Progress in Nutrition 2021; Vol. 23, N. 2: e2021120 DOI: 10.23751/pn.v23i2.11177

Original article

Association Between Sleep Quality and Depression in Women with Abdominal Obesity and Dietary Energy Density

Hülya Yılmaz Önal[1]; Aysun Yüksel[2]; Kezban Esen Karaca Çelik[3]

[1]Department of Nutrition and Dietetics, Istanbul Atlas University, Istanbul, Turkey; [2]Department of Nutrition and Dietetics, University of Health Sciences, Istanbul, Turkey; [3]Department of Nutrition and Dietetics, Izmir Demokrasi University, Izmir, Turkey

Abstract. Obesity has a multifactorial effect caused by genetic, metabolic, environmental, behavioural and socio-cultural factors. Depression and high-energy diet are observed in sleep deprivation. This study was planned to determine the relationship between sleep quality and depression in obese women and dietary energy density (DED) and abdominal obesity. Demographic information, anthropometric measurements, eating habits and sleep and depression status of 106 obese female participants with a BMI ≥30 kg/m^2 (Pittsburgh Sleep Quality Index-PSQI and Beck Depression Inventory (BDI) were evaluated. In this study, it was determined that 22.6% of the women had short sleep duration and 44.3% had poor sleep quality. No significant relationship was found between sleep quality and BDI results and the average amount of carbohydrates, proteins, fats and the energy contribution percentages of three-day food intake ($p>0.05$). There was no significant relationship between Dietary Energy Density (DED) and waist circumference, BMI, sleep duration and BDI score. However, there was a relationship between PSQI and BDI score results ($r=0.373$, $p<0.01$). As the sleep quality decreased, the prevalence of depression increased. The prevalence of obesity increasing in recent years in parallel with decreased sleep quality, high intake of energy-dense foods and increased prevalence of depression, is at significant levels. More comprehensive studies are needed to examine the relationship between DED, sleep quality, depression and obesity.

Keywords: Sleep quality, obesity, dietary energy density, abdominal obesity, depression

Introduction

It is known that obesity, which has become a global epidemic, affected more than 1.9 billion adults and 650 million of them were obese (13%) (1). The most commonly used anthropometric measurement for the assessment of obesity is Body Mass Index (BMI) (1, 2). But today, it is stated that the waist circumference (WC) value used to determine the intra-abdominal adipose tissue is more valid than the BMI value (3). In 2005 guidelines of IDF (International Diabetes Federation), the WC cut-off value for abdominal obesity was specified as >80cm for women and >94cm for men (4). There are many factors that cause obesity. These can be listed as physiological and psychological effects, high intake of energy-dense foods, lifestyle, environmental and genetic changes, and changes in sleep patterns (5). The rapid increase in the prevalence of obesity in the modern world shows parallelism with the significant decline in sleep duration (6). Sleep is an important modulator of neuroendocrine function and glucose metabolism, and decreased sleep duration has been found to cause many metabolic and endocrine changes, including glucose tolerance and mechanisms of appetite regulating hormone (7). In cross-sectional studies in adults, a significant relationship was found between short sleep duration and greater weight gain (8), obesity prevalence, waist circumference (9), and body fat

percentage (10). It has also been shown that short sleep duration (6 hours) is associated with a 45% increased risk of obesity compared to normal sleep duration (10).

It is well known that positive energy balance is often caused by excessive energy intake and is the main dietary factor associated with weight gain (11). Studies on energy intake show that, compared to normal sleepers, short sleepers have higher energy intakes especially from snacks (12) and fat (13). The energy density of the food consumed is an important determinant of the total energy intake. Energy density is the amount of energy per unit weight of a food (14). Evaluation of dietary components such as energy intake is widely preferred in assessing the overall effect of the diet. Among diet quality indices, Dietary Energy Density (DED) as a measure of the overall diet has been used in many recent studies (15). DED is a relatively new dietary index that is calculated by dividing the energy from food and beverages by the weight of the food and that has an important role in body weight control (16). DED represents the nutritional quality; the higher the energy density, the lower the nutritional quality (17, 18). Higher DED has been found to be associated with an increased risk of obesity (19) and obesity-related diseases (20). In addition, depressive symptoms are also thought to be related to diets characterized by high dietary energy density (DED) and unhealthy dietary patterns (21). It has been reported that depressive symptoms may be associated with increased appetite, energy-dense foods with high fat and carbohydrate content, low fruit and vegetable intake, and excessive food and alcohol consumption (22, 23). This is very worrying because it has been found that depression increases the risk of developing obesity (24), and major depression is related with abdominal obesity in men (25) and women (26). This study was conducted to determine the relationship between abdominal obesity, sleep quality, and depression in obese women and dietary energy density.

Materials and Methods

This study was carried out with 106 obese women with a BMI of 30 kg/m^2 who admitted to the diet outpatient clinic of Istanbul Sultanbeyli State Hospital between December 2016 and January 2017. Pregnant or lactating women, those with any chronic diseases (Diabetes Mellitus (DM), thyroid disease, Chronic Kidney Disease (CKD), chronic liver disease, cardiovascular disease), cancer, sleep apnoea and those using sedative drugs were not included in the study. "Ethics Committee Approval" was obtained from Acıbadem University Clinical Research Ethics Committee with decree no: 2016 / 17-1. A written consent form was obtained from the participants indicating that they voluntarily participated in the study. Patients who agreed to participate in the study were given an interview appointment, and when they arrived, a face-to-face interview was conducted, the questionnaire form assessing their demographic information, anthropometric measurements, eating habits and sleep status (Pittsburgh Sleep Quality Index-PSQI) was filled out by the researcher. PSQI is a scale consisting of a total of 24 questions that assesses sleep quality by taking into account the sleep habits over the past month. Total scale score ranges between 0 and 21. If the total score is 5 and above, it is considered as poor sleep quality (27). In addition, emotional states were determined using the Beck Depression Inventory (BDI). BDI contains a total of 21 self-report items and each item receives a score between 0 and 3. Total scale score is between 0 and 63 and the cut-off score is 17 (28). Participants were asked to keep a three-day food intake record (three consecutive days; two days on weekdays, one day on the weekend). "Computer Assisted Nutrition Program, Nutritional Information Systems Package Program (BEBIS)" were used in the evaluation of food intake (29). Only food-based calculation method was used in the calculation of dietary energy density. Solid foods and liquid foods such as cream and soup (except those consumed as beverages such as milkshakes and liquid meal replacements) were included in the calculation. Dietary energy density was calculated by dividing the energy (kcal) from solid foods and liquids consumed as food by weight (g) (17). The average value of three-day dietary energy density was obtained. Anthropometric measurements (height, body weight, waist circumference) were made by the researcher. Body composition of the patients were measured with Tanita BF 350 scale, height measurements with Seca stadiometer, waist circumference

measurement with a non-stretch tape measure sensitive to 0.1 cm. Before the measurement of the body composition, participants were informed about the rules regarding the measurement. Waist circumference >80 cm was considered risky.

Statistical Analysis

SPSS (Statistical Package for Social Sciences) 22.0 was used to evaluate the data obtained from the study and to create tables. Descriptive statistics (number (n), percentage (%), mean and standard deviation (±SD)) and one-way analysis of variance were used in the evaluation of the study data while Independent-Samples-T test and Pearson correlation coefficient were used for the comparisons of normally distributed parameters between two groups. Significance level was accepted as $p<0.05$.

Results

The mean age of the women was 32.48±7.52, and 87.7% were married. 47.2% of the women graduated from primary school, while 74.5% smoked and 97.2% did not drink alcohol. All the participants were obese; 54.7% were 1st degree obese, 31.1% 2nd degree obese, 14.2% 3rd degree obese, and 94.3% had abdominal obesity (Table-1). According to the PSQI score results, 77.3% of all women had normal sleep duration and 55.6% had good sleep quality. It was found that 72.6% of the women had symptoms of depression. The average value of three-day sleep for the women participating in the study was found to be 7.97±1.30 (Table-2), but no significant relationship was found between the average value of three-day sleep duration and waist circumference, BMI, and DED (Table-3). As the sleep quality decreases, the prevalence of depression increases. The relationship between PSQI and BDI scores was found to be statistically significant (r=0.373 $p<0.01$).

There was no statistically significant relationship between sleep duration and quality and waist circumference, BMI, energy, DED, carbohydrate, protein and fat amount and percentages ($p>0.05$) (Table-3). No statistically significant relationship was found between the susceptibility of depression, degrees of depression and waist circumference, BMI, energy, DED, carbohydrate, protein and fat amount and percentages ($p>0.05$) (Table-4).

There was no statistically significant relationship between sleep duration, PSQI score results, BDI score results and waist circumference, BMI and energy, DED, carbohydrate, protein and fat amount and percentages ($p>0.05$) (Table-5).

Table 1. Distribution of women according to their properties (n=106)

	n	(%)
Marital status		
Married	93	87.7
Single	13	12.3
Job		
Unemployed	87	82.1
Employed	19	17.9
Education		
İlliterate	3	2.8
Literate	3	2.8
Primary school	50	47.2
Secondary school	21	19.8
High school	19	17.9
University	10	9.4
Smoking		
Current smoker	17	16.0
Non-smoker	79	74.5
Stop smoking	10	9.4
Alcohol consumption		
Current drinker	3	2.8
Non-drinker	103	97.2
Abdominal Obesity		
No	6	5.7
Yes	100	94.3
BMI (kg/m^2)		
1st degree Obese	58	54.7
2nd degree Obese	33	31.1
3rd degree Obese	15	14.2

BMI: Body Mass Index

Table 2. Arithmetic averages, standard deviation, and significance test of some characteristics of the women

Variables	Mean	SS	Min	Max
Age (years)	32.48	7.52	18.0	49.0
WC (cm)	103.16	10.3	84.0	139.0
BMI (kg/m^2)	35.33	4.74	30.02	50.51
Sleep duration (h)	7.98	1.31	4.5	11.33
BDI Score	14.48	8.38	0	45
PSQI Score	4.55	2.87	0	13
DED (g/kcal)	1.55	0.36	0.79	2.76

WC: Waist Circumference, BMI: Body Mass Index, BDI: Beck Depression Inventory, PSQI: Pittsburgh Sleep Quality Index, DED: Dietary Energy Density

Discussion

In this study, no significant relationship was found between the increase in the degree of obesity and the decrease in sleep duration and sleep quality. In their study conducted with 105 women between the ages of 20-55, Öztürk and Ayhan (30) found similar results to our study, while in another study investigating the relationship between sleep quality and metabolic syndrome, a significant relationship was found between poor sleep quality and high BMI and waist circumference (31). Similarly, Rahe et al. (32) found a significant relationship between poor sleep quality and high waist circumference. Poor sleep quality may be associated with sleepiness and fatigue, which, in turn, may lead to reduced physical activity during the daytime, and may lead to imbalances between energy intake and expenditure, thereby contributing to weight gain and high waist circumference. In this study, it was established that 22.6% of the women had short sleep duration while 44.3% had poor sleep quality. In other studies on women, the rate of those with poor sleep quality was found to be 27.4% (30), 44.1% (32), and 31.1% (33). Studies showed the relationship between sleep duration of less than 5 and more than 8 hours and BMI. Compared to those with normal sleep duration (7-9 hours), the risk of obesity was found to be higher in those who sleep less than 7 hours and more than 9 hours. In addition to studies supporting the fact that short and long sleep duration can cause weight gain, there are also studies claiming the opposite (34, 35). In this study, no significant relationship was found between the average sleep duration and quality of women and the BMI classifications and abdominal obesity values. (Table 4). Almost half of the women (43.3%) had poor sleep quality in the study. However, there are few people with short sleep duration. In this case, we believe that it is effective for the majority to be housewives.

Table 3. Some characteristics of the women according to their sleep duration and quality.

Variables	Sleep Duration				Sleep Quality			
	<7 h (n=24)	7-9 h (n=82)	T	p*	Good (n=59)	Poor (n=47)	t	p*
WC (cm)	103.04±10.36	103.2±10.35	-0.064	0.949	102.88±10.74	103.51±9.83	-0.311	0.756
BMI (kg/m^2)	35.58±4.64	35.26±4.8	0.289	0.773	35.81±5.18	34.73±4.11	1.162	0.248
Energy (kcal)	1998.25±726.41	2112.8±955.71	-0.542	0.589	2105.18±1081.09	2063.87±634.72	0.232	0.817
DED (g/kcal)	1.47±0.31	1.58±0.37	-1.266	0.208	1.55±0.34	1.55±0.38	0.003	0.997
Carbohydrate(g)	231.72±93.97	245.06±142.91	-0.430	0.668	247.21±158.75	235.54±92.72	0.447	0.656
Carbohydrate (%)	47.17±7.41	46.66±6.89	0.312	0.755	47.27±6.59	46.15±7.46	0.821	0.413
Protein (g)	63.77±20.52	69.85±31.87	-0.882	0.380	67.1±32.34	70.2±26.26	-0.532	0.596
Protein (%)	13.25±2.15	13.59±2.77	-0.546	0.586	13.14±2.36	13.98±2.91	-1.648	0.102
Fat (g)	88.39±34.63	92.6±36.31	-0.504	0.615	92.15±40.72	91±28.94	0.163	0.871
Fat (%)	39.5±6.22	39.72±6.67	-0.144	0.886	39.53±6.21	39.85±7	-0.253	0.800

WC: Waist Circumference, BMI: Body Mass Index, DED: Dietary Energy Density
** Independent-Samples T-Test*

Table 4. Some variables of the women according to their depression susceptibility and BDI scores

Variables	Susceptibility of Depression				BDI Scores				
	Yes (≥9 p) (n=29)	No (<9 p) (n=77)	t	p*	Normal (0-9 p) (n=29)	Mild Depression (10-16 p) (n=45)	Modarate to High Depression (17-63 p) (n=32)	F	p**
WC (cm)	105.97±12.75	102.1±9.09	1.494	0.143	105.97±12.75	100.71±8.66	104.06±9.45	2.541	0.084
BMI (kg/m^2)	36.71±6.05	34.81±4.08	1.556	0.128	36.71±6.05	34.5±3.59	35.26±4.7	1.951	0.147
Energy (kcal)	2178.64±1342.15	2052.3±684.31	0.638	0.525	2178.64±1342.15	2017.58±655.05	2101.11±731.31	0.280	0.756
DED (g/kcal)	1.54±0.34	1.56±0.37	-0.202	0.840	1.54±0.34	1.54±0.34	1.59±0.42	0.183	0.833
Carbohydrate (g)	259.33±212.1	235.52±88.04	0.820	0.414	259.33±212.1	228.56±82.72	245.32±95.51	0.480	0.620
Carbohydrate (%)	46.66±6.55	46.82±7.17	-0.107	0.915	46.66±6.55	46.33±6.89	47.5±7.62	0.263	0.769
Protein (g)	71.66±35.04	67.28±27.59	0.675	0.501	71.66±35.04	66.94±27.09	67.76±28.72	0.232	0.793
Protein (%)	13.93±2.67	13.35±2.62	1.010	0.315	13.93±2.67	13.44±2.15	13.22±3.21	0.574	0.565
Fat (g)	92.67±42.27	91.26±33.38	0.181	0.857	92.67±42.27	90.65±32.88	92.11±34.57	0.032	0.969
Fat (%)	39.45±6.37	39.75±6.65	-0.213	0.832	39.45±6.37	40.2±6.74	39.13±6.56	0.272	0.763

WC: Waist Circumference, BMI: Body Mass Index, DED: Dietary Energy Density
**: Independent-Samples T-Test*
***One-Way ANOVA*

Table 5. Correlation between some variables

Variables	Sleep Duration	PSQI Score	BDI Score
WC (cm)	0.018	0.087	0.011
BMI (kg/m^2)	-0.005	-0.001	-0.081
Energy (kcal)	0.054	-0.091	-0.090
DED (g/kcal)	0.155	-0.046	-0.008
Carbohydrate	0.063	-0.089	-0.117
Carbohydrate (%)	0.024	-0.051	-0.038
Protein (g)	0.055	-0.043	-0.048
Protein (%)	-0.001	0.116	0.009
Fat (g)	0.027	-0.089	-0.037
Fat (%)	-0.018	0.017	0.026

WC: Waist Circumference, BMI: Body Mass Index, DED: Dietary Energy Density
*: *Pearson Correlation*

Sleep duration and quality can affect energy intake and expenditure. They do this by affecting the hormones in hunger and satiety mechanisms. Short sleep duration decreases the circulatory levels of leptin and increases the ghrelin levels, leading to an increase in hunger, appetite and obesity (36). Studies showed that, compared to normal sleepers, short sleepers have higher energy intakes especially from snacks (11) and fat (12). In addition, it was determined that short sleepers had a lower intake of protein, and they consumed fewer type of food than normal sleepers (37). Similarly, in the study of Taheri et al. (36), it was established that after poor quality and insufficient sleep, there was an increase in food intake and snack consumption, leading an increase in the total energy intake. Another study also found that, with an increase in energy intake, the proportion of energy from fat and carbohydrates increased (38). In this study, contrary to the data obtained from other studies, no significant relationship was found between the duration and quality of sleep and the total energy, carbohydrate and fat intake in the diet and their contribution to energy. High amount of fat and carbohydrate intake in the diet will result in an increase in DED. In this study, the contribution of dietary carbohydrate to energy was very close to the lower limit of the recommended value (45-60%), while that of fat was above the recommended value (20-35%). A relationship has been found between DED and increased BMI and/or WC in adults (14). In this study, no relationship was found between DED and BMI, waist circumference. In addition, no relationship was observed between DED and sleep quality. The high fat and carbohydrate content of the food determines the energy density of the food. Nutritional data in this study are based on participants' self-reporting. However, overweight people tend, in particular, to underreport foods with a high fat and sugar content, often with a high energy density, and thus their energy consumption (39). The fact that all participants in this study were obese may have contributed to the results of the study. Maddahi et al. (40) obtained similar results from their study. High-fat and high-carbohydrate dietary patterns have also been reported to be associated with higher risk of depression (41). In a study conducted with 87 overweight adults, it was clarified that increasing depressive symptoms in 73.6% of the individuals with a BMI of 32.1±6.1 kg / m^2 also increased the energy density of food and beverages. The increase was seen younger age, male gender, African-American race who consumed more foods and beverages with higher energy content. This may have affected the result (42). In this study, although most women are housewives and all of them are obese, it was shown that their total energy intake was not very high. There was no statistically significant difference in energy intake. In another study investigating the relationship between DED and depression, no relationship was found between DED and depression, which is consistent with our study (43). In this study, as in our study, the majority of participants reported no depressive symptoms or very few people reported, and those reported to have mild symptoms of depression could also be effective in this situation. Because depressive symptoms are associated with increased appetite, excessive intake of food, preference for high-fat and carbohydrate foods, and excessive intake of alcohol (44). In addition, Grossniklaus et al. (21) stated in their study that DED is not a mediator between depressive symptoms and high waist circumference in obese adults. Meanwhile, while depressive symptoms affect sleep, sleep status affects depression (45). In this study, the prevalence of depression increased as the sleep quality decreased. The relationship between PSQI and BDI scores was found to be statistically significant (r=0.373, p<0.01). A similar

result was found in the study conducted by Sarıarslan et al. on 229 patients (46). However, in another study, it was found that patients with depression and anxiety experience more intense sleep problems than those without depression and anxiety (47). The biological mechanisms between poor sleep and depression are still unclear. One study in rats found that sleep loss had a long-lasting effect on the activity of more than one hypothalamic area. These hypothalamic changes are thought to underlie the association between sleep loss and many illnesses, including depression(48).

Conclusions

Excess energy, poor sleep quality and depression are individual risk factors for obesity. While there was no significant relationship between dietary energy density and sleep quality, depression and obesity, a relationship was found between sleep quality and prevalence of depression. More comprehensive studies are needed to see the effects of DED on obesity, sleep quality and depression.

Limitations

Some limitations of the current study should be considered. Briefly, because of the cross-sectional design of this study, and the study population was restricted to women who are obese, which limits the generalizability of findings to men and normal-weight people; therefore, so the use of larger samples in both sexes that have different BMI is essential.

Conflict of Interest: Not reported

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correspondence:
Hülya Yılmaz Önal, PhD, Department of Nutrition and Dietetics, Istanbul Atlas University, Anadolu Street, No. 40 Kağıthane, Istanbul/Turkey.
Phone:+90 850 450 3439
E-mail: hlyaylmz12@gmail.com