INTRODUCTION

Sleep disorders are common in modern society, and the prevalence of chronic insomnia varies between 6 and 76.3% depending on diagnostic and screening methods used. The prevalence of obesity and sleep disorders is increasing worldwide.

The impact of sleep quality on the development of metabolic syndrome was evaluated in several studies. Sleep quality affects energy balance through appetite, hypothalamic-pituitary-adrenal axis activity, gut-peptide concentrations, and substrate oxidation. Poor sleep quality enhances positive energy balance through endocrine changes, such as lower leptin and higher ghrelin concentrations, which result in excess food intake and weight gain. Obese patients experience sleeplessness more likely with a reciprocal relationship whereby poor sleep leads to weight gain, which may, in turn, induce more sleep impairment.

Obstructive sleep apnea (OSA) and restless leg syndrome (RLS) are common sleep disturbances with higher prevalence in obese individuals. In OSA, the activity of respiratory tract upper muscle is decreased because of the fat deposits that cause airway narrowing and finally result in hypoxic episodes. RLS is composed of sensory symptoms that are accompanied by an irresistible urge to move legs. The prevalence of RLS in adults was reported as 4–29%.

To evaluate sleep disorders, the Stanford Sleepiness Scale, Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index (PSQI), Stop-Bang test, Berlin Questionnaire (BQ), and Restless Leg Syndrome (RLS) Questionnaire are used. The PSQI is an easy index that provides a standardized measure of sleep quality and discriminates “good” and “poor” sleepers.

The aim of this study was to determine the effect of obesity on sleep and the association of sleep with anthropometric and metabolic parameters. The secondary objective was to evaluate the frequency of OSA and RLS in obese individuals.
METHODS

The study was approved by the Ethics Committee of Dr. Lutfi Kirdar Kartal City Hospital (decision number: 2020/514/182/20, dated: July 27, 2020).

The medium effect size (effect size=0.3) was predicted to be statistically significant, and the alpha significance level (0.05) was calculated the sample size as 68 with 80% power. A total of 76 patients (41 females and 35 males; body mass index [BMI] >30 kg/m²) between the ages of 18 and 70 years who were followed up in the obesity outpatient clinic between July 2020 and February 2021 participated in this study. Notably, 27 volunteers with a BMI <30 kg/m² were determined as the control group. Participants were informed about the study and a written consent form was obtained.

Patients using medication for sleep disorders, malignancies, and severe psychiatric disorders were not included in the study.

Body mass index; waist, hip, and neck circumference; soft lean mass (SLM); and percent body fat (PBF) were measured. BMI was calculated as follows: body weight/height² (in kg/m²). Anthropometric measurements were done with Tanita MC-580 body composition analysis (TANITA, MC-580, Japan). Venous blood samples were taken after 8 h of fasting, and glucose, total cholesterol, low-density lipoprotein (LDL), triglyceride, and high-density lipoprotein (HDL) measurements were analyzed with AU 5800 (Beckman Coulter, Brea, CA, USA). Insulin and thyroid-stimulating hormone (TSH) values were analyzed with Unicel DxI 800 (Beckman Coulter). Homeostatic model assessment-insulin resistance (HOMA-IR) was calculated as follows: fasting blood glucose (mg/dL) x insulin (IU/mL) / 405. Finally, PSQI, BQ, and RLS Questionnaire were performed to evaluate sleep quality.

Pittsburgh sleep quality index

Pittsburgh Sleep Quality Index consists of a 19-item questionnaire. Using this index, subjective sleep quality, sleep latency, sleep duration, sleep efficiency, daytime dysfunction, use of medications to sleep, and the presence of sleep disorders are evaluated. Individual with a total PSQI score >5 was considered poor sleeper15.

Berlin questionnaire

Berlin Questionnaire consists of 11 items with three categories. The first category consists of questions related to snoring and breathing pause during sleep, the second category consists of questions related to daytime sleepiness, fatigue, and drowsiness during driving, and the third category consists of questions about obesity and hypertension. A positive answer to two or more questions from these three categories is considered to be a high risk for OSA16.

Statistical analysis

Statistical analysis was performed using the SPSS program (Statistical Package for Social Science, version 11.7; Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine the distribution of the parameters, and data were expressed as median (2.5–97.5 percentile). The comparison of the group medians was done with the Mann-Whitney U test. Correlations between clinical and anthropometric parameters and the PSQI were determined by Spearman’s correlation analysis. Multiple regression analyses were performed, considering PSQI as a dependent variable and BMI, HbA1c, neck circumference, and HOMA-IR as independent variables. Statistical significance for all tests was set at p<0.05.

RESULTS

The median (2.5–97.5 percentile) age and BMI values of the patients were 41 (19–69 years) and 40 (30–52) kg/ m², respectively.

A significant correlation was observed between PSQI and BMI, body fat index, muscle mass, hip, waist, and neck circumference, HbA1c, and HOMA-IR (Table 1). Poor sleep quality (PSQI>5) was observed in 79% (60) of the obese group and 36% (8) of the control group. Multiple regression analyses showed BMI as the predictor of PSQI (R²=0.162, F=3.726, analysis of variance [ANOVA] p=0.008) (Table 2). Among the Pittsburgh components, a significant correlation was observed between sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, and BMI. A significant difference was found between groups with and without RLS in terms of sleep latency and drug use (p=0.044, p=0.019, respectively) (Table 3).

According to BQ, 88% (67) of the patients were found to be at high risk for OSA. Out of 16 patients whose sleep quality was not impaired according to the PSQI, 12 patients were found to be at high risk for OSA by BQ. Notably, 95% (57) of the poor sleepers defined by PSQI also had high risk for OSA and 45% (34) of them had risk for RLS.
DISCUSSION

Obesity and sleeping disorders may be related to prevalent biological mechanisms, which encourage researchers to investigate the biological basis of these associations. Poor sleep quality (PSQI>5) was observed in 79% (60) of the obese group and 36% (8) of the control group. There was a significant correlation between PSQI and BMI, body fat index, muscle mass, hip, waist, and neck circumference, HbA1c, and HOMA-IR values (p<0.005). BMI was found to be the predictor on PSQI ($R^2=0.162, F=3.726, ANOVA p=0.008$). A significant correlation was observed between BMI and sleep quality, sleep latency, sleep duration, sleep efficiency, and sleep disorder (p<0.005).

Pearson et al. stated that there is an association between sleep problems and comorbid diseases like hypertension, congestive heart failure, anxiety or depression, and obesity, but not with diabetes. Bidulescu et al. reported that cognitive function was impaired with chronic sleep restriction, which also has an impact.

Table 1. Partial correlation of Pittsburgh sleep quality index with anthropometric and clinical parameters.

| Parameter                  | r    | p         |
|----------------------------|------|-----------|
| BMI (kg/m$^2$)             | 0.416| <0.0001   |
| Neck circumference (cm)    | 0.223| '0.023    |
| Body fat mass %            | 0.326| '0.009    |
| Waist circumference (cm)   | 0.339| '0.005    |
| SLM (cm)                   | 0.210| '0.032    |
| Hip circumference (cm)     | 0.387| '0.001    |
| HOMA-IR                    | 0.275| '0.011    |
| HbA1c (%)                  | 0.214| '0.030    |
| TSH (IU/L)                 | 0.058| 0.559     |
| LDL-cholesterol (mg/dL)    | 0.157| 0.113     |
| Triglyceride (mg/dL)       | 0.157| 0.115     |

*p<0.05 is accepted as significant.

Table 2. Multiple regression analyses with Pittsburgh sleep quality index as dependent variable and body mass index, hemoglobin A1c, neck circumference, and homeostatic model assessment-insulin resistance as independent variables.

| Variables                  | Unstandardized coefficients | Standardized coefficients | t     | p      |
|----------------------------|-----------------------------|---------------------------|-------|--------|
|                            | B   | Std. error | β    |       |       |
| Constant                   | -.1560| 3.539     | -.441| 0.661 |
| BMI (kg/m$^2$)             | 0.089| 0.042     | 0.252| 2.149 | 0.035 |
| HbA1c (%)                  | 0.522| 0.353     | 0.162| 1.478 | 0.143 |
| Neck circumference (cm)    | 0.057| 0.088     | 0.074| 0.648 | 0.519 |
| HOMA-IR                    | 0.021| 0.019     | 0.115| 1.089 | 0.280 |

$R^2=0.162, F=3.726, ANOVA p=0.008$.

Table 3. Comparison of Pittsburgh sleep quality index components in patients with and without restless leg syndrome.

|                           | RLS N=34 (Mean±SD) | Non-RLS N=36 (Mean±SD) | p    |
|---------------------------|--------------------|------------------------|------|
| Sleep quality             | 1.500±0.915        | 1.342±0.802            | 0.466|
| Sleep latency             | 2.843±1.985        | 1.971±1.484            | '0.044|
| Sleep duration            | 1.312±0.895        | 1.228±0.877            | 0.699|
| Sleep efficiency          | 0.500±0.803        | 0.51±0.950             | 0.947|
| Sleep disorder            | 1.593±0.665        | 1.400±0.650            | 0.232|
| Use of medication         | 0.500±0.983        | 0.085±0.284            | '0.019|
| Daytime dysfunction       | 1.937±2.213        | 1.371±1.554            | 0.227|
| Total score               | 10.294±4.994       | 7.833±2.922            | '0.013|

*p<0.05 is accepted as significant.
on cardiovascular and metabolic disorders. Metabolic disorders may be the result of sleep deprivation, which can also be the reason for increased inflammation and elevated sympathetic tone. Besides, the upward trend of ghrelin and lower trend of leptin result in the subsequent increase of hunger and appetite.

Pinto et al. revealed that bariatric surgery caused a significant improvement in the PSQI and BQ, with PSQI decreasing from 6.4±4.7 to 4.1±2.8 and the risk of OSA decreasing from 68.3 to 5% after operation.

Obstructive sleep apnea has been observed in 58% of obese individuals and polysomnography is the gold-standard method in diagnosis. Marta et al. defined the sensitivity, specificity, positive predictive value, and negative predictive value of the BQ for OSA as 87.2%, 11.8%, 73.2%, and 25%, respectively. They concluded that BQ was a valuable screening test and patients with high risk for OSA should be directed to polysomnography. In our study, 88% (67) of the obese patients were found to be at high risk for OSA. Likewise, 95% (57) of the poor sleepers had a high risk for OSA.

Several studies found a significant association between obesity and RLS. In a cross-sectional study with 1,803 adults; an increase of 5 kg/m² in BMI was found to be associated with a 31% increased likelihood of having RLS. In our study, 45% (34) of the obese patients also had RLS and 40% (23) of the patients with RLS also had OSA. In addition, patients with RLS had shorter sleep latency and showed more drug use.

Pittsburgh Sleep Quality Index is a valid tool for both clinicians and researchers, but it was not developed for a specific population and might function differently in different populations and settings. Nevertheless, if the sample size is sufficiently large, it will provide a sufficient estimate for sleep quality in the given population.

In our study, we defined OSA according to BQ and did not evaluate the polysomnography results of our patients, which may be the limitation of our study.

CONCLUSIONS

We observed a significant correlation between PSQI and the anthropometric and metabolic parameters in obese patients and BMI was the predictor on PSQI. The frequency of OSA and RLS was 88% and 45%, respectively, in obese individuals.

EHICAL APPROVAL

The study was carried at Dr. Lutfi Kirdar Kartal City Hospital in Istanbul.

AUTHORS’ CONTRIBUTIONS

MKT: Conceptualization, Data curation, Formal Analysis, Investigation, Resources, Writing – original draft, Writing – review & editing. ACI: Project administration. ÖÇM: Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing. KSK: Software, Visualization, Writing – review & editing.

REFERENCES

1. Benbir G, Demir AU, Aksu M, Ardic S, Firat H, Ilil O, et al. Prevalence of insomnia and its clinical correlates in a general population in Turkey. Psychiatry Clin Neurosci. 2015;69(9):543-52. https://doi.org/10.1111/pcn.12252
2. Baran RT, Atar M, Pirgon Ö, Filiz S, Filiz M. Restless legs syndrome and poor sleep quality in obese children and adolescents. J Clin Res Pediatr Endocrinol. 2018;10(2):131-8. https://doi.org/10.4274/jcrpe.5165
3. Laposky AD, Bass J, Kohsaka A, Turek FW. Sleep and circadian rhythms: key components in the regulation of energy metabolism. FEBS Lett. 2008;582(1):142–51. https://doi.org/10.1016/j.febslet.2007.06.079
4. Lauderdale DS, Knutson KL, Rathouz PJ, Yan LL, Hulley SB, Liu K. Cross-sectional and longitudinal associations between objectively measured sleep duration and body mass index: the CARDIA sleep study. Am J Epidemiol. 2009;170(7):805-13. https://doi.org/10.1093/aje/kwp230
5. Gonnissen HK, Hulshof T, Westerterp-Plantenga MS. Chronobiology, endocrinology, and energy- and food-reward homeostasis. Obes Rev. 2013;14(5):405-16. https://doi.org/10.1111/obr.12019
6. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med. 2004;1(3):e62. https://doi.org/10.1371/journal.pmed.0010062
7. Pinto TF, Bruin PFC, Bruin VMS, Lopes PM, Lemos FN. Obesity, hypersomnolence, and quality of sleep: the impact of bariatric surgery. Obes Surg. 2017;27(7):1775-9. https://doi.org/10.1007/s11695-016-2536-y
8. Bidulescu A, Din-Dzietham R, Coverson DL, Chen Z, Meng YX, Buxbaum SG, et al. Interaction of sleep quality and psychosocial stress on obesity in African Americans: the cardiovascular health epidemiology study (CHES). BMC Public Health. 2010;10(1):581. https://doi.org/10.1186/1471-2458-10-581
9. Jehan S, Zizi F, Pandi-Perumal SR, Wall S, Auguste E, Myers AK, et al. Obstructive sleep apnea and obesity: implications for public health. Sleep Med Disord. 2017;1(4):00019. PMID: 29517065
10. Stelmach-Mardas M, Iqbal K, Mardas M, Kostrzewska M, Piorunek T. Clinical utility of berlin questionnaire in comparison to polysomnography in patients with obstructive sleep apnea. Adv Exp Med Biol. 2017;980:51-7. https://doi.org/10.1007/5584_2017_7
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11. Cogen JD, Loghmanee DA. Sleep-related movement disorders. In: Sheldon SH, Ferber R, Kryger MH, Gozal D, editors. Principles and practice of pediatric sleep medicine. Philadelphia: Saunders/Elsevier; 2014. p. 333-6.

12. David Collister D, Rodrigues JC, Mazzetti A, Salisbury K, Morosin L, Rabbat C, et al. Screening questions for the diagnosis of restless legs syndrome in hemodialysis. Clin Kidney J. 2018;12(4):559-63. https://doi.org/10.1093/ckj/sfy129

13. Chiu H, Chen P, Chuang L, Chen N, Tu Y, Hsieh Y, et al. Diagnostic accuracy of the Berlin questionnaire, STOP-BANG, STOP, and Epworth sleepiness scale in detecting obstructive sleep apnea: a bivariate meta-analysis. Sleep Med Rev. 2017;36:57-70. https://doi.org/10.1016/j.smrv.2016.10.004

14. Mollayeva T, Thurairajah P, Burton K, Mollayeva S, Shapiro CM, Colantonio A. The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: a systematic review and meta-analysis. Sleep Med Rev. 2016;25:52-73. https://doi.org/10.1016/j.smrv.2015.01.009

15. Guo S, Sun W, Liu C, Wu S. Structural validity of the Pittsburgh sleep quality index in Chinese undergraduate students. Front Psychol. 2016;7:1126. https://doi.org/10.3389/fpsyg.2016.01126

16. Cole TJ. The LMS method for constructing normalized growth standards. Eur J Clin Nutr. 1990;44(1):45-60. PMID: 2354692

17. Allen RP, Picchietti DL, Hening WA, Trenkwalder C, Walters AS, Montplaisir J. Restless legs syndrome: diagnostic criteria, special considerations, and epidemiology. A report from the restless legs syndrome diagnosis and epidemiology workshop at the National Institutes of Health. Sleep Med. 2003;4(2):101-19. https://doi.org/10.1016/s1389-9457(03)00010-8

18. Picchietti DL, Bruni O, Weerd A, Durmer JS, Kotagal S, Owens JA. Pediatric restless legs syndrome diagnostic criteria: an update by the International Restless Legs Syndrome Study Group. Sleep Med. 2013;14(12):1253-9. https://doi.org/10.1016/j.sleep.2013.08.078

19. Pearson NJ, Johnson LL, Nahin RL. Insomnia, trouble sleeping, and complementary and alternative medicine: analysis of the 2002 national health interview survey data. Arch Intern Med. 2006;166(16):1775-82. https://doi.org/10.1001/archinte.166.16.1775

20. Saaresranta T, Polo O. Does leptin link sleep loss and breathing disturbances with major public diseases? Ann Med. 2004;36(3):172-83. https://doi.org/10.1080/078538903100024659

21. Grimm W, Becker HF. Obesity, sleep apnea syndrome, and rhythmogenic risk. Herz. 2006;31(3):213-8; quiz 219. https://doi.org/10.1007/s00059-006-2800-3

22. Phillips B, Young T, Finn L, Asher K, Hening WA, Purvis C. Epidemiology of restless legs symptoms in adults. Arch Intern Med. 2000;160(14):2137-41. https://doi.org/10.1001/archinte.160.14.2137

23. Ohayon MM, Roth T. Prevalence of restless legs syndrome and periodic limb movement disorder in the general population. J Psychosom Res. 2002;53(1):547-54. https://doi.org/10.1016/S0022-3999(02)00448-9

24. Kim J, Choi C, Shin K, Yi H, Park M, Cho N, et al. Prevalence of restless legs syndrome and associated factors in the Korean adult population: the Korean Health and Genome Study. Psychiatry Clin Neurosci. 2005;59(3):350-3. https://doi.org/10.1111/j.1440-1819.2005.01381.x

25. Pearson NJ, Johnson LL, Nahin RL. Insomnia, trouble sleeping, and complementary and alternative medicine: analysis of the 2002 national health interview survey data. Arch Intern Med. 2006;166(16):1775-82. https://doi.org/10.1001/archinte.166.16.1775