



Association Between Sleep Parameters and the Triglyceride-Glucose Index in Patients with Obstructive Sleep Apnea

Obstrüktif Uyku Apnesi Olan Hastalarda Uyku Parametreleri ile Trigliserid-Glukoz İndeksi Arasındaki İlişki

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Abstract

Objective: Obstructive sleep apnea syndrome (OSAS) is closely associated with insulin resistance and cardiometabolic disorders. The triglyceride-glucose (TyG) index is a practical marker of insulin resistance and cardiovascular risk. This study aimed to evaluate the association between polysomnographic sleep parameters and the TyG index in patients with OSAS.

Materials and Methods: In this retrospective study, adults who underwent polysomnography between January 2020 and January 2025 were evaluated. Demographic, biochemical, and polysomnographic parameters were recorded. The TyG index was calculated using fasting blood glucose and triglyceride levels. Correlations between the TyG index and sleep parameters were assessed using Spearman correlation analysis. Multivariable linear regression analysis was performed to identify factors independently associated with the TyG index.

Results: A total of 112 individuals, including 92 patients with OSAS and 20 controls, were included. The TyG index was significantly higher in the OSAS group than in the control group ($p = 0.027$). Weak correlations were found between the TyG index and apnea-hypopnea index ($r = 0.270$, $p = 0.004$), minimum oxygen saturation ($r = -0.366$, $p < 0.001$), and oxygen desaturation index ($r = 0.276$, $p = 0.003$). In multivariable regression analysis, minimum oxygen saturation remained independently associated with the TyG index ($B = -0.028$, 95% confidence interval: -0.052 to -0.004 , $p = 0.020$).

Conclusion: The TyG index is increased in patients with OSAS and is significantly associated with hypoxia-related sleep parameters. These findings suggest that the TyG index may serve as a practical indicator of metabolic and cardiovascular risk in patients with OSAS.

Keywords: Obstructive sleep apnea syndrome, triglyceride-glucose index, insulin resistance, hypoxia, cardiovascular risk, polysomnography

Öz

Amaç: Obstrüktif uyku apne sendromu (OUAS), insülin direnci ve kardiyometabolik bozukluklarla yakından ilişkilidir. Trigliserid-glukoz (TyG) indeksi, insülin direnci ve kardiyovasküler riskin pratik bir göstergesidir. Bu çalışmada, OUAS hastalarında polisomnografik uyku parametreleri ile TyG indeksi arasındaki ilişkinin değerlendirilmesi amaçlandı.

Gereç ve Yöntem: Bu retrospektif çalışmada, Ocak 2020 ile Ocak 2025 tarihleri arasında polisomnografi uygulanan erişkin bireyler değerlendirildi. Demografik, biyokimyasal ve polisomnografik parametreler kaydedildi. TyG indeksi, açlık kan glukozu ve trigliserid düzeyleri kullanılarak hesaplandı. TyG indeksi ile uyku parametreleri arasındaki korelasyonlar Spearman korelasyon analizi ile değerlendirildi. TyG indeksi ile bağımsız ilişkili faktörleri belirlemek amacıyla çok değişkenli lineer regresyon analizi yapıldı.

Bulgular: Çalışmaya 92 OUAS hastası ve 20 kontrol olmak üzere toplam 112 birey dahil edildi. TyG indeksi, OUAS grubunda kontrol grubuna göre anlamlı derecede daha yüksekti ($p = 0,027$). TyG indeksi ile apne-hipopne indeksi ($r = 0,270$, $p = 0,004$), minimum oksijen satürasyonu ($r = -0,366$, $p < 0,001$) ve oksijen desatürasyon indeksi ($r = 0,276$, $p = 0,003$) arasında anlamlı ancak zayıf korelasyonlar saptandı. Çok değişkenli regresyon analizinde minimum oksijen satürasyonu, TyG indeksi ile bağımsız olarak ilişkili bulundu ($B = -0,028$, %95 güven aralığı: $-0,052$ ila $-0,004$, $p = 0,020$).

Sonuç: TyG indeksi, OUAS hastalarında artmıştır ve hipoksi ile ilişkili uyku parametreleriyle anlamlı ilişki göstermektedir. Bu bulgular, TyG indeksinin OUAS hastalarında metabolik ve kardiyovasküler riskin pratik bir göstergesi olabileceğini düşündürmektedir.

Anahtar Kelimeler: Obstrüktif uyku apne sendromu, trigliserid-glukoz indeksi, insülin

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Introduction

Obstructive sleep apnea syndrome (OSAS) is a sleep-related breathing disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep, leading to intermittent hypoxia and sleep fragmentation. Epidemiological evidence indicates that OSAS constitutes a significant global health problem, affecting nearly one billion adults worldwide, with a considerable proportion having moderate-to-severe disease (1).

The clinical relevance of OSAS is not limited to impaired sleep quality and daytime symptoms, as the disorder is closely associated with several cardiometabolic abnormalities. Previous studies have demonstrated strong relationships between OSAS, obesity, insulin resistance, metabolic syndrome, and type 2 diabetes mellitus (2-10). These metabolic disturbances may contribute to endothelial dysfunction, systemic inflammation, and increased cardiovascular risk in affected individuals (3,8). Assessment of insulin resistance in patients with OSAS is important for predicting adverse metabolic and cardiovascular outcomes. Although the homeostatic model assessment for insulin resistance is commonly used in clinical practice and research, alternative markers that are simpler and more practical have recently gained attention. The triglyceride-glucose (TyG) index has emerged as an inexpensive and reliable surrogate marker of insulin resistance and has also been associated with cardiovascular morbidity, particularly heart failure, in different populations (11).

Polysomnography (PSG) provides objective parameters reflecting both the severity and physiological consequences of OSAS. Previous investigations have shown that indices such as the apnea-hypopnea index (AHI), oxygen desaturation index, and nocturnal oxygen saturation are independently associated with cardiovascular and metabolic risk factors (12). Nevertheless, data regarding the association between other PSG-derived sleep parameters and metabolic indicators such as the TyG index remain limited. Therefore, the present study aimed to evaluate the relationship between sleep parameters obtained by PSG and the TyG index in patients assessed for OSAS.

Materials and Methods

This retrospective study evaluated adult patients who underwent PSG in our sleep laboratory between January 2020 and January 2025. Demographic and clinical information, including age, sex, body mass index (BMI), smoking status, alcohol consumption, history of hypertension, obesity, diabetes mellitus, and systolic and diastolic blood pressure values, were obtained from medical records. PSG recordings were scored according to the criteria established by the American Academy of Sleep Medicine and the third edition of the International Classification of Sleep Disorders. Based on AHI values, participants were categorized as follows: AHI <5 events/hour was accepted as normal, AHI ≥5 to <15 events/hour as mild OSAS, AHI ≥15 to <30 events/hour as moderate OSAS, and AHI ≥30 events/hour as severe OSAS. Individuals with AHI values below 5 were assigned to the control group. The following PSG-derived

parameters were analyzed: total sleep time, sleep latency, rapid eye movement (REM) latency, sleep efficiency, arousal index, minimum oxygen saturation, and oxygen desaturation index. Laboratory measurements included fasting blood glucose (FBG), triglyceride (TG), total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) levels. The TyG index was calculated using the following formula: $\ln [TG \text{ (mg/dL)} \times FBG \text{ (mg/dL)} / 2]$. Clinical, biochemical, and sleep-related variables were compared between patients diagnosed with OSAS and control subjects. Individuals younger than 18 years of age, those with a history of upper airway surgery, prior oral appliance or continuous positive airway pressure treatment, severe systemic diseases such as advanced cardiac, pulmonary, or hepatic failure, additional sleep disorders including narcolepsy, restless legs syndrome, or severe insomnia, psychiatric disorders, and patients with incomplete medical records were excluded from the study.

The study protocol was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of University of Health Sciences Türkiye, Antalya Training and Research Hospital (approval number: 7/12; date: 17/04/2025). Due to the retrospective nature of the study, the requirement for written informed consent was waived.

Statistical Analysis

Descriptive statistics were summarized as frequency, percentage, mean $\pm$ standard deviation, median, minimum–maximum values, and interquartile range (Q1–Q3). Categorical variables were analyzed using the Pearson chi-square test, or Fisher's exact test if more than 20% of the expected cell counts were below 5. Data normality was evaluated using the Shapiro-Wilk test. For comparisons between two groups, the Independent Samples t-test was used for normally distributed variables, whereas the Mann-Whitney U test was preferred for non-normally distributed data. Comparisons involving more than two groups were performed using the Kruskal–Wallis H test. Correlations between numerical variables were assessed with Spearman's rank correlation analysis because the data did not meet normal distribution assumptions. Multivariable linear regression analysis was performed to evaluate the factors associated with the TyG index. Analyses were performed using IBM SPSS 31 software. A p-value <0.05 was considered statistically significant.

Results

A total of 112 participants were included in the analysis, of whom 92 (82.1%) were diagnosed with OSAS and 20 (17.9%) served as controls. Comparisons of demographic, biochemical, and polysomnographic characteristics are summarized in Table 1. Age distribution was comparable between the groups ($p = 0.108$). Patients with OSAS had significantly higher systolic blood pressure values than controls ($p = 0.028$), whereas diastolic blood pressure measurements did not differ significantly ($p = 0.481$).

Regarding laboratory findings, TG concentrations and TyG index values were significantly elevated in the OSAS group

Table 1. Comparison of clinical, biochemical, and sleep parameters between the study groups.

	Group		p-value
	OSAS (n = 92)	Control (n = 20)	
Age (years)	48.41 ± 14.19	42.75 ± 13.98	0.108*
BMI (kg/m ²)	31.5 (28-36)	27 (24-29.5)	0.001†
Systolic blood pressure (mmHg)	120 (110-125)	115 (110-120)	0.028†
Diastolic blood pressure (mmHg)	80 (70-80)	76 (70-80)	0.481†
Total cholesterol (mg/dL)	195.5 (172.5-228.5)	201.5 (171.5-226.5)	0.942†
Serum HDL (mg/dL)	50.5 (42-62)	46 (43-55.5)	0.362†
Serum LDL (mg/dL)	121.48 ± 37.51	123.35 ± 27.55	0.833*
Serum TG (mg/dL)	140 (107-179.5)	95.5 (83-174)	0.033†
FBG (mg/dL)	90 (81-102)	92.5 (83-101)	0.715†
TyG index	8.74 (8.43-9.22)	8.35 (8.12-8.98)	0.027†
AHI	25.55 (16.25-44.25)	3.3 (2.45-3.95)	<0.001†
Total sleep time (min)	360.79 ± 41.79	371.65 ± 32.56	0.278*
Sleep latency (min)	5.75 (1-10.5)	3.25 (1.5-11.25)	0.843†
REM latency (min)	122.5 (78.75-167.75)	98 (74-150)	0.271†
Sleep efficiency (%)	93.05 (88.25-96.1)	91.25 (85.2-96.65)	0.603†
Arousal index	16.9 (13-24.1)	9.4 (8.2-14.2)	<0.001†
Minimum oxygen saturation (%)	83 (77-87)	91 (89-92)	<0.001†
Oxygen desaturation index	21.7 (13.75-40.3)	3.7 (2.2-4.45)	<0.001†

*Independent Samples t-test, †Mann-Whitney U test. Variables that conformed to normal distribution were presented as mean ± standard deviation, whereas variables that did not conform to normal distribution were presented as median (Q₁-Q₃). OSAS: Obstructive sleep apnea syndrome, BMI: Body mass index, FBG: Fasting blood glucose, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglyceride, TyG index: Triglyceride-glucose index, AHI: Apnea-hypopnea index, REM: Rapid eye movement.

(p = 0.033 and p = 0.027, respectively). However, no significant differences were observed between the groups in FBG, total cholesterol, HDL cholesterol, or LDL cholesterol levels (all p > 0.05).

Analysis of sleep-related parameters demonstrated significantly higher AHI, arousal index, and oxygen desaturation index values in patients with OSAS compared with controls, while minimum oxygen saturation values were significantly lower (all p < 0.001). Conversely, total sleep time, sleep latency, REM latency, and sleep efficiency showed no statistically significant differences between the groups (all p > 0.05).

Table 2 summarizes categorical variables in both groups. Sex distribution differed significantly between the groups, with males constituting a greater proportion of the OSAS group (p = 0.007). Obesity prevalence was also significantly higher among patients with OSAS than among controls (p = 0.004). In contrast, smoking, alcohol consumption, hypertension, dyslipidemia, and diabetes mellitus frequencies were similar between the groups (all p > 0.05).

Comparison of TyG index values according to OSAS severity revealed no statistically significant difference among the mild, moderate, and severe OSAS subgroups (p = 0.479) (Table 3).

Correlation analyses demonstrated no significant relationship between TyG index values and total sleep time, sleep latency, REM latency, sleep efficiency, or arousal index (all p > 0.05). However, the TyG index showed a weak positive correlation

with AHI (r = 0.270, p = 0.004) and oxygen desaturation index (r = 0.276, p = 0.003), whereas a weak negative correlation was identified between the TyG index and minimum oxygen saturation (r = -0.366, p < 0.001) (Table 4).

Subgroup analyses demonstrated that within the OSAS group, the TyG index was negatively correlated with minimum oxygen saturation (r = -0.363, p < 0.001) and positively correlated with the oxygen desaturation index (r = 0.209, p = 0.046). No significant correlations were observed between TyG index values and the remaining sleep parameters. Similarly, no statistically significant associations were detected between the TyG index and sleep-related variables in the control group (Table 5).

Because substantial multicollinearity was identified between AHI and oxygen desaturation index in the preliminary regression model, AHI was excluded from the final analysis. The final multivariable linear regression model included sex, BMI, minimum oxygen saturation, and oxygen desaturation index as independent variables. The model was statistically significant [F (4,107) = 4.915, p = 0.001] and explained 15.5% of the variance in TyG index values. Minimum oxygen saturation remained independently associated with the TyG index (B = -0.028, 95% confidence interval: -0.052 to -0.004, p = 0.020), whereas sex, BMI, and oxygen desaturation index did not show independent associations (Table 6).

Table 2. Distribution of categorical variables and comparison between the study groups.

	Group			
Parameters	OSAS n (%)	Control n (%)	Total n (%)	p-value
Sex				
Female	26 (28.3)	12 (60)	38 (33.9)	0.007†
Male	66 (71.7)	8 (40)	74 (66.1)	
Total	92 (100)	20 (100)	112 (100)	
Smoking status				
Non-smoker	59 (64.1)	9 (45)	68 (60.7)	0.112†
Smoker	33 (35.9)	11 (55)	44 (39.3)	
Total	92 (100)	20 (100)	112 (100)	
Alcohol use				
Absent	78 (84.8)	16 (80)	94 (83.9)	0.737‡
Present	14 (15.2)	4 (20)	18 (16.1)	
Total	92 (100)	20 (100)	112 (100)	
Obesity				
Absent	36 (39.1)	15 (75)	51 (45.5)	0.004†
Present	56 (60.9)	5 (25)	61 (54.5)	
Total	92 (100)	20 (100)	112 (100)	
Hypertension				
Absent	69 (75)	19 (95)	88 (78.6)	0.069‡
Present	23 (25)	1 (5)	24 (21.4)	
Total	92 (100)	20 (100)	112 (100)	
Dyslipidemia				
Absent	38 (41.3)	10 (50)	48 (42.9)	0.476†
Present	54 (58.7)	10 (50)	64 (57.1)	
Total	92 (100)	20 (100)	112 (100)	
Diabetes				
Absent	72 (78.3)	17 (85)	89 (79.5)	0.760‡
Present	20 (21.7)	3 (15)	23 (20.5)	
Total	92 (100)	20 (100)	112 (100)	
†Pearson chi-square test, ‡Fisher’s exact test. OSAS: Obstructive sleep apnea syndrome.				

[†]Pearson chi-square test, [‡]Fisher's exact test. OSAS: Obstructive sleep apnea syndrome.

Table 3. Comparison of the TyG index according to OSAS severity.

OSAS severity	n	TyG index, Median (Q ₁ –Q ₃)	p-value
Mild	18	8.65 (8.36-9.11)	0.479
Moderate	34	8.75 (8.32-9.24)	
Severe	40	8.77 (8.48-9.31)	

Kruskal-Wallis H test. TyG index: Triglyceride-glucose index, OSAS: Obstructive sleep apnea syndrome.

Table 4. Correlations between the TyG index and sleep parameters (n = 112).

		AHI	Total sleep time (min)	Sleep latency (min)	REM latency (min)	Sleep efficiency (%)	Arousal index	Minimum oxygen saturation (%)	Oxygen desaturation index
TyG index	r	0.270**	-0.078	0.066	0.164	0.007	0.024	-0.366**	0.276**
	p	0.004	0.416	0.491	0.084	0.941	0.801	<0.001	0.003

*p < 0.05, **p < 0.01. TyG index: Triglyceride-glucose index, AHI: Apnea-hypopnea index, REM: Rapid eye movement, r: Spearman correlation coefficient

Table 5. Correlations between the TyG index and sleep parameters in study groups.

Group			AHI	Total sleep time (min)	Sleep latency (min)	REM latency (min)	Sleep efficiency (%)	Arousal index	Minimum oxygen saturation (%)	Oxygen desaturation index
OSAS (n = 92)	TyG index	r	0.195	0.006	0.060	0.183	-0.045	-0.046	-0.363**	0.209*
		p	0.062	0.957	0.572	0.081	0.673	0.661	<0.001	0.046
Control (n = 20)	TyG index	r	0.002	-0.280	0.136	-0.063	-0.005	-0.056	0.195	-0.206
		p	0.994	0.232	0.568	0.791	0.982	0.813	0.410	0.384

*p < 0.05, **p < 0.01. TyG index: Triglyceride-glucose index, AHI: Apnea-hypopnea index, REM: Rapid eye movement, r: Spearman correlation coefficient, OSAS: Obstructive sleep apnea syndrome.

Table 6. Multivariable linear regression analysis of factors associated with the TyG index.

Variables	B	SE	β	95% CI	p	VIF
Sex	0.050	0.129	0.036	-0.206, 0.306	0.700	1.085
Minimum oxygen saturation (%)	-0.028	0.012	-0.344	-0.052, -0.004	0.020	2.688
Oxygen desaturation index	0.002	0.004	0.084	-0.006, 0.011	0.560	2.616
BMI (kg/m ²)	-0.003	0.012	-0.025	-0.027, 0.021	0.821	1.599

B: Unstandardized regression coefficient, SE: Standard error, β: Standardized regression coefficient, CI: Confidence interval, VIF: Variance inflation factor, BMI: Body mass index, TyG index: Triglyceride-glucose index. Sex was coded as a binary variable (reference: male).

Discussion

The present study investigated the relationship between the TyG index and polysomnographic parameters in individuals with OSAS. The findings demonstrated that patients with OSAS had significantly higher TyG index values compared with the control group. In addition, the observed associations between the TyG index and hypoxia-related sleep parameters suggest that intermittent nocturnal hypoxia may contribute substantially to metabolic dysfunction in these patients.

The elevated TyG index values in this study support the association between OSAS and metabolic impairment. Previous investigations have demonstrated that the TyG index is associated not only with insulin resistance but also with subclinical atherosclerosis and adverse cardiovascular outcomes (13,14). Therefore, increased TyG index values in patients with OSAS may indicate an elevated cardiometabolic risk even in the early stages of the disease.

The relationship between OSAS and insulin resistance is considered to be multifactorial. Recurrent intermittent hypoxia may promote oxidative stress, systemic inflammation, and sympathetic nervous system activation, all of which contribute to impaired glucose metabolism and reduced insulin sensitivity (6,8,15). Previous experimental and clinical studies have also suggested that hypoxia may alter adipocyte function and increase circulating free fatty acid levels, thereby aggravating insulin resistance (16). In this context, the elevated TyG index observed in patients with OSAS in the present study may reflect the metabolic consequences of chronic intermittent hypoxia.

Highlighting the specific role of this hypoxic burden, our analysis demonstrated a significant negative correlation between the TyG index and minimum oxygen saturation, as well as a positive correlation with oxygen desaturation index. Moreover, minimum oxygen saturation remained independently associated

with the TyG index after adjustment for potential confounding variables, including sex, BMI, and oxygen desaturation index. Intermittent hypoxia has been reported to increase hepatic glucose production, stimulate lipolysis, and promote inflammatory pathways that contribute to insulin resistance (15-17). Therefore, the findings of the current study further support the hypothesis that hypoxia-related mechanisms play a central role in the metabolic alterations observed in OSAS.

In contrast, the relationship between AHI and metabolic impairment appears limited in this study. There was no statistically significant difference in TyG index values among the OSAS severity groups. Furthermore, while a weak positive association was initially identified between AHI and the TyG index, AHI was ultimately excluded from the final regression model due to multicollinearity with the oxygen desaturation index. Together, these findings suggest that metabolic abnormalities in OSAS may not be explained solely by AHI. Instead, parameters reflecting nocturnal hypoxic burden provide more meaningful information regarding metabolic dysfunction. Consistent with this interpretation, recent evidence indicates that hypoxia-related indices may be more strongly associated with cardiometabolic consequences than AHI alone (18). Nevertheless, the relatively weak correlation coefficients observed in the present study suggest that these relationships should be interpreted with caution in clinical practice.

Furthermore, the absence of significant correlations between the TyG index and other sleep-related parameters, including total sleep time, sleep latency, REM latency, and sleep efficiency, suggests that metabolic impairment in OSAS may be more strongly associated with respiratory disturbances and nocturnal hypoxia rather than general sleep architecture. Similar findings have been reported in previous large-scale studies demonstrating

relatively weak associations between sleep duration or sleep efficiency and metabolic risk markers (12,19).

Regarding potential confounding factors, the higher prevalence of obesity observed in the OSAS group in the present study further supports the well-established association between OSAS and metabolic syndrome. Obesity contributes to upper airway collapse and plays a major role in the pathogenesis of OSAS while simultaneously promoting insulin resistance and dyslipidemia (7,8,20). However, BMI was not independently associated with the TyG index in multivariable analysis, suggesting that hypoxia-related mechanisms may have a more prominent contribution to metabolic dysfunction in this patient population.

Finally, no statistically significant correlations were identified between the TyG index and sleep parameters in the control group. However, these findings should be interpreted cautiously because the relatively small number of control participants may have limited the statistical power of subgroup analyses. Therefore, the absence of significant associations in the control group cannot be considered definitive evidence of a lack of relationship between metabolic parameters and sleep characteristics.

Study Limitations

The present study has several limitations. First, its retrospective and single-center design may restrict the generalizability of the findings. Second, the relatively limited size of the control group may have reduced the power of comparative and correlation analyses. In addition, the lack of comparison between the TyG index and established insulin resistance markers such as HOMA-IR may limit the evaluation of its diagnostic performance. Nevertheless, the study also has important strengths, including comprehensive polysomnographic assessment and detailed evaluation of metabolic parameters in patients with OSAS.

Conclusion

The TyG index is increased in patients with OSAS and shows significant associations with hypoxia-related parameters in particular. These findings suggest that the TyG index may serve as an early and practical indicator of metabolic and cardiovascular risk in patients with OSAS.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee of University of Health Sciences Türkiye, Antalya Training and Research Hospital (approval number: 7/12; date: 17/04/2025).

Informed Consent: The requirement for informed consent was waived due to the retrospective design of the study.

Footnotes

Authorship Contributions: Concept: İ.A., Design: İ.A., Ö.T.S., Data Collection or Processing: M.G., A.H., Analysis or Interpretation: İ.A., Ö.T.S., Literature Search: İ.A., A.H., Writing: İ.A., Ö.T.S.

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