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Nutritional Status and Dietary Patterns in Adults with Severe Obstructive Sleep Apnea

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Abstract

Obstructive sleep apnea (OSA) is associated with daytime sleepiness, obesity, and lifestyle and dietary changes. The potential role of diet in OSA has been largely unexplored. The aim of the study was to assess nutritional status and dietary patterns in OSA patients. The study was conducted in 137 adult patients (48 women and 89 men) aged 31–79 suffering from OSA. The following diagnostic procedures were undertaken: polysomnography, anthropometric measurements, and a dietary pattern questionnaire. We found that 128 (93.4%) patients were overweight or obese with the mean body mass index (BMI) of 33.2 ± 6.1 kg/m^2 and weight of 98.0 ± 20.2 kg. The mean percentage of total body fat was $45.0 \pm 5.5\%$ in women and $32.5 \pm 5.5\%$ in men. Obesity was associated with the severity of OSA, expressed by apnea/hypopnea index. We further found that the waist-to-hip ratio in women, but the neck circumference or percentage of body fat in men, characterizes best the OSA patients. Referring to dietary habits, half of the patients consumed white bread on a daily basis, 35.8% of them had whole grain bread in the diet, and only 16.8% consumed fish at least two portions a week. A third of patients used butter as a spread for bread or a source of fat for cooking, 2.9% of them used soft margarine, and 20.4% used olive or canola oil. Fruits and vegetables were consumed by 60% and 38% of patients, respectively. Refined sugar and sweets were used by 31.4% of patients every day. We conclude that excessive body weight, which may portend the development of OSA, is characterized by different anthropometric variables in men and women. Further, improper dietary habits seem conducive to the gain in body weight and thus may be at play in the pathogenesis of OSA.

Keywords

Body fat · Dietary patterns · Nutritional status · Obesity · Obstructive sleep apnea

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1 Introduction

Obstructive sleep apnea (OSA) is one of the very common diseases in the general population. Among the other factors, the prevalence of OSA depends on age and sex and is estimated at 13% in men and 6% in women aged 30–70 years; it has shown a relative percentage increase by 14–55% over the last 20 years (Peppard et al. 2013). OSA is characterized by recurrent collapse of the upper airway during sleep, resulting in partial or complete obstructive of airflow limitation, leading to a decrease in blood oxygenation, subsequent arousals, fragmented sleep, and excessive daytime sleepiness. Untreated OSA is associated with significant comorbidity and can lead to many cardiovascular complications (Kumor et al. 2013). The main risk of OSA is obesity. According to WHO data, the number of obese patients is growing and has significant impact on the healthcare system. In 2016, 39% of women and 39% of men aged 18 and over were overweight worldwide. Fifty to 70% of overweight and obese subjects have OSA (Young et al. 2002). Including epidemiological data, OSA still remains underdiagnosed in obese subjects. Moreover, OSA and obesity are considered independent risk factors for cardiovascular diseases and atherosclerosis progression. The main measure of obesity is body mass index (BMI), strongly correlated with the severity of OSA. Other anthropometric parameters are also closely related to OSA. Waist-to-hip ratio is a reliable correlate of OSA irrespective of gender. Neck circumference is an independent risk factor for male, but not for female OSA patients. These different aspects of obesity may contribute to the pathogenesis of OSA (Lim et al. 2014). BMI, neck circumference, and a high Epworth Sleepiness Scale (ESS) are independently predictive of moderate-to-severe OSA in males, whereas age, neck circumference, and morning headaches are independently predictive in females (Earl et al. 2019). The waist-to-hip ratio and neck measures also associate with OSA severity assessed from arterial oxygen desaturations or apnea/hypopnea index (AHI) (Tom et al. 2018). De Melo et al. (2019) have reported that a higher amount of food intake during the evening period may diminish sleep quality in moderate and severe OSA patients. Those authors also report the presence of a moderate association between the resting energy expenditure or sleep quality and the incidence of OSA, although this association seems insensitive to disease severity.

The present study seeks to define the nutritional status of OSA patients by dietary intake and anthropometric measures and to evaluate the relation of OSA to the obesity metrics, such as BMI, body fat content, muscle mass, neck circumference, and their association with OSA severity, assessed by AHI.

2 Methods

2.1 Patients

There were 137 untreated patients enrolled into the study (M/F, 89/48), who presented symptoms suggestive of OSA and were referred to the in-sleep polysomnography (PSG) investigation (Nox Medical, Reykjavík, Iceland) between June 2017 and June 2018. The assessment of a sleep structure was performed according to the recommendations of Hori et al. (2001). The patients completed a questionnaire on snoring, observed apneas, comorbidities, and medicines used. Sleepiness was assessed with EPS, with scores $\geq$10 classified as excessive daytime sleepiness. All of the patients with previously diagnosed or treated OSA and those after bariatric surgery were not eligible for the study.

The diagnosis OSA was established according to the recommendations of the American Academy of Sleep Medicine, which require an AHI $\geq$5/h of sleep in the presence of typical OSA symptoms or AHI $\geq$15/h, regardless of the clinical manifestation (Kapur et al. 2017). Only were patients with the severe OSA (AHI >30/h) recruited to the study.

2.2 Nutritional Assessment

A physical examination was performed, and the following parameters were recorded: neck circumference, waist-to-hip ratio (WHR), body mass index (BMI, kg/m^2), and the central (visceral) obesity as a WHR >1 and peripheral obesity as a WHR <0.8. Body weight and height were measured using a Seca 799 station and column scales, with the accuracy of ±0.1 kg/cm (Seca, Chino, CA). The interpretation of BMI data followed the classification set by the WHO, i.e., underweight <18.5 kg/m^2, normal weight 18.5–25.0 kg/m^2, overweight 25–30 kg/m^2, and obese ≥30 kg/m^2. Whole-body impedance (BIA, wrist to ankle) was measured using the Maltron BioScan 920-II multi-frequency bioelectrical impedance analyzer (Maltron BioScan, Rayleigh, UK) according to the manufacturer's instructions. Before taking the BIA measurement, the patients were instructed with the following guidelines: no heavy exercise 12 h before the test, no large meals or caffeinated products 4 h before the test, and consumption of liquids limited to 1% of body weight or two 8 oz. glasses of water 2 h before the test.

A 62-item non-quantitative food frequency questionnaire (FFQ-6) was used for the assessment of food intake. The questionnaire was used in the form of a table that included selected food products (see Table 4). Patients determined the frequency of food consumption using a 6-point scale, using the following score: daily, 6 points; 4–5 times a week, 5 points; 2–3 times a week, 4 points; once a week, 3 points; 2–3 times a month, 2 points; and rarely, 1 point. The tool collected information on the frequency of consumption of 62 assorted product groups, representing 8 main food groups consumed in the last 12 months.

2.3 Statistical Elaboration

Data were expressed as means ± SD. Differences between groups were evaluated with a *t*-test and one-way analysis of variance ANOVA, followed by post hoc Fisher's test as appropriate. The association between the frequency of consumption of food products and gender was assessed with Pearson's correlation coefficient. A *p*-value <0.05 denoted statistically significant differences. A commercial statistical package of Statistica v13.3 was used (StatSoft, Tulsa, OK).

3 Results

3.1 Obstructive Sleep Apnea (OSA) Patients' Characteristics

Thirty nine subjects (28.5%) were overweight (25 ≤ BMI ≤30 kg/m^2), and 88 subjects (64.2%) were obese (BMI >30 kg/m^2). According to the International Diabetes Federation criteria for waist circumference, 89.3% of men and 100% of women had abdominal obesity. Further, 95.2% men and 87.5% women have elevated WHR (>0.90 for men and > 0.85 for women). Most of the anthropometric parameters were greater in men than those in women, particularly the neck circumference, waist circumference, WHR, and muscle mass. Only were the hip circumference and body fat statistically greater in women (Table 1).

All of the OSA patients had increased sleepiness measured by the ESS scale. Sleepiness score was higher in women than that in men (11.2 ± 4.9 vs. 10.1 ± 4.8, respectively, $p = 0.239$). In contrast, the mean AHI was higher in men – 39.7 ± 23.9 *per* hour of sleep – and it was somehow lower in women, 31.6 ± 25.3 *per* hour ($p > 0.05$). There was no difference in SpO_2 between genders (Table 2).

In male OSA patients, AHI, and thus disease severity, significantly associated with the neck circumference, hip circumference, waist circumference, body fat, and BMI. In female patients, AHI associated with WHR only (Table 3).

3.2 Frequency of Food Consumption (FFQ Questionnaire Results) in Obstructive Sleep Apnea Patients

About one half of the OSA patients (53.5%) consumed white bread every day. Only did 35.8% of

Table 1 Patients' anthropometric characteristics

Parameter	Men ($n = 89$)	Women ($n = 48$)	p
Age (years)	54.2 ± 12.3	58.4 ± 11.8	0.054
Body mass index (kg/m^2)	32.6 ± 6.1	34.1 ± 6.1	0.176
Neck circumference (cm)	44.5 ± 5.1	39.0 ± 2.1	<0.001
Waist circumference (cm)	110.5 ± 15.7	104.1 ± 11.1	0.020
Hip circumference (cm)	109.3 ± 11.8	114.4 ± 9.7	0.017
Waist-to-hip ratio	1.0 ± 0.1	0.9 ± 0.1	<0.001
Body fat (%)	32.5 ± 5.8	45.0 ± 5.5	<0.001
Muscle mass (kg)	33.8 ± 4.7	21.1 ± 2.8	<0.001

Data are means ± SD; *t*-test

Table 2 Polysomnography parameters

Parameters	Men ($n = 89$)	Women ($n = 48$)	p
AHI (*per* hour of sleep)	39.7 ± 23.9	31.6 ± 25.3	0.090
ESS score (points)	10.1 ± 4.8	11.2 ± 4.9	0.239
Mean SpO_2 during sleep (%)	90.3 ± 12.0	91.8 ± 2.9	0.460
Minimum SpO_2 during sleep (%)	78.0 ± 12.8	80.4 ± 8.1	0.288

Data are means ±SD; *AHI* apnea/hypopnea index – event per hour of sleep, *ESS* Epworth Sleepiness Scale, SpO_2 peripheral blood oxygen saturation (finger pulse oximetry); *t*-test

Table 3 Associations between obstructive sleep apnea (OSA) severity assessed by apnea/hypopnea index (AHI) and anthropometric parameters

	AHI – men		AHI – women	
	r	*p*	*r*	*p*
Age	−0.035	0.767	0.034	0.849
Neck circumference	0.427	<0.001	−0.029	0.871
Hip circumference	0.435	<0.001	0.036	0.842
Waist circumference	0.421	<0.001	0.332	0.055
Waist-to-hip ratio	0.155	0.191	0.388	0.024
Body fat	0.496	<0.001	−0.022	0.901
Body mass index	0.488	<0.001	0.010	0.519

r Pearson's correlation coefficient

patients use grain bread, and 16.8% consume at least two portions of fish a week. Butter was a daily source of fat for 34.3%, soft margarine was for 2.9%, and olive oil or canola oil was for 20.4% of patients. Fruits were daily consumed by 60% and vegetables by 38% of patients. Sugar and sweets were everyday products for 31.4% of patients (Table 4).

The mean frequency of bread consumption was similar in male and female OSA patients, amounting to 2–3 times per week. Milk consumption also was similar in both genders, consisting mostly of 2% fat milk; it varied from once a week to 2–3 times a month. All of the patients showed increased intake of poultry and pork rather than beef (once a week to 2–3 times a week vs. 2–3 times a month, respectively). Consumption of fruits and vegetables, whether fresh or refined, was similar in OSA women and men (Table 5).

4 Discussion

OSA is a common disease worldwide, affecting over 13% of men and 6% of women (Peppard et al. 2013). In a Polish epidemiological study, the diagnosis of OSA has been established in 7.5% of middle-aged population, and the prevalence of

Table 4 Percentage of patients consuming each of the products listed corresponding to the frequency indicated by points from 6 to 1 as indicated in the table legend

Food products	Men (%)						Women (%)					
	6	5	4	3	2	1	6	5	4	3	2	1
White bread	53.9	12.4	12.4	3.4	1.1	15.7	52.1	4.2	10.4	8.3	0.0	20.8
Whole grain bread	37.1	13.5	16.9	9.0	2.2	21.3	33.3	10.4	16.7	8.3	2.1	27.1
Milk 2% fat	25.8	5.6	5.6	2.2	3.4	57.3	12.5	2.1	8.3	8.3	4.2	60.4
Milk 3.2% fat	5.6	6.7	10.1	6.7	3.4	67.4	2.1	8.3	6.3	6.3	0.0	75.0
Pork	9.0	14.6	34.8	24.7	6.7	9.0	4.2	4.2	31.3	29.2	6.3	22.9
Poultry	2.2	21.3	42.7	19.1	4.5	10.1	10.4	8.3	50.0	22.9	0.0	6.3
Fish	1.1	4.5	10.1	31.5	19.1	23.6	2.1	0.0	16.7	31.3	14.6	22.9
Olive oil, canola oil	20.2	7.9	23.6	16.9	5.6	16.9	20.8	12.5	31.3	14.6	6.3	2.1
Butter	31.5	11.2	11.2	6.7	5.6	24.7	39.6	2.1	4.2	2.1	8.3	33.3
Fresh vegetables	25.8	28.1	16.9	7.9	4.5	7.9	35.4	20.8	18.8	2.1	0.0	12.5
Fresh fruits	40.4	13.5	20.2	5.6	5.6	5.6	50.0	20.8	10.4	0.0	2.1	6.3
Sugar and sweets	34.8	6.7	4.5	9.0	9.0	27.0	25.0	4.2	4.2	6.3	2.1	43.8

Food frequency points: daily, 6 points; 4–5 times a week, 5 points; 2–3 times a week, 4 points; once a week, 3 points; 2–3 times a month, 2 points; rarely, 1 point

Table 5 Mean frequency of consumption of food products by gender

	Men	Women	Statistics
White bread	4.7 ± 1.8	4.4 ± 2.0	$\chi2 = 0.809$ df = 5 $p = 0.976$
Whole grain bread	4.1 ± 1.9	3.8 ± 2.0	$\chi2 = 5.01$ df = 5 $p = 0.414$
Milk 0.5% fat	1.3 ± 1.0	1.5 ± 1.2	$\chi2 = 3.98$ df = 5 $p = 0.553$
Milk 2% fat	2.8 ± 2.2	2.2 ± 1.8	$\chi2 = 8.08$ df = 5 $p = 0.152$
Milk 3.2% fat	2.0 ± 1.6	1.8 ± 1.5	$\chi2 = 3.42$ df = 5 $p = 0.635$
Beef	2.1 ± 1.3	2.0 ± 1.1	$\chi2 = 7.10$ df = 5 $p = 0.213$
Pork	3.7 ± 1.3	3.0 ± 1.4	$\chi2 = 8.97$ df = 5 $p = 0.110$
Poultry	3.7 ± 1.2	3.9 ± 1.2	$\chi2 = 10.55$ df = 5 $p = 0.061$
Fish	2.5 ± 1.2	2.6 ± 1.2	$\chi2 = 3.82$ df = 5 $p = 0.576$
Olive oil, canola oil	3.7 ± 1.7	4.2 ± 1.3	$\chi2 = 7.28$ df = 5 $p = 0.200$

(continued)

Table 5 (continued)

	Men	Women	Statistics
Butter	3.8 ± 2.1	3.6 ± 2.3	$\chi 2 = 8.17$ df = 5 $p = 0.147$
Soft margarine	1.4 ± 1.2	1.1 ± 0.5	$\chi 2 = 3.90$ df = 4 $p = 0.419$
Fresh vegetables	4.4 ± 1.5	4.6 ± 1.7	$\chi 2 = 6.36$ df = 5 p = 0.273
Stewed vegetables	2.1 ± 1.9	2.3 ± 1.7	$\chi 2 = 5.46$ df = 6 $p = 0.486$
Steamed vegetables	2.7 ± 1.8	3.2 ± 1.8	$\chi 2 = 2.78$ df = 5 $p = 0.733$
Fresh fruits	4.7 ± 1.5	5.1 ± 1.4	$\chi 2 = 7.12$ df = 5 $p = 0.212$
Nuts and seeds	1.8 ± 1.4	1.7 ± 1.4	$\chi 2 = 3.49$ df = 5 $p = 0.625$
Legumes	1.9 ± 1.2	1.8 ± 1.3	$\chi 2 = 9.98$ df = 5 $p = 0.076$
Sugar and sweets	3.7 ± 2.2	3.0 ± 2.2	$\chi 2 = 6.35$ df = 5 $p = 0.274$

Data were expressed as means ± SD. Food frequency points: daily, 6 points; 4–5 times a week, 5 points; 2–3 times a week, 4 points; once a week, 3 points; 2–3 times a month, 2 points; rarely, 1 point; Pearson's Chi-squared test

OSA was more than threefold greater in men (11.2%) than that in women (3.4%) (Plywaczewski et al. 2008). In the present study, we evaluated the nutritional habits of OSA patients. The most important drawback concerned the high intake of white bread, simple carbohydrates, and the presence of sweets and confectionery in the diet. In addition, a higher than recommended by WHO consumption of red meat and butter leads to high intake of saturated fatty acids. These findings demonstrate a less than healthy or optimum dietary pattern that falls rather far from the standard recommendations in the prevention of cardiovascular or metabolic, such as diabetes, disorders in OSA patients.

Data on food consumption in OSA patients are scarce, although such patients should require nutritional interventions due to the accompanying obesity. Reid et al. (2019) have shown that OSA associates with lower intake of whole grains, higher intakes of red meat, and a lower overall diet quality. Araghi et al. (2013) highlight the role of body weight in managing OSA by showing that weight gain and loss are consistently associated with increasing and decreasing AHI. The estimate is that a 10% weight loss may lead to as much as a 26% reduction in AHI (Peppard et al. 2013). A recent meta-analysis has confirmed that a significant reduction in AHI and other OSA signs and symptoms is caused by weight reduction and lifestyle interventions, the effect of which depended, to an extent, on OSA severity and gender (Carneiro-Barrera et al. 2019).

We further evaluated the patients' body composition and anthropometric parameters. The majority of patients showed overweight or obesity, with BMI and BF exceeding the recommended norms of the American Council on Exercise (BF% >25% for men and >32% for women). BMI values were greater in OSA men than those in women. We further found that the neck, hip, and waist circumference as well as the percentage of body fat were associated with increasing severity of OSA in men, but not clearly so in women, which underscores the presence of gender differences in the expression of disease severity. Nonetheless, an increased waist-to-hip ratio appears a much more sensitive indicator of OSA severity in women than in men. These findings are in line with the previous studies on sleep-related breathing disorders. Young et al. (2002) have reported an association between the risk of OSA and obesity, WHR, or neck circumference. Ip et al. (2004) and Ip et al. (2001) have shown that higher BMI is accompanied by a higher risk of apnea in Chinese patients, even though the BMI remains in the normal range. Similar conclusions have been reached in the Korean population, where BMI, male gender, and hypertension are closely associated with the risk for OSA (Kang et al. 2014; Kim et al. 2004). Likewise, Udwadia et al. (2004) have reported an association between BMI, neck circumference, and diabetes and the risk for OSA in Indian men. Polesel et al. (2019) have reached the same conclusion in the Brazilian population. These authors argue that waist circumference and waist-to-hip ratio best prognosticate sleep-related breathing disorders in women, whereas neck circumference and waist-to-hip circumference are the best harbingers of mild OSA in men, with BMI remains a factor the most closely associated with severe OSA. However, BMI may not be a perfect parameter for the assessment of OSA severity. Sutherland et al. (2019) have found that South American OSA patients have a larger AHI when compared to African Americans, having a similar BMI. Cho et al. (2016) have also reported that OSA patients have a larger neck circumference than that in healthy control subjects. Further, the authors did not show any significant differences in BMI, waist circumference, or waist-to-hip ratio in OSA patients when compared with a control group, nor have they noticed any differences in neck circumference between Asian and Caucasians patients. In contradistinction, Davidson and Patel (2008) have shown a much stronger association between waist circumference and the severity of sleep-related breathing disorders than that for neck circumference or BMI. In that study, however, only were half of the patients obese, with waist circumference of more than 102 cm. The factors that have the greatest potential for prognosticating the development and identification of sleep-related breathing disorders seemingly are highly multifarious and vary from study to study. Aside from disease severity, these factors depend not only on body built and anthropometric parameters but also on genetic and ethnic differences. From the clinical standpoint, there is a consistent impression that BMI and neck circumference rank first as prognostics of OSA development (Cizza et al. 2014; Simpson et al. 2010; Onat et al. 2009).

In conclusion, most of OSA patients are overweight and obese. There are gender differences in prognosticating the severity of OSA on the basis of anthropometric parameters. In women, waist-to-hip ratio seems an optimum predictor of OSA severity, whereas the neck circumference and waist-to-hip circumference rank first in men. Most of OSA patients run an unhealthy and proarteriosclerotic diet, high in calories, fat, and simple carbohydrates and low in fish, fresh fruits, and vegetables. A nutritional intervention should become a routine part of counseling and management OSA patients.

Conflict of Interest The authors declare no conflicts of interest in relation to this article.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of the Medical University of Warsaw in Poland.

Informed Consent Written informed consent was obtained from all individual participants included in the study.

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