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RESEARCH ARTICLE

INTERACTION BETWEEN PHYSICAL PERFORMANCE AND HEALTH METRICS IN PATIENTS WITH OBSTRUCTIVE SLEEP APNEA SYNDROME

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ABSTRACT

Purpose: The study aimed to investigate the potential correlation between physical performance and health metrics in patients with obstructive sleep apnea syndrome (OSA), while also comparing variations in health metrics (such as obesity, hypoxia, quality of life, etc.) and physical performance across different severities of OSA.
Material and Methods: Eighty-four participants undergoing polysomnography with the suspected presence of OSAS were included. Participants completed the Epworth Sleepiness Scale (ESS), 36-Item Short Form (SF-36), Hospital Anxiety-Depression Scale (HADS) questionnaires. Physical performance was assessed using the 30-Second Sit-to-Stand Test (30CST). Participants were categorized into two groups to compare health metrics based on the severity of OSA.
Results: Body mass index, neck circumference, ESS scores, hypoxia levels, emotional well-being, and energy levels of SF-36, differed statistically according to the severity of OSA. While there was no correlation between 30CST scores and social functioning ($r=.125$, $p=.290$), all other SF-36 subheadings and 30CST were significantly correlated ($p<.05$). 30CST variance is predicted significantly by SF-36 ($p<.001$), HADS ($p<.001$), ESS ($p<.001$), obesity ($p=.001$), and hypoxia ($p=.011$).
Conclusion: These results indicate that the physical performance of patients with OSA is correlated with health metrics, including quality of life, daytime sleepiness, anxiety-depression, hypoxia, and obesity, irrespective of the severity of apnea-hypopnea.

Keywords: apnea; quality of life; depression; obesity; physical performance.

INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is a common sleep disorder characterised by repeated episodes of collapse of the upper airway during sleep (1, 2). The incidence in the general population ranges from 9% to 38%, it is seen more in men than in women, and it increases with age (3). The main complaints of patients are snoring, fatigue, decreased

cognitive activity and excessive daytime sleepiness (3, 4). Snoring, fatigue, decreased cognitive activity and excessive daytime sleepiness are the main complaints of patients. In addition to these disease effects, nocturnal low oxygen saturation and reduced attention span may affect physical performance in the OSAS population (5-7).

A limited number of studies have shown that physical performance is affected (8-11) or not (12) in patients with OSAS. Physical performance assessment is related to obstructive sleep apnea syndrome (OSAS) because OSAS can impair cardiovascular and muscular function (13), leading to reduced physical performance (14). Assessing physical performance is necessary to understand the extent of these impairments, monitor the effectiveness of treatments, and tailor interventions to improve overall health and quality of life in individuals with OSAS. However, no study on functional performance was encountered. Methods used to evaluate functional performance include the six-minute walk test (15), timed up and go test (16), and sit-to-stand performance test (17, 18). Sit-to-stand performance is achieved by the continuous and effective integration of the central nervous system with vestibular, visual, musculoskeletal, and proprioceptive information (17, 19). According to the data of Byun et al., patients with OSAS had a higher incidence of peripheral vestibular disorders than subjects without OSAS (20). Furthermore, it was shown that a higher incidence of vestibular dysfunction has been observed in patients with moderate to severe OSAS compared with patients with mild OSAS (12, 21). Considering physical performance and vestibular connectivity, in patients with OSAS, it is essential to take into account the contributing factors to impairment. First, excessive daytime sleepiness (EDS), which is the main factor in patients with OSAS, increases the risk of accidents and injuries by causing loss of attention (22, 23), and fatigue (24). Indeed, another factor is nocturnal hypoxia experienced by OSAS patients may cause neurophysiological changes by causing damage to the brain stem centers (25). Additionally, it's crucial to focus on chronic nasal congestion and inadequate oxygen intake, which contribute to hypoxia in OSAS patients (26). Understanding these interconnected factors can provide insights into the mechanisms underlying impairment in physical performance and vestibular function in OSAS, thereby guiding more effective assessment and management strategies.The chronic hypoxia experienced by OSAS patients can damage the cerebellum and vestibulocochlear nuclei, which are the signal centers of physical performance (27). Also, the current review results reported that OSAS may cause falls by damaging the vestibulo-ocular reflex, visual acuity, cognitive functions (27), and muscle function, which are essential physiological functions (28, 29). Chronic hypoxia in sleep disorders causes neurological damage, impairing cognition, while also increasing the risk of cardiovascular diseases through vascular remodeling and metabolic disturbances, heightening susceptibility to obesity and diabetes (30). Despite all these risk factors, no definite consensus on physical performance loss has been reached yet in OSAS patients, and a standard clinical assessment profile has not yet been established for physical performance assessment in the OSAS population. Explaining the relationship between the loss of physical performance and OSAS is necessary because it helps clinicians and researchers understand the potential consequences of OSAS beyond just sleep disturbances. This understanding underscores the importance of comprehensive assessments and interventions to address not only sleep-related issues but also the broader impact of OSAS on physical health and functioning, such as increased risk of falls (7) due to impairments in various physiological functions such as vestibulo-ocular reflex, visual acuity, cognitive functions, and muscle function (25-30). It also highlights the need to establish standardized protocols for the assessment of physical performance in people with OSAS in order to guide clinical management effectively.

The link between obesity and OSAS is significant, as obesity contributes to the development and exacerbation of OSAS. Excess weight, especially around the neck and throat area, can lead to airway obstruction during sleep, resulting in episodes of apnea or hypopnea (31). Considering the fact that obesity is an important cause of OSAS (32), the risk of falling (7), and vestibular issues (20, 21, 33) of the patients, examining the functional physical performance test (16) which includes an activity that is frequently performed in daily routine such as sitting and standing, maybe a holistic assessment approach for physical performance risk factors in OSAS. The physical performance has been reported to be influenced by multiple physiological and psychological processes (18), representing a specific transfer skill rather than a surrogate measure of lower

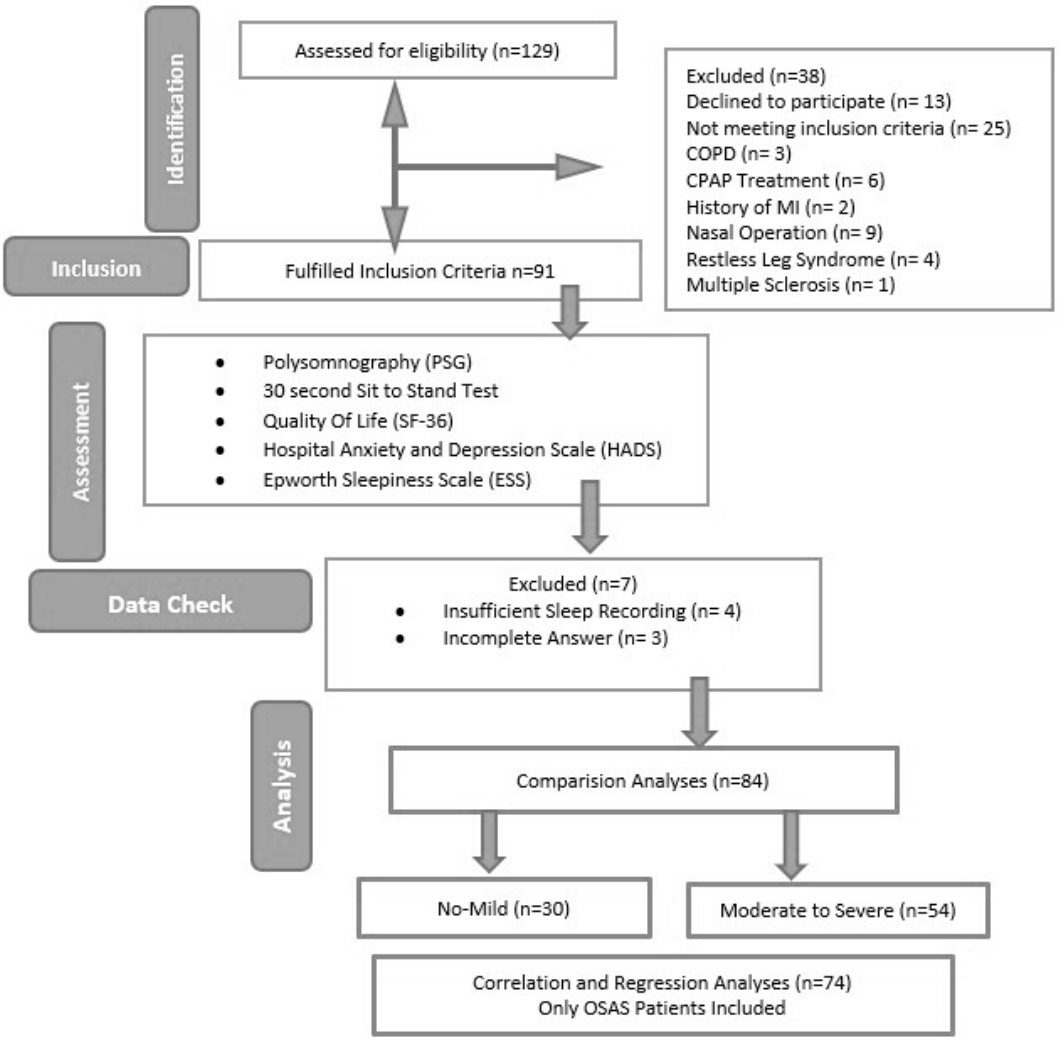

Figure 1. Study flow

extremity strength (17). Also, when the close association of obesity alone (21) or sarcopenic obesity (12) with OSAS and the effect of obesity on postural balance (22) are combined, it is concluded that physical performance examinations may be important in patients with OSAS.

Previous studies have reported that disease severity is not associated with the level of patients' anxiety-depressive symptoms (ADS) (34), EDS correlates weakly with depression and anxiety, and EDS complaints are higher in severe OSAS patients (35, 36). Although studies are showing that the prevalence of depression and anxiety is high in OSAS patients (37), conflicting results have been reported in the literature (38, 39). Decreased deep sleep duration, increased arousal index, and a high ratio of sleep duration with oxygen saturation below 90% to overall sleep duration in OSAS patients increase EDS and depressive symptoms, thus impairing health-related quality of life (QoL) (40). Untreated OSAS patients have a worse QoL than the general population (5, 41-43). However, there was no correlation between apnea severity usually measured by apnea–hypopnea index (AHI), and QoL of OSAS patients (6, 42, 44). Depression (6), age (45), obesity (35, 36, 46), the severity of hypoxia (42) and EDS (47) have been reported to be the main factors affecting patients' health-related QoL. Unlike the above studies, no study was found that investigated the physical performance and related health metrics in OSAS patients.

The primary objective of this study is to compare the physical performance, QoL, ADS, EDS, and obesity in terms of the severity of OSAS. Subsequently, the

study aims to investigate potential relationships between physical performance and QoL, ADS, EDS, obesity, and hypoxia in patients with OSAS. It was hypothesized that greater severity of OSAS will be associated with poorer physical performance, lower QoL, increased EDS and ADS, and higher obesity rates. Additionally, we hypothesized that there will be significant correlations between physical performance and each of the aforementioned factors, among patients with OSAS.

MATERIAL AND METHODS

Study Design

The study included adults who had undergone a complete sleep assessment in the sleep centre. Informed consent was obtained from all participants. They were all assessed while awake, one hour after their follow-up in the laboratory of the sleep centre. The neck circumference was measured at the level of the cricoid cartilage, and the waist circumference was measured at the level of the navel with a measuring tape. Body height (cm) and weight (kg) were recorded, and BMI (kg/m2) was calculated. Epworth Sleepiness Scale (ESS), Hospital Anxiety Depression Scale (HADS), and 36-Item Short Form (SF-36) questionnaires were completed after polysomnography follow-up. Finally, the physical performance assessment of the participants was performed using the 30-Second Sit to Stand Test (30CST).

Participants

Individuals were included in the study if they were 18 years of age or older, had a body mass index (BMI) of <40 kg/m2, and were willing to participate. Exclusion criteria included (i) any tonsillar or pharyngeal disease (including neuromuscular diseases), nasal polyps, or conchal obstruction due to other causes, (ii) a history of systemic disease causing general health impairment, (iii) other defined sleep disorders, (iv) pathology on PA chest X-ray (asthma, COPD, bronchiectasis, etc.), (v) use of sleeping pills or alcohol. The number of participants was determined using a power analysis conducted in the G*Power software package (version 3.1.9.2). Specifically, the linear multiple regression (fixed model, R^2 deviation from zero) model setting was utilized with the following parameters: effect size (f^2) of 0.30, significance level (α) of 0.05, number of predictors set to 8, and a total desired sample size of 84. This analysis confirmed that the chosen sample size was adequate, with a statistical power ($1 - \beta$) greater than 0.95. Maintaining a large sample size was an intentional effort to enhance the study's statistical power and influence, ensuring robustness and reliability of the findings.

Of the 129 participants invited to the study, 13 refused to participate and 25 patients did not meet the inclusion criteria, leaving 91 participants who were assessed.

Polysomnography Recording and Protocol

The study included individuals assessed by video recording and overnight polysomnography (Neuron-Spectrum-5, Neurosoft Sleep Systems, Ivanovo, Russia). Standard leads were used, including 6-channel electroencephalography, electrocardiography, bilateral electrooculography, 1-channel chin electromyography, thermistor and nasal pressure transducer for airflow, piezo bands for chest and abdominal wall motion, body position sensor, a pulse oximeter and microphone recording of snoring. Sleep stages were scored in 30-second epochs following the criteria outlined by the American Academy of Sleep Medicine (AASM). All data from the sleep study were recorded. According to the AASM scoring guidelines, OSAS was defined as normal if the AHI was < 5 events/hour, mild if the AHI was 5-15 events/hour, moderate if the AHI was ≥ 15-30 events/hour, and severe if the AHI was ≥ 30 events/hour (48). After all data were collected, participants were examined in two groups according to their AHI scores, as no-mild (n= 30) and moderate or higher (n= 54).

Epworth Sleepiness Scale

The Turkish version of the Epworth Sleepiness Scale (ESS) was used to assess sleepiness level of participants (49). The ESS is an 8-item self-report questionnaire assessing sleepiness during 8 different activities Each question is scored on a scale of 0 to 3 points. Excessive daytime sleepiness (EDS) is indicated by a high ESS score. The cut-off for subjective daytime sleepiness is a scale score >10 (50).

Sit-to-Stand Performance

The 30-Second Sit-To-Stand Test (30CST) was used to assess the functional physical performance of the

Table 1. Demographic, clinical features, and polysomnographic findings of participants

	No-Mild OSAS	Moderate to Severe OSAS			95% CI	
Characteristics	Mean (SD)	Mean (SD)	MD	t/Z	Lower	Upper
Age (year)	46.00 (9.38)	43.78 (11.35)	2.22	0.91	-2.62	7.07
BMI (kg/m2)	28.87 (2.94)	32.00 (5.09)	-3.12	-3.09	-5.14	-1.11
Waist Circum. (cm)	105.13 (10.55)	109.50 (12.58)	-4.37	-1.61	-9.76	1.03
Neck Circum. (cm)	39.00 (3.54)	41.65 (3.65)	-2.65	-3.22	-4.29	-1.01
ESS Score	3.80 (3.76)	8.78 (6.68)	-2.98	-2.25	-5.61	-0.35
Sleep Study						
AHI (event/hour)	5.89 (3.21)	40.62 (19.66)	-34.74	-9.58	-41.95	-27.52
TB (min)	445.10 (31.29)	443.64 (35.28)	1.46	0.19	-13.91	16.82
TSPT (min)*	394.71 (49.80)	393.02 (70.95)	1.69	-0.76	-27.42	30.80
TST (min)	346.33 (69.06)	336.39 (53.07)	9.94	0.74	-16.88	36.77
SOL (min)*	24.11 (15.59)	35.69 (61.18)	-11.57	-0.02	-34.25	11.10
PSL (min)	27.28 (15.26)	27.56 (20.32)	-0.28	-0.07	-8.74	8.19
SEI (TST/TB) %	77.85 (14.44)	75.46 (10.92)	2.38	0.85	-3.18	7.95
SEI (TSP/TB) %	88.54 (7.77)	91.15 (6.57)	-2.61	-1.63	-5.79	0.57
SQI	104.34 (35.32)	117.05 (29.27)	-12.71	-1.77	-27.00	1.58
RSQI*	20.02 (11.66)	21.99 (7.90)	-1.97	-1.85	-6.23	2.29
REM SL (min)	172.72 (82.76)	162.60 (90.87)	10.12	0.51	-29.78	50.03
N1%*	3.93 (3.67)	4.05 (3.31)	-0.13	-1.05	-1.69	1.44
N2%	74.01 (8.80)	71.54 (9.13)	2.47	1.21	-1.61	6.56
N3%	7.65 (6.05)	9.20 (6.59)	-1.56	-1.07	-4.46	1.34
REM%	14.42 (6.61)	15.20 (7.77)	-0.78	-0.46	-4.12	2.56
Baseline SaO_2 %	95.20 (2.04)	92.33 (2.76)	2.87	4.98	1.72	4.01
Mean SaO_2% in Sleep	93.33 (1.95)	87.74 (6.42)	5.59	4.64	3.20	7.99
Minimal SaO_2 % in Sleep	84.53 (4.50)	66.04 (19.52)	18.50	5.10	11.29	25.71
Average HR*	80.33 (20.34)	84.22 (29.02)	-3.89	-0.93	-15.79	8.02
Minimum HR*	40.13 (11.91)	42.41 (28.35)	-2.27	-0.37	-13.09	8.54
Maximum HR	167.67 (15.88)	161.81 (22.70)	5.85	1.25	-3.46	15.16
Sit-to-Stand Performance						
30CST	12.93 (3.97)	13.11 (3.87)	-0.178	-0.2	-1.947	1.592
Quality of Life (%)						
Physical functioning	63.7 (29.8)	54.3 (25.0)	9.37	1.46	-3.41	22.15
RL due to physical health	38.9 (43.6)	45.0 (39.6)	-6.11	-0.64	-25.25	13.03
RL due to emotional problems	45.7 (40.1)	37.8 (44.4)	7.91	0.83	-10.97	26.78
Energy	52.6 (22.2)	38.0 (14.5)	14.59	3.23	5.61	23.57
Emotional well-being	61.8 (19.9)	48.0 (23.6)	13.78	2.84	4.14	23.42
Social functioning	74.5 (20.5)	65.8 (31.3)	8.70	1.54	-2.55	19.96
Pain	60.7 (29.4)	51.5 (33.9)	9.24	1.31	-4.85	23.33
General health	50.2 (23.3)	45.0 (21.8)	5.19	1.00	-5.15	15.52
Depression and Anxiety						
Depression Score	7.4 (3.8)	8.5 (4.8)	-1.06	-1.11	-2.95	0.83
Anxiety Score	8.2 (4.8)	10.0 (5.6)	-1.85	-1.60	-4.15	0.45

Data are shown as means (SD). MD: Mean difference. No OSAS: Apnea-Hypopnea Index < 5. Mild OSAS: Apnea-Hypopnea Index: 5-15. Moderate OSAS: Apnea-Hypopnea Index: 16-30. Severe OSAS Apnea-Hypopnea Index > 30. BMI: Body Mass Index. Circum: Circumference. ESS: Epworth Sleepiness Scale. AHI: Apnea-Hypopnea Index. TB: Time in Bed. TSPT: Total Sleep Period Time. TST: Total Sleep Time. SOL: Sleep Onset Latency. PSL: Persistent Sleep Latency SEI: Sleep Efficiency Index. SQI: Sleep Quality Index. RSQI: Relative Sleep Quality Index. SL: Sleep Latency. N1: Light Sleep. N2: The Second Stage of Sleep. N3: Deep Sleep. REM: Rapid Eye Movement. HR: Heart Rate. SaO2: Oxygen Saturation. 30CST: 30 Second Sit To Stand Test. RL: Role limitations.
*Mann-Whitney U Test.

assessing lower limb strength, balance, and mobility. Specific physical attributes measured in this test often include:

- Lower Limb Strength: The ability to stand up from a seated position requires sufficient strength in the muscles of the legs, particularly the quadriceps, hamstrings, and glutes.
- Balance: Maintaining stability while transitioning from sitting to standing and vice versa involves balance control, which relies on coordination between muscles and sensory feedback.
- Mobility: The ease and fluidity with which an individual performs the sitting to standing movement can indicate their overall lower limb mobility, including factors such as flexibility and joint range of motion (51). An armless chair with a seat height of 43 cm was used for the test. Participants were seated with their backs to their sides, their feet about shoulder distance apart, and their arms crossed Participants were then instructed to perform as many full squats as possible within 30 seconds. Performing less than 10 sit-ups in 30 seconds is an indication of poor performance (52, 53).

Quality of Life

The Turkish version of 36-Item Short Form was used to assess quality of life (54). It is a reliable, valid and widely used self-report measure of health status. There are 36 questions covering eight areas. These are physical function (10 items), social function (2 items), role limitation due to physical problems (4 items) and emotional problems (3 items), mental health (5 items), vitality (4 items), pain (2 items) and general health (5 items). The scores of the items for each dimension were coded and converted to a scale ranging from 0 (worst health) to 100 (best health) by proportional calculation. The survey was completed by the patients and scores were calculated and recorded for eight subdomains.

Anxiety and Depression

The Hospital Anxiety and Depression Scale (HADS) in the native language of the participants was used (55). It is a self-report scale for the assessment of individuals at risk of anxiety and depression. The HADS consists of two subscales, one measuring anxiety with seven items and another measuring depression with seven items. These are scored separately. High-risk individuals are defined as those who score 10 or more on the anxiety subscale and 7 or more on the depression subscale. Participants were asked to read the questionnaire carefully and answer the questions according to the answer that was most appropriate for them, and then the scores were recorded.

Statistical analysis

Statistical analysis was performed using SPSS for Windows 21.0 software (SPSS Inc, Chicago, IL, USA). The normality was checked with the Shapiro-Wilk test. The Chi-Square test was used for the categorical analysis of nominal data. Descriptive data for variables were presented in the form of mean and standard deviation, percentiles and frequencies. The Independent Samples T-Test was used to assess variability differences among groups based on the presence and severity of OSAS, taking into account the normal distribution of data (SF-36, HADS, 30CST, ESS, and BMI). The Mann-Whitney U Test was applied for analysing data that did not show a normal distribution (total sleep period time, sleep onset latency, relative sleep quality ındex light sleep period, and heart rate). The correction for multiple comparisons was performed for p-values that reached a statistically significant difference. Pearson correlation analysis was used to analyse the relationship between physical performance, AHI, hypoxia, and the independent variables of QoL, ADS, EDS, and obesity. Correlation coefficient (r) values of 0.00-0.24, 0.25-0.49, 0.50-0.74, and 0.75-1.00 were accepted to present weak, moderate, strong, and very strong correlations, respectively. Using multivariate linear regression analysis, the predictive level of QoL and ADS for physical performance was investigated. The predictive ratio of ESS, hypoxia, and BMI to physical performance was analysed using simple linear regression analysis. Control for VIF (<3), linear relationship, extreme values (Cook's Distance, Mahal Distance), normal distribution of residuals, and homoscedasticity of changes were checked. The significance has been evaluated at a level of $p<.05$.

Ethical Considerations

The study was approved by the Istanbul Medipol University, Non-Interventional Research Ethics Committee (Date: 16.04.2020, Decision No: 314), and followed the standards of the Declaration of Helsinki. Participants were recruited from the respiratory department and sleep centre of Bitlis State Hospital.

Table 2. Interaction Between Physical Performance and Health Metrics in Patients with Obstructive Sleep Apnea

	Sit-To-Stand Performance					
	Unstandardized		Standardized		Adjusted R^2	$F(8, 65)$
Quality of life	B	SE_B	β	t	0.396	6.98
Constant	8.90	1.34		6.62		
Physical functioning	0.04	0.02	0.31	2.09		
Role limitations due to physical health	-0.01	0.01	-0.10	-0.68		
Role limitations due to emotional problems	0.01	0.02	0.07	0.45		
Energy	0.07	0.03	0.36	2.26		
Emotional well-being	0.05	0.03	0.29	2.06		
Social functioning	-0.01	0.02	-0.04	-0.30		
Pain	0.04	0.02	0.29	1.89		
General health	0.00	0.02	0.00	0.02		
Depression and Anxiety	B	SE_B	β	t	Adjusted R^2	$F(2, 73)$
Constant	17.15	0.86		19.89	0.266	14.196
Depression Score	-0.11	0.13	-0.122	-0.88		
Anxiety Score	-0.34	0.11	-0.442	-3.17		

	Unstandardized						
Excessive Day Time Sleepiness	B	SE_B	t	p	R	R^2	$F(1, 72)$
Constant	15.65	0.51	30.69	<.001	0.612	0.375	43.213
ESS Score	-0.39	0.06	-6.57	<.001			
Obesity						R^2	$F(1, 72)$
Constant	22.81	2.89	7.89	<.001	0.364	0.133	11.005
BMI (kg/m^2)	-0.30	0.09	-3.32	.001			
Hypoxia						R^2	$F(1, 72)$
Constant	8.84	1.77	4.99	<.001	0.294	0.087	*6.825*
Min. SaO_2 (%)	-0.06	0.02	-2.61	.011			

ESS: Epworth Sleepiness Scale. BMI: Body Mass Index. Kg: Kilogram. m2: Square Meter. Min SaO2: Minimal Arterial Oxygen Saturation. **p<.05.

RESULTS

The data of three people who had missing answers in the survey results and four people who had problems with their PSG records were not included in the analysis.

Comparative analyses were performed using data from a total of 84 participants with a mean age of 44.6±10.8 years, and 54 men (64%). Regression analyses were performed with the data of 74 OSAS patients with AHI> 5 events/hour. The clinical characteristics, demographic features, and polygraphic sleep study results of the participants are summarized in Table 1. Of those involved in the study; 11.9% were simple snorers (AHI < 5); 23.8% had mild OSAS (AHI=5-15); 26.2% had moderate OSAS (AHI=16-30); 38.1% had severe OSAS (AHI > 30), and 66.7% of the study participants never smoked (p<.05). Overall participants were categorized as no-mild (n=30), and moderate to severe (n=54) OSAS groups, according to AHI results.

In comparison to the no-mild OSAS group, the moderate to severe OSAS group exhibited statistically significant lower mean differences in BMI (-3.12 kg/m2), neck circumference (-2.65 cm), ESS score (-2.98 points), and AHI (-34.74 events/hour) (p<.05). The baseline (2.87%), mean (5.59%), and minimal (18.50%) SaO2 scores were higher in the no-

mild group than in the moderate to severe OSAS group (p<.001). Energy (14.59%), and emotional well-being (13.78%) QoL parameters were higher in the no-mild group than in the moderate to severe OSAS group (p<.05). All other QoL subheadings of participants did not differ according to the presence or severity of apnea (p>.05). There were no significant differences in other demographic characteristics and polysomnographic findings between the two groups (p>.05).

As a result of the multivariate linear regression analysis (Table 2), a significant regression model, F(8, 65)=6.98, p<.001, was found, at the same time it was determined that 40% of the physical performance variance (R2adjusted= .396) was explained by the quality of life sub-variables. Accordingly, physical functioning (β =.31, t (65)=2.09, p=.041, pr2=.06), energy (β=.36, t (65)=2.26, p=.027, pr2=.07), and emotional well-being (β=.29, t (65)=2.06, p=.043, pr2=.06) variables of QoL predict physical performance variable positively and significantly. No significant regression pattern was observed between other QoL variables (p>.05).

A multivariate linear regression analysis (Table 2), was performed to predict physical performance with ADS. As a result of the analysis, a significant regression model, F(2, 71)= 14.196, p<.001, was found. At the same time, it was determined that 27% of the physical performance variance (R^2 adjusted=.266) was explained by ADS. Accordingly, anxiety predicts physical performance negatively and significantly (β= -.44, t (71)=-3.17, p=0.02, pr2=.12). Depression, on the other hand, does not significantly predict physical performance (β= -0.12, t(71)= -0.87, p=.383, pr2= .01).

Using simple linear regression analysis, a significant regression model (F(1, 72)= 43.213, p<.001) was found in the analysis results of EDS predicting physical performance, and it was found that 38% of physical performance variance (R^2= .375) was explained by EDS. Accordingly, EDS predicts physical performance negatively and significantly (β = -.39, t (72)= -6.57, p<.001).

A significant regression model (F(1, 72)=11.0, p=.001) was found in the analysis results of BMI predicting physical performance, and 13% of physical performance variance (R2=.133) was explained by BMI. Accordingly, BMI predicts physical performance negatively and significantly (β = -.30, t (72)=-3.32, p=.001).

A significant regression model (F(1, 72)= 6.83, p=.011) was found in the analysis results of desaturation predicting physical performance, and it was found that 9% of physical performance variance (R^2= .087) was explained by desaturation. Accordingly, desaturation predicts physical performance negatively and significantly (β= -.06, t(72)= -2.61, p= .011).

A significant regression model was not formed in the analysis results of AHI's predictive physical performance (p= .211).

DISCUSSION

The objective of the research was to investigate the potential relationship between physical performance and health metrics among individuals diagnosed with obstructive sleep apnea (OSA). Additionally, the study aimed to analyse the differences in health metrics such as obesity, hypoxia, quality of life, etc., and physical performance across varying severities of OSA. Based on the study results, the physical performance is associated with hypoxia, anxiety-depression, daytime sleepiness, obesity, and especially with the pain and physical dimensions of QoL of patients with OSAS. However, the physical performance levels of the participants were within normal limits and did not differ according to the presence and severity of the disease.

Some of the previous studies reported that while physical performance is not affected by disease severity in mild and moderate-severe OSAS patients, only severe OSAS causes abnormal vestibular responses (12), and functional capacity decreases as the severity of apnea increases (9, 10, 12). Unlike these studies, Demir et al. stated that OSAS patients had more balance impairments compared to their healthy peers, especially in cases where head rotation was added or the floor was narrowed when the eyes were closed (8). Also decreased pulmonary function was associated with lower physical performance in OSAS patients (15). Moreover, physical performance is affected by disease severity in OSAS patients, and the factors of this are decreased attention due to impaired sleep quality, increased daytime sleepiness, and low oxygen saturation (8). Results of this study showed that OSAS patients received different responses on physical performance and postural balance according to the type of assessment method. Some of the responses worsened or unchanged according to the

severity of the disease. The observed associations of health metrics with physical performance suggest that functional physical performance evaluations should be included in the assessments of this patient population.

A 1% decrease in oxygen desaturation could cause a 0.59-point decrease in the physical function score of QoL and a 0.13-point decrease in EDS scores according to Huang et al(42). Asghari et al. also showed that physical component scores in the QoL were correlated at a low level with mean oxygen saturation (44). The level of hypoxia was better in individuals with simple snoring and mild OSA than in moderate to severe OSAS patients in the current study. As the severity of the disease increased, hypoxia (9%) slightly worsened. The QoL was more effective (40%) than increased daytime sleepiness (38%) in predicting physical performance regardless of the severity of apnea in patients with OSAS. Similarly, in previous studies, researchers did not observe a difference in QoL according to AHI (6, 44), and only the physical component scores, one of the sub-headings of QoL, were lower in OSAS patients than in their healthy peers (44). Lee et al. reported that hypoxia was associated with obesity, QoL, and the amount of daytime sleepiness was similar to the presented study physical performance results. But unlike the findings of this study, they reported that hypoxia only interacts with the physical components of QoL (6). In light of these, we conclude that by examining the level of physical performance, or hypoxia detailed information can be taken about vestibular function or other sub-headings of QoL, especially the physical components.

In OSAS patients, the prevalence of depression comorbidity is between 7-63%, and for anxiety disorder, it is between 5% and 11-70% (39). Lee et al. showed that both anxiety and depression were independently associated with a lower QoL in patients with OSAS (56). In contrast, the findings of the current study indicate that the severity of OSAS was not related to the level of depression-anxiety experienced by the OSAS patients. Similarly, Asghari et al. reported that the severity of OSAS was not associated with the severity of depression-anxiety (35). Moreover, according to Pamidi et al., higher depression scores are more effective than OSAS severity in predicting QoL and daytime sleepiness in patients with OSAS (32). According to these results, we could say that the relationship between OSAS severity and anxiety along with depression is not yet clear. To our knowledge, the relationship between physical performance and mental health of OSAS patients is investigated for the first time with our study. The correlation of depression-anxiety level for physical performance was found 27% and it shows that instead of associating the severity of OSAS with the depression and anxiety states of the patients (57), the relationship between physical performance and mental state can be examined. The lower level of depression-anxiety, the better the physical performance of the OSAS patients can be observed. In this population, considering that physical performance slightly affects depression and anxiety symptoms, improvements in mental health can be observed with attempts to improve physical performance. Moreover, Yosunkaya et al. stated that depressed patients with OSAS had worse QoL and increased daytime sleepiness as their depressive state worsened (40). The prediction of daytime sleepiness in physical performance was at the level of 38% in the current study. The effects of increased daytime insomnia comorbidity on physical performance in OSA have demonstrated once again with these results. To minimize the risk of trauma and accident, combined interventions to reduce daytime sleepiness and QoL improvement can be prioritized in the primary preventive treatment phase.

Obesity is the main factor affecting OSAS patients' health-related QoL (35, 46). It is also an important factor in not being able to take better results in physical performance tests (58). Supporting this, Pływaczewski et al. previously reported that obesity is associated with lower physical performance in patients with OSAS (15). In this study, the result of higher BMI in the moderate to severe OSAS group than in the no-mild group was expected. However, while it was thought that the effect of obesity on the physical performance of OSAS patients would be much higher, it did not play an active role as much as other health metrics (quality of life, daytime sleepiness, anxiety, depression, etc.). Unlike the previous literature, the predictive effect of obesity on the physical performance of patients with OSAS was investigated in this study and concluded that it was only 13%. The reason for these results may be not including a specific BMI classification in the study. Another reason may be that the functional physical performance test chosen for the study was not sufficient to reflect the effect of obesity in this patient population. However, with our study results showing that obesity has a small effect on physical

performance in patients with OSAS, we could say that approaches to obesity management should be included in the routine clinical follow-ups of patients.

Limitations

The main limitations are the inability to make a physical performance assessment which suggests that more objective outcome measures should be included in further studies to examine the effect of disease severity on physical performance. Further studies should be conducted in a larger sample by including different functional physical performance tests in the assessment. Also, further research can be done with functional tests that require more effort to examine the effects of hypoxia and obesity on physical performance.

CONCLUSION

To conclude, the results of this study reveal that OSAS patients experienced more physical and mental health limitations, the amount of daytime sleepiness they experienced increased, and their energy worsened or vice versa. In these patients, if functional physical performance can be improved with therapeutic options, the patients experienced role limitation, worsened emotional well-being, and energy levels, the level of depressive and anxiety symptoms, and the amount of daytime sleepiness can be reduced.

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