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Assessment of Impact of Dietary Patterns on Obstructive Sleep Apnea Patients

Fatma Esra Gunes[1] Kadriye Agan[2] Sule Aktac[1] Derya Karadeniz[3] Gulin Sunter[2] Ezgi Vural[2]
Gulcin Benbir-Senel[3]

[1] Department of Nutrition and Dietetics, Faculty of Health Sciences, Marmara University, Istanbul, Turkey
[2] Department of Neurology, School of Medicine, Marmara University, Istanbul, Turkey
[3] Sleep and Sleep Disorders Unit, Department of Neurology, Cerrahpaşa Faculty of Medicine, Istanbul University-Cerrahpaşa, Istanbul, Turkey

Address for correspondence Ezgi Vural, MD (email: ezgi.vural@marmara.edu.tr).

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Abstract

Objective Obstructive sleep apnea syndrome (OSAS) is characterized by episodic cessations of breathing due to upper airway obstruction during sleep, which may cause disturbances in dietary patterns resulting from appetite-related hormonal changes. The aim of the present study was to investigate the relationship between OSAS and nutritional and dietary patterns.

Materials and Methods A total of 20 female and 53 male OSAS patients aged > 30 years were enrolled. Demographic data, as well as data on smoking and alcohol habits, were noted, anthropometric measures were made, and a questionnaire regarding chronic diseases including OSAS and four questionnaires on recent food intake frequency and content of nutrition were filled out. The content of nutrition was noted under seven categories: meat, legumes, milk and dairy products, fruits and vegetables, bread and cereals, fat and carbohydrates, and beverages.

Results The severity of OSAS (assessed by the apnea-hypopnea index. AHI) was positively correlated with the body mass index (BMI), the circumferences of the waist, chest, and buttocks, and, in males, with the circumference of the neck as well. There was no correlation between the AHI and nutritional habits in terms of the frequency of meals or snacks, the scores on the Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender (STOP-BANG) Questionnaire and the corresponding macro- and micronutrients. Worsening apnea scores led to increased intake of macronutrients of carbohydrate and protein and micronutrients of niacin and pyridoxine ($p < 0.05$), and decreased intake of fat ($p < 0.05$).

Conclusion The present study demonstrated an association between OSAS severity and recent food intake, manifested in increased intake of carbohydrates, niacin, and pyridoxine, and decreased fat intake.

Keywords
- obstructive sleep apnea syndrome
- body mass index
- food analysis
- diet

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Introduction

Obstructive sleep apnea syndrome (OSAS) is characterized by episodic cessations of breathing due to upper airway obstruction during sleep. This pathology leads to disturbed sleep as well as increased daytime sleepiness, which are the leading symptoms of patients.[1] The prevalence of OSAS is reported as ranging from 4% to 14%; it increases with older age, and is most commonly observed between 40 and 65 years.[2] Patients with OSAS face a higher risk of vascular complications such as congestive heart failure, coronary heart disease, cardiac arrhythmia, myocardial infarction, cerebrovascular disease, diabetes, and metabolic syndrome.[3] Excessive fat tissue in the abdominal region triggers hypoventilation and worsens the collapse of the upper respiratory airways.[4]

Hedonic and hormonal factors are the underlying pathophysiological mechanisms involved in food intake and insufficient sleep. The intake of unhealthy food leads to insufficient sleep, which triggers reward-related networks in the brain, including the putamen, the nucleus accumbens, the thalamus, the insula, and the prefrontal cortex. Hedonic stimulants are activated in conditions of limited sleep time, especially in the insular cortex, orbitofrontal cortex, and dorsolateral prefrontal cortex. Ghrelin and leptin, known as the hunger and satiety hormones, regulate food intake predisposition, which is affected by poor sleep quality and shorter sleep periods.[5,6] Obstructive sleep apnea syndrome causes episodic hypoxemia, sympathetic nervous system activation, and insulin resistance. Therefore, in OSAS, sleep fragmentation and insufficient sleep are closely related to unhealthy dietary habits due to hormonal irregularities and disturbed responses of the central nervous system towards unhealthy food.[7] Despite public health recommendations, the relationship between sleep and dietary habits is not fully understood. In the present study, we aimed to investigate the relationship between OSAS and dietary patterns.

Materials and Methods

Subjects

The patients attending the Sleep Centers of a Neurological Sciences Institute and a Neurology Department were randomly selected, and of 73 (20 female and 53 male) patients diagnosed with OSAS were enrolled in the present study. Block randomization without stratification was used in the allocation of the participants. The inclusion criteria were as follows: patients aged > 18 years, capable of eating independently, and willing to participate. The subjects were allocated randomly into groups after confirmation that they fulfilled the inclusion criteria during their visits to the study'a physicians. The present study was approved by the institutional Ethics in Research Committee, and written informed consent was obtained from all participants.

Intervention

Data were collected in face-to-face interviews by dietitians using an inquiry form with questions on age, schooling level, employment status, smoking, alcohol consumption, anthropometric measurements, time of OSAS diagnosis, other chronic diseases, and the Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender (STOP-BANG) Questionnaire.[8] The participants were asked about the food they had consumed in the previous 24 hours, as well as in the past 15 days through the Food Frequency Questionnaire (FFQ), which were collected within the same time period.[9] A dietician interviewed each patient face-to-face using a food atlas to determine the amount of food consumption. A database of the most frequently consumed foods was developed in the FFQ, and the recorded food frequencies were analyzed. Dieticians grouped 229 frequently-consumed foods under 6 categories representing features of Turkish cuisine: meat group, dairy group, cereal group, oil and margarine, sweet food items, and fruits and vegetables). The frequency of food consumption was recorded in 9 categories: > 6 times/day, 4 to 5 times/day, 2 to 3 times/day, once a day, 5to 6 times/week, 2to 4 times/week, once a week, 1to 3 times/month, once to none/month. The size of each portion was determined using a food atlas, which enabled us to standardize the amount of food consumption and prevent over- or underreporting. The body mass index (BMI) was calculated, and the circumferences of the waist, chest, neck, and hip of each participant.

Statistical Analysis

The calories and nutritional value of each food were calculated. The daily nutrient intake and consumption of each food group (in grams) were assessed using a computer software (EBISpro, Willstätt, Baden-Württemberg, Germany; Turkish version: BeBiS, version 8). In total, 97% of the software's data source originated from the Bundeslebensmittelschlüssel (BLS), version II.3, and 3%, from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference, Release 19 (SR19). The consumption data analyzed was interpreted according to OSAS severity. The statistical analysis was performed with the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States) software, version 23.0, And statistical significance was set at $p < 0.05$. Data were expressed as mean ± standard deviation (SD) values. The unpaired *t*-test was used to compare independent groups.

Results

Association between OSAS and Anthropometric Characteristics

The mean age of the participants was of 52.9 ± 11.5 years. Demographic data and anthropometric measurements are summarized in ►**Table 1**. No significant correlations were found regarding the demographic data, the apnea-hypopnea index (AHI) and the STOP-BANG score ($p > 0.05$).

The anthropometric measurements were found to be correlated with OSAS severity. For both female and male patients, as the BMI increases, so does the OSAS severity ($p < 0.05$; ►**Table 2**).

Table 1 Demographic characteristics and anthropometric measurements of the study sample.

Gender: n (%)	
Female	20 (27.4)
Male	53 (72.6)
Age group: n (%)	
≤ 50 years	36 (49.3)
51 to 70 years	30 (41.1)
> 70 years	7 (9.6)
Smoking status: n (%)	
≤ 1 package per day	23 (31.5)
> 1 package per day	11 (15.1)
Not smoking	39 (53.4)
Alcohol consumption: n (%)	
Positive	28 (38.4)
Negative	45 (61.6)
Stop-BANG risk group: n (%)	
Medium	7 (9.7)
High	66 (90.3)
Height (in cm): median (range)	
Female patients	156.5 (150–174)
Male patients	175 (162–190)
Body weight (in kg): median (range)	
Female patients	86.5 (60–120)
Male patients	94 (65–150)
BMI (in kg/m^2): median (range)	
Female patients	34.6 (25–46.3)
Male patients	29.7 (23.3–47.3)
Waist circumference (in cm): median (range)	
Female patients	111 (89–137.5)
Male patients	111 (90–153)
Hip circumference (in cm): median (range)	
Female patients	116 (97–149)
Male patients	110 (96–140)
Chest circumference (in cm): median (range)	
Female patients	113 (93–132)
Male patients	108 (93.5–152)
Neck circumference (in cm): median (range)	
Female patients	39.75 (33–51)
Male patients	43.5 (35–54)

Abbreviations: BMI, body mass index; STOP-BANG, Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender Questionnaire.

Table 2 Relationship between anthropometric measurements by gender and severity of obstructive sleep apnea syndrome.

Anthropometric measurements	Apnea-hypopnea index	
	r	*p*
Body weight (in kg)		
Female patients	0.635	0.003
Male patients	0.615	< 0.001
Waist circumference (in cm)		
Female patients	0.632	0.003
Male patients	0.591	< 0.001
Hip circumference (in cm)		
Female patients	0.641	0.002
Male patients	0.433	0.002
Chest circumference (in cm)		
Female patients	0.560	0.010
Male patients	0.542	< 0.001
Neck circumference (in cm)		
Female patients	0.494	0.027
Male patients	0.440	0.001
Apnea-hypopnea index		
Female patients	0.609	0.004
Male patients	0.572	< 0.001

Association between OSAS and Dietary Patterns

No correlation was observed between the AHI and the total number of main meals or snacks. However, we found a significant correlation between STOP-BANG scores and the number of daily snacks ($p = 0.005$; ►**Table 3**,). No significant correlations were found regarding the energy percentages of the daily intake of carbohydrate, fat, or proteins with the severity of OSAS ($p > 0.05$).

►**Table 4** shows the STOP-BANG scores and corresponding macro- and micronutrients. Higher scores were significantly associated with an increased intake of macronutrients of carbohydrate and protein, as well as of micronutrients of niacin and pyridoxine ($p < 0.05$), in addition to a decrease in the fat intake ($p < 0.05$).

The patients with higher AHI significantly consumed fish, sugar, and pastry products more frequently (►**Table 5**). The patients with higher STOP-BANG scores consumed more white and wholemeal bread ($p < 0.05$). Chicken and cheddar cheese were more frequently consumed by the patients complaining of fatigue in the morning. Chicken and coffee were found to be more frequently consumed by the patients with a history of witnessed apnea ($p < 0.05$).

Discussion

Obstructive sleep apnea syndrome is more frequent among older male patients. Although Gabbay and Lavie[10] suggested

Table 3 Comparison of the number of meals with the STOP-BANG risk and severity of OSAS.

Number of meals	Severity of OSAS				STOP-BANG risk		
	Mild n (%)	Moderate n (%)	Severe n (%)	χ^2; *p*	Moderate n (%)	High n (%)	χ^2; *p*
Number of main meals							
2 meals	2 (22.2)	4 (19)	10 (23.8)	0.184;	3 (42.9)	14 (21.2)	1.66; 0.34
3 meals	7 (77.8)	17 (81)	32 (76.2)	0.912	4 (57.1)	52 (78.8)	
Number of snacks							
None	1 (11.1)	1 (4.8)	6 (14.3)	5.787; 0.447	1 (14.3)	7 (10.6)	12.78; 0.005
1 meal	4 (44.4)	8 (38.1)	23 (54.8)		2 (28.6)	34 (51.5)	
2 meals	4 (44.4)	9 (42.9)	10 (23.8)		1 (14.3)	22 (33.3)	
3 meals	0 (0)	3 (14.3)	3 (8.3)		3 (42.9)	3 (4.5)	

Abbreviations: χ^2, Chi-squared test; OSAS, obstructive sleep apnea syndrome; STOP-BANG, Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender Questionnaire.

Table 4 STOP-BANG risk groups and energy and nutrient uptake.

Nutrition	Moderate STOP-BANG: median (mean rank)	High STOP-BANG: median (mean rank)	χ^2; *p*
Energy (in kcal)	1542.1 (20.71)	1882.5 (38.73)	4.56; 0.03
Carbohydrate (in g)	114.8 (17.43)	188.5 (39.08)	6.58; 0.01
Carbohydrate (%)	32 (24.86)	43 (38.29)	1.59; 0.11
Protein (in g)	55.5 (20.43)	70.3 (38.76)	4.72; 0.03
Protein (%)	16 (34.79)	16 (37.23)	0.29; 0.77
Fat (in g)	95.6 (34.29)	85.2 (37.29)	0.12; 0.72
Fat (%)	52 (55.36)	41 (35.05)	2.41; 0.01
Fiber (in g)	20.3 (33.93)	21.7 (37.33)	0.16; 0.68
Cholesterol (in mg)	335.3 (39.21)	314.5 (36.77)	0.08; 0.77
Saturated fatty acid (in g)	32.4 (35.93)	30.6 (37.11)	0.02; 0.88
Polyunsaturated fatty acid (in g)	17.9 (41.07)	16 (36.57)	0.28; 0.59
Niacin (in mg)	7.5 (21.57)	11.3 (38.64)	4.09; 0.04
Pyridoxine (in mg)	1 (20.79)	1.2 (38.72)	4.55; 0.03

Abbreviations: χ^2, Chi-squared test; OSAS, obstructive sleep apnea syndrome; STOP-BANG, Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender Questionnaire.

that the AHI was higher among older male patients, no correlations involving the AHI and gender or age were found in the present study.

Previous studies[11,12] have reported a correlation between OSAS and the BMI. It has been proven[11] that a 10% increase in weight leads to a 32% increase in the AHI, whereas a 10% decrease in weight leads to a 26% decrease in the AHI. A previous study[12] on the relationship between metabolic syndrome and OSAS with 209 patients found positive correlations involving the AHI, the BMI, the waist-hip circumference, and visceral fat tissue. The present study corroborated these findings, as the AHI increased significantly with increasing BMI, and hip, chest, and neck circumferences both for male and female patients.

Low fiber, high sugar and high saturated fat intake are related to insufficient restorative sleep compared with ad libitum dietary habits.[13] It has been shown that a high carbohydrate/low fat diet is related to poor sleep quality compared to a balanced diet. Consuming meals with high glycemic index four hours before bedtime causes a shift in sleep onset and shortens the period before going to sleep, which is the reason behind the tryptophan surge after carbohydrate consumption. In a randomized controlled trial, St-Onge et al.[13] reported that low fiber, high saturated fat, and high sugar intake is related to more frequent arousals in young to middle-aged individuals. In the present study, we observed that carbohydrate consumption rises with increasing AHI; however, this difference was not statistically significant.

In the present study, according to the STOP-BANG classification, an increase in energy, carbohydrate, and protein intake was observed with worsening scores, but no

Table 5 Relationship between consumption of foods and clinical features of OSAS.

Food Consumption		AHI Group				STOP-BANG risk		
		Light: n (%)	Moderate: n (%)	Severe: n (%)	χ^2; *p*	Moderate: n (%)	High: n (%)	χ^2; *p*
Fish	Everyday	0 (0)	0 (0)	0 (0)	10.12; 0.038	0 (0)	0 (0)	3.384; 0.184
	Every other day	2 (22.2)	1 (4.8)	2 (4.8)		0 (0)	5 (7.6)	
	1 or 2 times a week	5 (55.6)	7 (33.3)	27 (64.3)		2 (28.6)	37 (56.1)	
	Once every 15 days	2 (22.2)	13 (61.9)	13 (31)		5 (71.4)	24 (36.4)	
Sugar	Everyday	2 (22.2)	6 (28.6)	20 (47.6)	18.665; 0.005	1 (14.3)	28 (42.4)	3.036; 0.386
	Every other day	2 (22.2)	0 (0)	1 (2.4)		0 (0)	3 (4.5)	
	1 or 2 times a week	1 (11.1)	0 (0)	0 (0)		0 (0)	1 (1.5)	
	Once every 15 days	4 (44.4)	15 (71.4)	21 (50)		6 (85.7)	34 (51.5)	
Pastry	Everyday	0 (0)	0 (0)	0 (0)	10.410; 0.034	0 (0)	0 (0)	2.02; 0.367
	Every other day	2 (22.2)	1 (4.8)	0 (0)		0 (0)	3 (4.5)	
	1 or 2 times a week	2 (22.2)	2 (9.5)	7 (16.7)		0 (0)	12 (18.2)	
	Once every 15 days	5 (6.9)	18 (85.7)	35 (83.3)		7 (100)	51 (77.3)	
White bread	Everyday	3 (33.3)	14 (66.7)	26 (61.9)	8.008; 0.238	1 (14.3)	42 (63.6)	11.401; 0.01
	Every other day	0 (0)	0 (0)	1 (2.4)		0 (0)	1 (1.5)	
	1 or 2 times a week	0 (0)	2 (9.5)	5 (11.9)		0 (0)	7 (10.6)	
	Once every 15 days	6 (66.7)	5 (23.8)	10 (23.8)		6 (85.7)	16 (24.2)	
Wholemeal bread	Everyday	6 (66.7)	9 (42.9)	20 (47.6)	3.241; 0.778	7 (100)	29 (43.9)	7.957; 0.047
	Every other day	0 (0)	0 (0)	2 (4.8)		0 (0)	2 (3)	
	1 or 2 times a week	1 (11.1)	4 (19)	5 (11.9)		0 (0)	10 (13.7)	
	Once every 15 days	2 (22.2)	8 (38.1)	15 (35.7)		0 (0)	25 (37.9)	
Chicken	Everyday	0 (0)	0 (0)	0 (0)	4.765; 0.574	0 (0)	1 (1.5)	6.938; 0.074
	Every other day	2 (22.2)	8 (38.1)	10 (23.8)		1 (14.3)	19 (28.8)	
	1 or 2 times a week	3 (33.3)	10 (47.6)	17 (40.5)		1 (14.3)	30 (45.5)	
	Once every 15 days	4 (44.4)	3 (14.3)	14 (33.3)		5 (71.4)	16 (24.2)	
Cheddar cheese	Everyday	3 (33.3)	7 (33.3)	13 (31)	1.597; 0.953	3 (42.9)	20 (30.3)	2.097; 0.553
	Every other day	1 (11.1)	2 (9.5)	5 (11.9)		0 (0)	9 (13.6)	
	1 or 2 times a week	2 (22.2)	4 (19)	13 (31)		1 (14.3)	18 (27.3)	
	Once every 15 days	3 (33.3)	8 (38.1)	11 (26.2)		3 (42.9)	19 (28.8)	

Table 5 (*Continued*)

Food Consumption		AHI Group				STOP-BANG risk		
		Light: n (%)	Moderate: n (%)	Severe: n (%)	X^2; *p*	Moderate: n (%)	High: n (%)	X^2; *p*
Coffee	Everyday	5 (55.6)	10 (47.6)	22 (52.4)	0.897; 0.989	6 (85.7)	31 (47)	4.442; 0.218
	Every other day	1 (11.1)	4 (19)	6 (14.3)		0 (0)	11 (16.7)	
	1 or 2 times a week	2 (22.2)	3 (14.3)	7 (16.7)		0 (0)	13 (19.7)	
	Once every 15 days	1 (11.1)	4 (19)	7 (16.7)		1 (14.3)	11 (16.7)	

Abbreviations: X^2, Chi-squared test; AHI, apnea-hypopnea index; OSAS, obstructive sleep apnea syndrome; STOP-BANG, Snoring, Tiredness, Observed Apnea, and High Blood Pressure-Body Mass Index, Age, Neck Circumference, and Gender Questionnaire.

relationship was observed regarding fat intake. The percentage of fat intake was found to have a statistically significant negative correlation with OSAS severity. Vasquez et al.[14] reported that daily consumption of fat was higher in individuals with OSAS. On the other hand, other studies[15,16] have reported no associations involving fat intake and sleep quality or insomnia symptoms.

Deficiencies in magnesium, iron, folate, phosphorus, zinc, calcium, carotene, selenium, and vitamin B1 have been reported to be associated with shorter sleep times and difficulty in sleeping. Vitamin D and lycopene were found to be associated with sleep, and low calcium and vitamin C intake was found to be related to non-restorative sleep.[17] Short-term studies[18,19] have found that nighttime melatonin, zinc or magnesium intake and vitamin D supplementation improve sleep quality, delay, and duration in adults with sleep disorders and in nursing home residents with insomnia. In the present study, niacin and pyridoxine uptake was significantly associated with higher STOP-BANG scores and an increased risk of developing OSAS.

Alcohol consumption is another factor with a negative impact on sleep. Consumption of one to two glasses of alcohol may help an individual fall asleep, but drinking more than two glasses causes snoring and sleep apnea, and adversely affects the quality of sleep.[20] Alcohol consumption may interfere with sleep by affecting serotonin and norepinephrine levels.[21] In the present study, we did not observe statistically significant relationships involving alcohol consumption or smoking and the AHI and OSAS severity.

The intake of stimulant foods and beverages also affects sleep. Caffeine and theobromine are known to be competitive antagonists for adenosine.[22] Although caffeine and theobromine provide energy immediately after consumption, they are known to have effects that last for hours after ingestion, which may affect sleep patterns, including sleep delay, and cause reduced total sleep time, sleep inefficiency, poor perceived sleep quality, and rapid-eye-movement (REM) sleep behavior disorder.[23] The present study demonstrated a significant relationship between the frequency of coffee consumption and the severity of difficulties in breathing during sleep.

Diet is one of the lifestyle factors associated with sleep patterns. The Mediterranean diet may help maintain stable sleep time and improve sleep quality, which may be related to a direct impact on health or indirect effects on the improvement of body weight.[24–26] Meat is of interest for sleep because of its content of high-quality protein, saturated fatty acids, and trans fatty acids. Lana et al.[25] reported that snoring and poor sleep quality were independently affected by excessive meat consumption; these results were similar for processed meat and white meat, and there was little change after rearranging food intake, which could have a detrimental effect. In previous studies,[27] protein intake and fat intake appear to be independent risk factors for OSAS. In the present study, we found no relationship between the frequency of consumption of red meat and OSAS; however, a significant positive correlation was found between the frequency of consumption of chicken and fish and disease severity. Moreover, the frequency of consumption of sugar, white bread and pastries was demonstrated to be positively correlated with OSAS severity.

Changes in the composition of the daily diet and eating behaviors may affect the macroelements of sleep.[28] Laboratory studies[29–31] with small samples of healthy adults have reported an increase in energy expenditure or a decrease in alertness and recovery with internal circadian mechanisms that regulate hunger, saturation, and food-specific appetite, and sleep deprivation. When behavioral mechanisms are investigated, both short sleep duration and poor sleep quality are associated with adverse feeding patterns that may lead to increased energy intake, poor nutrition quality, and weight gain.[32] Individuals who sleep less than 7 hours per night have significantly higher energy intake from fat than those who sleep 7-9 hours per night. In the present study, we showed that higher energy intake was present in the patients with higher AHI and more severe OSAS. In addition, a negative correlation was found between severity according to the STOP-BANG and the consumption of snacks.

In conclusion, the present study demonstrated that there is a relationship between recent food intake and OSAS severity investigated in a cross-sectional fashion. As weight loss has been shown to be beneficial in reducing the effects of OSAS through healthy eating programs, efforts should be made towards multidisciplinary approaches that enable patients to make healthy food choices. Further research is needed to clarify the underlying mechanisms of sleep quality and certain food and eating behaviors that would affect it. Larger randomized clinical trials, as well as longitudinal analyzes of diet and sleep investigating dietary patterns both before and after the diagnosis of OSAS, may help us reach this goal. These studies may help identify potential underlying mechanisms that mediate sleep, diet, and chronic disease risk.

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Conflict of Interests

The authors have no conflict of interests to declare.

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