effects model)

with shorter sleep duration. Similarly, it has been shown that short sleepers tended to have a higher consumption of snacks than those with longer sleep duration.[31]

The mechanisms by which greater intakes of the "western" dietary pattern may contribute to shorter sleep duration are not fully understood. The evidence showing that restricted sleep duration can alter the levels of appetite hormones such as leptin and ghrelin and might affect food habits, are accumulating.[32,33] For instance, it has been observed that the levels of ghrelin is decreased in subjects with restricted sleep and this change might lead to increased food intake and sucrose preference.[34,35] Various studies have also revealed that during a period of restricted sleep, brain regions involved in food-related behaviors such as the orbitofrontal cortex and insula are activated to a greater degree in response to unhealthy foods rather than healthy ones, and consequently stimulating these areas can result in increased food intake and affect food preferences.[36,37] Indeed, a bidirectional association between the intake of unhealthy foods and short sleep duration can be assumed; most foods in the "western" dietary pattern have a great amount of saturated fatty acids which in turn might be associated with short sleep duration.[38] On the other hand, a short sleeper commonly eats during unconventional hours (late night and early morning) usually involved unhealthy foods which are high in energy, fats, and saturated fats.[36,39]

It is worth mentioning that in the Shahedieh study, the "western" dietary pattern was positively associated with short and long sleep duration. This finding is consistent with the study of Sangmi and colleagues,[40] who reported that short and long sleepers had higher intakes of sweets and fat and lower intakes of fruits and vegetables, which is reflective of a nutritionally poor diet. In the Shahedieh study, there was also a significant association between the "high-carbohydrate, high-fat" dietary pattern and long-term sleep. There are different findings in terms of the effects of carbohydrate intake on sleep duration, such that short sleepers had a considerably higher intake of carbohydrate in some evidence,[28,41] inversely longer sleep duration was accompanied by increased intake of carbohydrate in another study.[31] Although since there was no significant association between long sleep duration and the "western" or "high-carbohydrate, high-fat" dietary patterns in the YaHS-TAMYZ study, the results of the Shahedieh study should be interpreted with caution.

The observed associations were not similar for the YaHS-TAMYZ and Shahedieh studies. Typically, inhabitants of disadvantaged areas have different diets than those in more socioeconomically advantaged areas,[42] and also the details of methods used for dietary assessment were not exactly similar in two studies. Moreover, we excluded night shift workers from the Shahedieh study and those with major depression in the YaHS-TAMYS study, but we did not have the same data in the YaHS-TAMYS and Shahedieh studies, respectively. Another possible explanation for different observations in the YaHS-TAMYS and Shahedieh studies is that there were different lists of confounding factors in these studies.

The main strength of this research study is that we investigated a large, nationally representative sample and considered several potential confounders in the data analysis. To best of our knowledge, this study is the largest of its kind to examine the association between dietary patterns and sleep duration. Nevertheless, some limitations of our study should be considered. First, causal, and temporal inference cannot be made by this cross-sectional study. More studies especially with prospective design are thus needed to confirm the observed associations between some dietary patterns and sleep duration in this research. Secondly, the dietary intakes were assessed by using a semi-quantitative food frequency questionnaire which may have resulted in measurement error. It must also mention that the ideal approach for extracting of dietary patterns might seem to be in a combined data set from both cohorts, but this was not deemed suitable due to some heterogeneity in these two studies. Indeed, the lists of confounding factors were not exactly similar in the Shahedieh and YaHS-TAMYZ studies. Also, the YaHS-TAMYZ study was conducted on the urban population of Yazd and the Shahedieh study was conducted on Shahedieh city annexed to Yazd city (non-urban site). Besides, the FFQs used to assess dietary intakes in these two studies were different. The socioeconomic status of the participants in these two studies were also different.

Conclusions

Our findings show that a “western” dietary pattern is significantly associated with short sleep duration. Further prospective studies are required to elucidate the relationship between diets and sleep health. If our data are supported by future prospective studies, modifications in dietary intakes can be considered an effective strategy against unsuitable sleep duration.

Ethical approval

These two cohorts were approved by the research council and ethic committees of Shahid Sadoughi University of Medical Sciences. The present study was also approved by the ethics committee of Shahid Sadoughi University of Medical Sciences’ ethics committee (Approval code: IR.SSU.SPH.REC.1397.143)

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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References

1. Shechter A, Grandner MA, St-Onge MP. The role of sleep in the control of food intake. Am J Lifestyle Med 2014;8:371-4.
2. Ford ES, Cunningham TJ, Croft JB. Trends in self-reported sleep duration among US adults from 1985 to 2012. Sleep 2015;38:829-32.
3. Itani O, Jike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: A systematic review, meta-analysis, and meta-regression. Sleep Med 2017;32:246-56.
4. Yin J, Jin X, Shan Z, Li S, Huang H, Li P, *et al*. Relationship of sleep duration with all-cause mortality and cardiovascular events: A systematic review and dose-response meta-analysis of prospective cohort studies. J Am Heart Assoc 2017;6:e005947.
5. Jike M, Itani O, Watanabe N, Buysse DJ, Kaneita Y. Long sleep duration and health outcomes: A systematic review, meta-analysis and meta-regression. Sleep Med Rev 2018;39:25-36.
6. Knutson KL. Sleep duration and cardiometabolic risk: A review of the epidemiologic evidence. Best Pract Res Clin Endocrinol Metab 2010;24:731-43.
7. Qureshi AI, Giles WH, Croft JB, Bliwise DL. Habitual sleep patterns and risk for stroke and coronary heart disease: A 10-year follow-up from NHANES I. Neurology 1997;48:904-11.
8. Mallon L, Broman JE, Hetta J. Sleep complaints predict coronary artery disease mortality in males: A 12-year follow-up study of a middle-aged Swedish population. J Intern Med 2002;251:207-16.
9. Penev PD. Update on energy homeostasis and insufficient sleep. J Clin Endocrinol Metab 2012;97:1792-801.
10. Dashti HS, Scheer FA, Jacques PF, Lamon-Fava S, Ordovas JM. Short sleep duration and dietary intake: Epidemiologic evidence, mechanisms, and health implications. Adv Nutr 2015;6:648-59.
11. Pot G, Al Khatib H, Perowicz M, Hall W, Harding S, Darzi J. Sleep duration, nutrient intake and nutritional status in UK adults. Proc Nutr Soc 2016;75 (OCE3), E180.
12. Kant AK, Graubard BI. Association of self-reported sleep duration with eating behaviors of American adults: NHANES 2005-2010. Am J Clin Nutr 2014;100:938-47.
13. Chaput JP. Sleep patterns, diet quality and energy balance. Physiol Behav 2014;134:86-91.
14. 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;141:846-50.

15. Peuhkuri K, Sihvola N, Korpela R. Diet promotes sleep duration and quality. Nutr Res 2012;32:309-19.
16. Steiger A, Dresler M, Schussler P, Kluge M. Ghrelin in mental health, sleep, memory. Mol Cell Endocrinol 2011;340:88-96.
17. Dockray GJ. Cholecystokinin and gut-brain signalling. Regul Pept 2009;155:6-10.
18. Hu FB. Dietary pattern analysis: A new direction in nutritional epidemiology. Curr Opin Lipidol 2002;13:3-9.
19. Beigrezaei S, Ghiasvand R, Feizi A, Iraj B. Relationship between dietary patterns and incidence of Type 2 Diabetes. Int J Prev Med 2019;10:122.
20. Khanna P, Chattu VK, Aeri BT. Nutritional Aspects of Depression in Adolescents - A Systematic Review. Int J Prev Med 2019;10:42.
21. Czekajlo A, Rozanska D, Zatonska K, Szuba A, Regulska-Ilow B. Association between dietary patterns and cardiovascular risk factors in a selected population of Lower Silesia (PURE Study Poland). Ann Agric Environ Med 2018;25:635-41.
22. Mondin TC, Stuart AL, Williams LJ, Jacka FN, Pasco JA, Ruusunen A. Diet quality, dietary patterns and short sleep duration: A cross-sectional population-based study. Eur J Nutr 2019;58:641-51.
23. Kimiagar S, Ghaffarpour M, Houshiar Rad A, Hormozdyari H, Zellipour L. Food consumption pattern in the Islamic Republic of Iran and its relation to coronary heart disease. East Mediterr Health J 1998;4:539-47.
24. 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. Food Nutr Bull 2022.
25. Mirzaei M, Salehi-Abargouei A, Mirzaei M, Mohsenpour MA. Cohort Profile: The Yazd Health Study (YaHS): A population-based study of adults aged 20-70 years (study design and baseline population data). Int J Epidemiol 2018;47:697-698h.
26. Poustchi H, Eghtesad S, Kamangar F, Etemadi A, Keshtkar AA, Hekmatdoost A, *et al*. Prospective epidemiological research studies in Iran (the PERSIAN cohort study): Rationale, objectives, and design. Am J Epidemiol 2018;187:647-55.
27. Ghafarpour M, Houshiar-Rad A, Kianfar H. The Manual for Household Measures, Cooking Yields Factors and Edible Portion of Food. Tehran: Keshavarzi Press; 1999.
28. Haghighatdoost F, Karimi G, Esmaillzadeh A, Azadbakht L. Sleep deprivation is associated with lower diet quality indices and higher rate of general and central obesity among young female students in Iran. Nutrition 2012;28:1146-50.
29. Sato-Mito N, Sasaki S, Murakami K, Okubo H, Takahashi Y, Shibata S, *et al*. The midpoint of sleep is associated with dietary intake and dietary behavior among young Japanese women. Sleep Med 2011;12:289-94.
30. Kleiser C, Wawro N, Stelmach-Mardas M, Boeing H, Gedrich K, Himmerich H, *et al*. Are sleep duration, midpoint of sleep and sleep quality associated with dietary intake among Bavarian adults? Eur J Clin Nutr 2017;71:631-7.
31. Weiss A, Xu F, Storfer-Isser A, Thomas A, Ievers-Landis CE, Redline S. The association of sleep duration with adolescents' fat and carbohydrate consumption. Sleep 2010;33:1201-9.
32. Cirelli C. Cellular consequences of sleep deprivation in the brain. Sleep Med Rev 2006;10:307-21.
33. Morselli L, Leproult R, Balbo M, Spiegel K. Role of sleep duration in the regulation of glucose metabolism and appetite. Best Pract Res Clin Endocrinol Metab 2010;24:687-702.
34. Bodosi B, Gardi J, Hajdu I, Szentirmai E, Obal F Jr, Krueger JM. Rhythms of ghrelin, leptin, and sleep in rats: Effects of the normal diurnal cycle, restricted feeding, and sleep deprivation. Am J Physiol Regul Integr Comp Physiol 2004;287:R1071-9.
35. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med 2004;1:e62.
36. St-Onge MP, McReynolds A, Trivedi ZB, Roberts AL, Sy M, Hirsch J. Sleep restriction leads to increased activation of brain regions sensitive to food stimuli. Am J Clin Nutr 2012;95:818-24.
37. Benedict C, Brooks SJ, O'Daly OG, Almen MS, Morell A, Aberg K, *et al*. Acute sleep deprivation enhances the brain's response to hedonic food stimuli: An fMRI study. J Clin Endocrinol Metab 2012;97:E443-7.
38. Dashti HS, Follis JL, Smith CE, Tanaka T, Cade BE, Gottlieb DJ, *et al*. Habitual sleep duration is associated with BMI and macronutrient intake and may be modified by CLOCK genetic variants. Am J Clin Nutr 2015;101:135-43.
39. de Castro JM. The time of day and the proportions of macronutrients eaten are related to total daily food intake. Br J Nutr 2007;98:1077-83.
40. Kim S, DeRoo LA, Sandler DP. Eating patterns and nutritional characteristics associated with sleep duration. Public Health Nutr 2011;14:889-95.
41. Nedeltcheva AV, Kilkus JM, Imperial J, Kasza K, Schoeller DA, Penev PD. Sleep curtailment is accompanied by increased intake of calories from snacks. Am J Clin Nutr 2009;89:126-33.
42. Turrell G, Blakely T, Patterson C, Oldenburg B. A multilevel analysis of socioeconomic (small area) differences in household food purchasing behaviour. J Epidemiol Community Health 2004;58:208-15.

Supplementary Table 1: Food grouping used for factor analysis in the YaHS-TAMYZ and Shahedieh studies

Food groups	Food items
Red, processed and organ meats	Lamb, Beef, Kebab, Sausages, Hamburgers, Beef liver, Lamb organ (Tongue, Tripe, Head and trotters, Brain, Foot, Abomasum)
Fish	Fish
Canned fish	Canned fish
Poultry	Chicken with skin, Chicken without skin, Chicken with or without skin (Liver, Heart, Gizzard)
Eggs	Eggs
Solid fats	Butter, Margarine, Hydrogenated fats, Animal fats
Dairy products	Milk, Yogurt, Cheese, Curd, Ice-cream, Flavored milk, Chocolate milk, Coffee milk, Honey milk, Cream
Fruits	Pears, Apricots, Cherries, Apples, Grapes, Bananas, Cantaloupe, Melons, Watermelon, Kiwi, Strawberries, Peaches, Mulberry, Plums, Persimmons, Pomegranates, Figs, Dates, Greengage, Sour cherry, Pineapples, Citrus fruits (Oranges, Tangerine, Grapefruit, Lemons), All types of canned fruit (Canned pineapple, Other canned fruits), All types of natural fruit juices (Apple juice, Orange juice, Grapefruit juice, Cantaloupe juice, Other fruit juices)
Dried fruits	Dried Figs, Dried Mulberries, Raisins, Dried plums, Dried apricots, Dried peach, Other dried fruit
Tomatoes	Tomatoes, Tomato paste
Vegetables	Cucumber, Cabbage, Cauliflower, Brussels sprouts, Kale, Carrots (row or boiled), Squash, Spinach, Lettuce, Mixed vegetables (row or cooked), Eggplant, Celery, Kohlrabi, Green Peas, Green Beans, Turnip, Corn, Mushrooms, Onions, Beet, Beet root, Artichokes, Bell pepper, Pepper
Legumes	Beans, Peas, Lima Beans, Broad Beans, Lentils, Soy, Split Peas, Mung beans
Potatoes	Potatoes, French fries
Whole grains	Iranian dark bread (Sangak, Taftoon, Barbari), Local bread (Korno, Tanoori), Wheat germ, Oatmeal, barley, Bulgur, Whole grain biscuit (Saghe talaee)
Refined grains	White breads (Lavash, Baguettes), Noodles, Pasta, Rice, Biscuits and wafers
Pizza	Pizza
Snacks	Potato chips, Corn puffs
Nuts	Peanuts, Almonds, Pistachios, Hazelnuts, Walnuts, Sunflower, Pumpkin and watermelon seeds
Mayonnaise	Mayonnaise sauce
Olive	Olives, Olive oil
Vegetable oils	Vegetable oils (except for olive oil)
Sugars	Jam, Honey, Sugars, Candies, Syrup, Nabat (An Iranian confectionery made of sugar and served by tea), Noql (An Iranian confectionery), Pashmak
Sweets and desserts	Chocolates, Cookies, Cakes, Confections, Traditional sweets (Kamache sen, Poshtzik, Pirashki, Qottab, Baqlava, Loz, Haji badam, Nan berenj, Sohan, Yazdi cake), Ardeh (Liquid Sesame), Homemade halva, Halva shekari (A sweet breakfast food in Iran), Creme caramel, Homemade cake
Condiments	Pomegranate paste, Other sauces and pastes
Soft drinks	Soft drinks, Non-alcoholic beer, All types of artificial fruit juices
Yoghurt drink	Doogh
Salt	Salt
Pickles	Pickles
Garlic	Garlic
Coffee	Coffee

Supplementary Table 2: Factor-loading matrix for major dietary patterns in the YaHS-TAMYZ study[1]

Food groups	Dietary patterns			
	Western	Healthy	Tradition	High-carbohydrate high-fat
Sweets and desserts	0.692	-	-	-
Sugars	0.684	-	-	-
Soft drinks	0.622	-	-	-
Nuts	0.611	-	-	-
Snacks	0.568	-	-	-
Red, processed and organ meats	0.520	-	-	-
Mayonnaise	0.419	-	-	-
Coffee	-	-	-	-
Pizza	-	-	-	-
Vegetables	-	0.563	-	-
Fruits	-	0.548	-	-
Dried fruits	-	0.503	-	-
Dairy products	-	0.426	-	-
Olive	-	0.425	-	-
Fish	-	0.381	-	-
Garlic	-	0.376	-	-
Yogurt drink	-	0.306	-	-
Vegetable oils	-	-	0.608	-
Salt	-	-	0.538	-
Condiments	-	-	0.511	0.338
Tomatoes	-	-	0.403	-
Canned fish	-	-	-0.340	-
Eggs	-	-	0.325	-
Poultry	-	-	-	-
legumes	-	-	-	-
Solid fats	-	-	-	0.633
Potatoes	-	-	-	0.480
Whole grains	-	-	-	0.364
Pickles	-	-	-	0.351
Refined grains	-	-	-	0.304
Percentage of variance explained (%)	9.39	6.57	5.69	4.73
Cronbach's alpha	0.49	0.30	0.18	0.16

[1]Values <0.30 were excluded for simplicity

Supplementary Table 3: Factor-loading matrix for major dietary patterns in the Shahedieh study[1]

Food groups	Dietary patterns			
	Healthy	Western	High-carbohydrate high-fat	Tradition
Vegetables	0.683	-	-	-
Fruits	0.614	-	-	-
Tomatoes	0.563	-	-	-
Garlic	0.448	-	-	-
Dried fruits	0.445	-	-	-
Dairy products	0.432	-	-	0.330
Pickles	0.319	0.311	-	-
Condiments	-	-	-	-
Pizza	-	0.581	-	-
Soft drinks	-	0.535	-	-
Snacks	-	0.486	-	-
Nuts	-	0.440	-	-
Sweets and desserts	-	0.425	-	-
Mayonnaise	-	0.413	-	-
Red, processed and organ meats	-	0.358	-	-
Coffee	-	0.339	-	-
Refined grains	-	0.329	0.308	0.328
Fish	-	0.314		-
Canned fish	-	0.313		-
Potatoes	-	-	0.521	-
Solid fats	-	-	0.478	-0.470
Eggs	-	-	0.473	-
legumes	-	-	0.433	-
Sugars	-	-	0.392	-
Whole grains	-	-	0.357	-
Olive	-	-	-0.307	-
Salt	-	-	-	-
Vegetable oils	-	-	-	0.551
Poultry	-	-	-	0.378
Yogurt drink	-	-	-	0.370
Percentage of variance explained (%)	7.91	7.81	6.24	5.18
Cronbach's alpha	0.47	0.33	0.18	0.12

[1]Values <0.30 were excluded for simplicity