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

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 Shahadieh 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.[1-6] 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 systems.

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neurons which have a significant effect on sleep.\textsuperscript{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.\textsuperscript{18}

Although the relationship between dietary patterns and chronic diseases such as cardiovascular diseases, diabetes, neurological disease, etc., has been widely investigated so far,\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{24} The methodology of the YaHS-TAMYZ study has been published in detail elsewhere.\textsuperscript{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,\textsuperscript{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.\textsuperscript{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 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-TAMYS 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-TAMYS 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-TAMYS 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-TAMYS and Shahedieh studies because the participants were heterogeneous regarding their lifestyle. If the same dietary patterns were derived in both YaHS-TAMYS 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-TAMYS 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-TAMYS, and 4927 participants aged 29-73 years from Shahedieh studies were included in the analyses. The mean BMI was 26.6 kg/m² in the YAHS-TAMYS study and 28.1 kg/m² in the Shahedieh study. The gender distributions were 47.8% and 56.1% female, and 52.2% and 43.9% male in the YAHS-TAMYS 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-TAMYS 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-TAMYS and Shahedieh studies, respectively. The Cronbach’s alpha coefficients ranged from 0.12 to 0.47 in the YaHS-TAMYS 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
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Table 1: Baseline characteristics of 5524 subjects aged 20-70 years who participated in the YaHS-TAMYZ Study

| Variable                        | <6     | 6-8    | >8     | P*        | Total   |
|---------------------------------|--------|--------|--------|-----------|---------|
| 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/m²)                     |        |        |        | <0.001    |         |
| Physical activity (MET*h/wk)    |        |        |        | <0.001    |         |
| 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±53.64 | 28.12±55.84 | 0.944 | 28.18±54.01 |
| Television (min)                | 34.47±61.94 | 30.42±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.
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.
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### 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 B₆ (mg)                                   | 2.90±1.54                | 2.71±1.43 | 2.83±1.46 | 0.182 |
| Vitamin B₂ (mg)                                   | 2.44±1.03                | 2.39±1.03 | 2.38±1.07 | 0.887 |
| Vitamin B₃ (mg)                                   | 31.68±15.31              | 30.52±14.92 | 30.77±14.71 | 0.170 |
| Vitamin B₃ (mg)                                   | 2.48±1.16                | 2.47±1.26 | 2.40±1.15 | 0.138 |
| Vitamin B₁₂ (µg)                                  | 562.40±280.75            | 506.82±272.89 | 549.29±270.92 | 0.294 |
| Vitamin C (mg)                                    | 158.99±137.70            | 166.82±141.42 | 152.93±142.37 | 0.128 |
| 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 results 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                            |
|                                | Q₁       | Q₂       | Q₃       | Q₄       | P trend | Q₁       | Q₂       | Q₃       | Q₄       | P trend |
| YaHS-TAMYZ study               |         |         |         |         |         |         |         |         |         |         |         |
| Subjects (n)                   | 1247     | 1247     | 1247     | 1247     |         | 1247     | 1247     | 1247     | 1247     |         |
| Healthy dietary pattern        |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 1.09 (0.86, 1.39) | 0.83 (0.64, 1.08) | 0.87 (0.68, 1.16) | 0.89 (0.71, 1.19) | 0.936  |
| Model I                        | 1.22 (0.93, 1.60) | 1.00 (0.77, 1.29) | 1.03 (0.80, 1.34) | 0.91 (0.68, 1.23) | 0.836  |
| Model II                       | 1.17 (0.89, 1.54) | 1.03 (0.80, 1.34) | 0.85 (0.66, 1.13) | 0.85 (0.63, 1.14) | 0.506  |
| Western dietary pattern        |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.99 (0.76, 1.33) | 1.00 (0.80, 1.33) | 0.96 (0.74, 1.24) | 0.99 (0.76, 1.27) | 0.933  |
| Model I                        | 1.07 (0.83, 1.38) | 0.98 (0.76, 1.27) | 0.90 (0.74, 1.26) | 0.99 (0.76, 1.27) | 0.947  |
| Model II                       | 1.18 (0.91, 1.53) | 1.07 (0.81, 1.41) | 0.90 (0.74, 1.26) | 0.94 (0.76, 1.27) | 0.486  |
| Traditional dietary pattern    |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.99 (0.76, 1.29) | 1.00 (0.80, 1.32) | 0.97 (0.74, 1.26) | 0.94 (0.76, 1.27) | 0.927  |
| Model I                        | 1.07 (0.83, 1.38) | 0.98 (0.76, 1.27) | 0.90 (0.74, 1.26) | 0.94 (0.76, 1.27) | 0.947  |
| Model II                       | 1.12 (0.91, 1.53) | 1.07 (0.81, 1.41) | 0.90 (0.74, 1.26) | 0.94 (0.76, 1.27) | 0.932  |
| High-carbohydrate, high-fat dietary pattern |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.91 (0.70, 1.18) | 0.87 (0.66, 1.14) | 0.88 (0.66, 1.14) | 0.88 (0.66, 1.14) | 0.376  |
| Model I                        | 0.91 (0.70, 1.18) | 0.85 (0.65, 1.12) | 0.85 (0.66, 1.15) | 0.87 (0.63, 1.20) | 0.316  |
| Model II                       | 0.91 (0.70, 1.18) | 0.85 (0.65, 1.12) | 0.85 (0.66, 1.15) | 0.87 (0.63, 1.20) | 0.316  |
| Shahedieh study                |         |         |         |         |         |         |         |         |         |         |         |
| Subjects (n)                   | 1019     | 1029     | 1034     | 1071     | 979     | 1032     | 992     | 966     |         |         |         |
| Healthy dietary pattern        |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 1.40 (1.13, 1.75) | 1.14 (0.91, 1.43) | 1.32 (1.06, 1.64) | 1.01 (0.81, 1.26) | 0.016  |
| Model I                        | 1.37 (1.10, 1.70) | 1.09 (0.87, 1.36) | 1.22 (0.98, 1.53) | 1.00 (0.81, 1.25) | 0.065  |
| Model II                       | 1.40 (1.12, 1.76) | 1.06 (0.83, 1.34) | 1.20 (0.95, 1.51) | 1.04 (0.83, 1.30) | 0.532  |
| Western dietary pattern        |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.96 (0.77, 1.18) | 1.12 (0.91, 1.38) | 1.26 (1.01, 1.57) | 1.25 (1.00, 1.57) | 0.164  |
| Model I                        | 1.14 (0.92, 1.44) | 1.43 (1.13, 1.81) | 1.27 (1.01, 1.59) | 1.50 (1.17, 1.93) | 0.001  |
| Model II                       | 1.22 (0.96, 1.53) | 1.49 (1.17, 1.90) | 1.20 (0.95, 1.52) | 1.46 (1.12, 1.90) | 0.014  |
| High-carbohydrate, high-fat dietary pattern |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.95 (0.75, 1.19) | 1.21 (0.96, 1.53) | 0.99 (0.78, 1.27) | 1.11 (0.87, 1.43) | 0.005  |
| Model I                        | 1.12 (0.90, 1.39) | 1.18 (0.95, 1.46) | 1.19 (0.95, 1.49) | 1.49 (1.18, 1.87) | 0.003  |
| Model II                       | 1.14 (0.92, 1.41) | 1.18 (0.95, 1.47) | 1.22 (0.98, 1.56) | 1.49 (1.18, 1.90) | 0.005  |
| Traditional dietary pattern    |         |         |         |         |         |         |         |         |         |         |         |
| Crude                          | 0.99 (0.75, 1.15) | 0.93 (0.75, 1.15) | 1.02 (0.83, 1.27) | 0.73 (0.58, 0.93) | 0.299  |
| Model I                        | 0.87 (0.70, 1.09) | 0.99 (0.80, 1.23) | 0.87 (0.70, 1.09) | 0.70 (0.56, 0.88) | 0.480  |
| Model II                       | 0.86 (0.69, 1.08) | 0.99 (0.79, 1.24) | 0.87 (0.70, 1.09) | 0.70 (0.56, 0.88) | 0.628  |

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.
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

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

| Food groups               | Food items                                                                                                                                                                                                 |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Red, processed            | Lamb, Beef, Kebab, Sausages, Hamburgers, Beef liver, Lamb organ (Tongue, Tripe, Head and trotters, Brain, Foot, Abomasum)                                                                                   |
| and organ meats           |                                                                                                                                                                                                          |
| 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                | 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 |
| desserts                  | Condiments                                                                                                                                     |
| Salt                      | Salt                                                                                                                                                                                                     |
| Pickles                   | Pickles                                                                                                                                                                                                    |
| Garlic                    | Garlic                                                                                                                                                                                                     |
| Coffee                    | Coffee                                                                                                                                                                                                     |
| Food groups                              | 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                      |

1Values <0.30 were excluded for simplicity
### Supplementary Table 3: Factor-loading matrix for major dietary patterns in the Shahedieh study

| Food groups                  | 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      |

*Values <0.30 were excluded for simplicity*