Original Article

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TANAFFOS

Evaluating Work Limitations in Obstructive Sleep Apnea Patients before and after the Application of Positive Airway Pressure

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Background: Obstructive sleep apnea (OSA) is the most prevalent sleep-related breathing disorder that adversely affects health, safety, and productivity. Positive airway pressure (PAP) is the primary treatment of OSA. This study aimed to examine the work limitations experienced by patients with OSA both before and after using PAP.

Materials and Methods: This cohort study was conducted from October 2021 to August 2023 at the Sleep Diseases Clinic of Mashhad University of Medical Sciences. Our study included 30 working patients diagnosed with OSA by polysomnography who had therapeutic indications for PAP. These patients completed the work limitation questionnaire (WLQ) before starting PAP treatment and again three months after initiating PAP. The results were then compared.

Results: Among the 30 participants, 28 (93.3%) were male, and 2 (6.7%) were female. The mean age was 45.96±10.01 years, and the mean apnea–hypopnea index (AHI) was 57.13 ± 32.07 events/h. The mean score of the WLQ before and after using PAP was 31.17±16.32 and 17.06±11.59, respectively. The use of PAP significantly improved work limitations and enhanced time management, physical activity, mental-interpersonal relationships, and work efficiency (P<0.001). However, patients who used PAP for less than 4 hours nightly showed a significantly lower mean change in work limitation scores than those who used it for more than 4 hours nightly (P<0.001).

Conclusion: Based on the findings of our study, the use of PAP in patients with OSA significantly improved work limitations in all areas.

Keywords: Apnea-Hypopnea Index (AHI); Positive airway pressure; Obstructive sleep apnea; Work Limitation Questionnaire (WLQ)

INTRODUCTION

Obstructive sleep apnea (OSA), a prevalent and potentially severe nocturnal respiratory condition, is characterized by recurrent upper airway constriction or reduction during sleep. This condition manifests when the muscles in the throat relax and obstruct the airway during sleep, resulting in symptoms such as snoring, gasping, and choking (1). Common symptoms of OSA include morning dry mouth, daytime drowsiness, and restless sleep (2). The pathogenesis of obstructive sleep apnea (OSA) is complex and involves a combination of anatomical and mechanical factors that increase susceptibility to upper airway collapse. Additionally, elements that contribute to the instability of ventilatory control and arousal from sleep, which subsequently cause apnea and hypopnea, are implicated in its pathogenesis (3).

The prevalence of OSA is conservatively estimated at 3% in women, 10% in men aged 30–49 years, 9% in women, and 17% in men aged 50–70 years (4). It is important to note that OSA can manifest at any age. Statistically, one in every five adults is likely to have mild OSA, and one in every 15 adults may have a moderate form of the condition (5). The reported prevalence of OSA varies significantly among studies and populations. A comprehensive meta-analysis of 42 studies conducted between 2011 and 2018 revealed that the prevalence of OSA in Iran was approximately 44%, with a 95% confidence interval ranging from 35% to 53%. This indicates the substantial presence of the condition within the Iranian population (6).

Certain conditions that reduce pharyngeal lumen size or increase upper airway collapsibility are recognized as risk factors for OSA. Among these, obesity was the most significant factor. Accumulation of adipose tissue in the tongue and pharynx can reduce the dimensions of the upper airway, thereby increasing its susceptibility to collapse during sleep (7). It has been observed that OSA is prevalent in over 40% of individuals with a body mass index (BMI) exceeding 40 (8), and in 60% of individuals diagnosed with metabolic syndrome (9). Male gender is another notable risk factor for OSA; however, hormonal factors may also play a role. For instance, progesterone-induced stimulation of the upper airway muscles and ventilation could potentially explain the lower prevalence of OSA among premenopausal women compared to their older counterparts. Conversely, elevated androgen levels may augment muscle mass in the tongue, thereby exacerbating OSA (8).

OSA has a substantial influence on an individual's quality of life (10). The implications of this condition extend beyond mere daytime sleepiness, permeating various facets that are typically associated with health-related quality of life. Symptoms, such as pronounced daytime sleepiness, fatigue, and personality alterations, are common (10). In addition, diminished energy levels may restrict an individual's capacity to participate in daily activities. Mood fluctuations, including irritability and depression, are also frequently observed (11). Moreover, OSA has been associated with an elevated risk of vehicular accidents, cardiovascular and cerebrovascular morbidities, and mortality (12). It has been noted that OSA can independently affect numerous quality-of-life domains, even after accounting for variables such as age, gender, BMI, and comorbidity (13). In summary, OSA can profoundly affect diverse aspects of life, highlighting the critical need for timely diagnosis and effective treatment (12).

OSA treatment encompasses a range of strategies that are often tailored to the severity of the condition. Common treatments include positive airway pressure (PAP) therapy, oral appliances, lifestyle changes, hypoglossal nerve stimulation, and surgical interventions (14). Since OSA was first described, PAP has emerged as the main treatment for these patients, given its proven efficacy in resolving sleep-disordered breathing events and improving clinical outcomes (15). Typically, PAP therapy is employed for patients with moderate-to-severe OSA, irrespective of the presence of symptoms or comorbidities, as well as for patients with mild OSA who exhibit symptoms or comorbidities (16).

The wider social and public health implications of OSA have garnered increasing attention. Given the impact of OSA on an individual's job performance, particularly in safety-sensitive roles, and the effectiveness of PAP therapy as a primary treatment, understanding these effects is crucial (17). However, few studies have explored the influence of PAP therapy on work limitations, specifically concerning the extent and methods of device usage. Therefore, this study aimed to examine the efficacy of PAP therapy in enhancing employee productivity, as measured using a work limitation questionnaire (WLQ).

MATERIALS AND METHODS

Study population

This cohort study was conducted at the Sleep Diseases Clinic of the Mashhad University of Medical Sciences from October 2021 to August 2023. The study included

employed individuals who had been stable in their current job for the past year, had been diagnosed with OSA based on polysomnography, and were utilizing PAP for treatment. The exclusion criteria for the study were patients with other diseases that influence daily sleepiness, individuals with other conditions such as heart failure or disability, and those who were taking sleeping pills.

Study protocol

Patients were selected using the census method, and all individuals meeting the inclusion criteria during the project timeframe were included in the study. Upon obtaining informed consent, initial data collection included patient demographics, such as age, gender, BMI, job type, work experience, underlying disease history, use of neuroleptics, and shift work (referring to any work schedule outside of 7 am to 6 pm) (18). Additionally, the apnea-hypopnea index (AHI), hours of PAP use per night, and average number of days of PAP use in 90 days were recorded. In adults, the severity of obstructive sleep apnea is classified according to the AHI. Mild apnea has an AHI of 5-14.9, moderate apnea has an AHI of 15-29.9, and severe apnea has an AHI of 30 or more events per hour of sleep (19).

Subsequently, patients were asked to complete a work limitation questionnaire (WLQ) (20). Initially, the questionnaires were distributed by the researcher or their representatives, and the contents were explained to the patients. After three months of PAP device usage, the patients were requested to complete the questionnaire again. This was facilitated through phone contact or by sending the questionnaire via email or messenger. Participants completed and returned the questionnaire to the researcher. Finally, the questionnaire results before and after PAP machine usage were compared.

Work Limitations Questionnaire (WLQ)

The WLQ assesses the impact of illness and physical and mental health issues on work performance across four domains (25 questions). The first five questions gauge the degree of limitation in time management skills (Time demands), encompassing issues related to task scheduling and job planning. The subsequent six questions evaluated the extent of limitations in the physical capabilities required for work, such as physical strength, body movements, endurance, coordination, and flexibility (Physical demands). The third domain, comprising nine questions, measured the limitations in mental abilities and interpersonal relationships caused by the illness (Mental /Interpersonal demands). The final five questions (about work efficiency) examined the decline in both the quality and quantity of work attributable to the illness (Output demands).

Patients rated their responses to the questions on a scale from zero (indicating no problem at all) to four (representing a 100% problem). The overall score on the questionnaire was derived from the sum of the scores across all domains. To express this percentage, the total score was multiplied by 25. The resulting figure represents the index of work limitations caused by the illness.

The questionnaire was translated into Farsi and then back into English to ensure its accuracy. The research group then reviewed these, ensuring alignment with the original English questionnaire, and made the necessary corrections to produce a unified version. To verify the face validity from the perspective of the target group, the questionnaire was randomly distributed among 20 individuals. The researcher conducted interviews to identify any issues with understanding, ambiguity, misinterpretation, or inadequacies in the meaning of words and phrases. Content validity ratio (CVR) and content validity index (CVI) were used to determine content validity. The questionnaire was distributed to 14 medical specialists to improve its reliability. Internal reliability was evaluated using Cronbach's alpha, with scores ranging from 0.772 for physical tasks to 0.923 for the entire questionnaire, indicating good reliability across all the sections.

Statistical analysis

Data were analyzed using the SPSS software (version 11.5, Chicago, IL, USA). Descriptive statistics were presented for both quantitative (mean, standard deviation, median, and interquartile range) and qualitative variables (number and frequency percentage). The Kolmogorov-Smirnov test was used to investigate the variable distribution. Based on these results, the paired t-test was used to compare the pre- and post-PAP use results. The chi-square test was used for qualitative variables. Statistical significance was set at $p<0.05$.

Ethical considerations

The study protocol was reviewed and approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (No. IR.MUMS.REC.1400.242). The study was conducted in accordance with applicable ethical guidelines and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. Participants' rights, privacy, and confidentiality were maintained throughout the study, and all collected data were securely stored and handled without disclosure of participants' identities.

RESULTS

The study included 30 patients: 28 (93.3%) male and 2 (6.66%) female, employed patients with OSA, confirmed by polysomnography, who opted for PAP treatment. The study subjects had a mean age of 45.96 ± 10.01 years (range 28-65), a mean BMI of 31.01±4.80 kg/m² (range 23.37-47.12), a mean work experience of 17.86±8.47 years (range 1-32), and a mean AHI of 57.13±32.07 events/hour (range 20.7-153.5). Table 1 displays the frequencies of the qualitative variables of the study participants. The mean adherence rate for the use of PAP over 90 days was 72.86±14.27, ranging from 35 to 90 nights.

Table 2 displays the mean scores from the WLQ before and after using PAP. The results indicated that the use of PAP significantly improved work limitations ($P<0.001$). Furthermore, after using PAP, there were significant improvements in time management, physical activity, mental-interpersonal relationships, and work efficiency ($P<0.001$).

The mean change in work limitation scores was significantly lower in the group of patients who used PAP for less than 4 h nightly compared to those who used it for more than 4 h nightly ($P=0.01$). The mean changes in work limitation scores in the mental-interpersonal relationship domain ($P=0.01$) and output demands ($P=0.04$) were statistically significant between the two groups, with greater changes observed in the group that used PAP for more than 4 hours. However, the mean age, AHI, and work experience did not differ significantly between the two groups ($P>0.05$) (Table 3).

Additionally, the statistical analysis results showed that there was no statistically significant difference in age, AHI, BMI, work experience, mean initial score, final score, or change in work limitation score among the three occupational groups: health care worker, office worker, and others. This was also applied to the mean initial score, final score, and change in score in different areas of the WLQ among the three occupational groups: health and hygiene, office, and other ($P>0.05$) (Table 4).

There was no significant relationship between work shift and job type, and the hours of using PAP at night ($P>0.05$). The correlation test results showed a strong and statistically significant correlation between the mean initial work limitation score and the mean change in the work limitation score ($P<0.001$). However, there was a weak negative correlation between AHI and both the mean initial work limitation score and the mean change in the work limitation score. Similarly, a weak negative correlation was observed between work history and the mean initial work limitation score, and a weak positive correlation was observed between work history and the change in work limitation score. None of the correlations were statistically significant ($P>0.05$).

Table 1. The frequency of the qualitative variables

Variable		Frequency (%)
Type of job	Office	15 (50)
	Healthcare	8 (26.7)
	Other	7 (23.3)
Underlying disease	Hypothyroidism	1 (3.3)
	Hypertension and diabetes	3 (10)
	Ischemic heart disease	1 (3.3)
	Digestive Diseases	2 (6.7)
	None	23 (76.6)
Use of neuropsychiatric drugs	Yes	3 (10)
	No	27 (90)
Shift work	Yes	5 (16.7)
	No	25 (83.3)
Apnea-hypopnea index (AHI)	Mild	0 (0)
	Moderate	4 (13.3)
	Severe	26 (86.6)
Duration of positive airway pressure therapy (PAP)	Less than 4 hours nightly	9 (30)
	More than 4 hours nightly	21 (70)
90-day PAP adherence rate	Less than 70%	4 (13.3)
	More than 70%	26 (86.7)

Table 2. The scores of WLQ before and after using PAP

Variable	Before using PAP (Mean ± SD)	After using PAP (Mean ± SD)	P-value
Time Demands	6.9 ± 4.53	4.36 ± 3.30	< 0.001*
Physical Demands	73.7 ± 4.87	4.27 ± 3.33	0.001*
Mental /Interpersonal Demands	10.13 ± 7.06	5.1 ± 5.18	< 0.001*
Output demands	6.03 ± 4.13	2.9 ± 2.89	< 0.001*
Total	31.17 ± 16.32	17.06 ± 11.59	< 0.001*

* Student's t-test

Table 3. Comparison of patients using PAP for less than 4 hours nightly with those using PAP for more than 4 hours nightly

Variable	using PAP for less than 4 hours nightly (Mean ± SD)	using PAP for more than 4 hours nightly (Mean ± SD)	P-value
Age (year)	40.55 ± 8.56	48.28 ± 9.86	0.05
Work experience (year)	13.66 ± 10.31	19.66 ± 7.08	0.07
Apnea-hypopnea index (AHI) (events/hour)	59.65 ± 43.88	56.5 ± 26.78	0.78
Total work limitations score	5.88 ± 11.68	17.80 ± 10.97	0.01*
Time demands	2.88 ± 3.65	5.23 ± 2.93	0.07
Physical demands	1.44 ± 4.30	3.85 ± 3.82	0.14
Mental /Interpersonal demands	1.77±3.45	6.42 ± 4.83	0.01*
Output demands	1.33 ± 2.59	3.90 ± 3.14	0.04*

* Student's t-test

Table 4. Comparison of three occupational groups in terms of quantitative and qualitative variables

Variable	Office Worker (Mean ± SD)	Health Care Worker (Mean ± SD)	Other (Mean ± SD)	P-value
Age (year)	45.60 ± 9.75	47.12 ± 12.99	45.42 ± 7.93	0.93
Apnea-hypopnea index (AHI) (events/hour)	55.46 ± 21.47	63.57 ± 49.12	53.35 ± 31.65	0.80
Body mass index (BMI) (kg/m²)	30.00 ± 3.74	33.89 ± 6.68	29.88 ± 3.36	0.13
Work experience (year)	18.40 ± 8.25	18.25 ± 8.58	16.28 ± 9.92	0.86
First score of work limitations	29.20 ± 15.22	31.37 ± 23.22	34.71 ± 7.08	0.76
Final score of work limitations	17.64 ± 10.96	12.25 ± 10.13	21.42 ± 13.90	0.31
Score change of work limitations	11.25 ± 11.64	19.12 ± 15.01	13.28 ± 11.14	0.39

* ANOVA test

DISCUSSION

Although OSA itself is not immediately life-threatening, it can lead to many physical and psychological complications if left untreated (21). The adverse effects of OSA extend beyond the life of the patient, impacting family dynamics, work performance, and society as a whole (21). In this study, we examined the extent of work limitations in OSA patients before and after PAP treatment. The results indicated a significant improvement in the mean score of overall work limitations as well as in all areas assessed by the questionnaire, both before and after treatment. The changes in the mean score of total work limitations, the mental-interpersonal relationship domain, and the work efficiency domain were significantly greater in individuals who used PAP for more than 4 hours a night than in those who used PAP for less than 4 hours a night. There were no statistically significant differences in mean age, AHI, BMI, work history, mean initial score, final score, or change in work limitation scores among the three occupational groups: administrative, health, and others. This was also applied to the mean initial score, final score, and change in score in different areas of the WLQ.

Various tools have been utilized to assess the impact of OSA on job performance and work productivity. Using the Work Role Functioning Questionnaire (WRFQ), Botokeky et al. demonstrated that OSA patients experienced significant improvements in scheduling, productivity, and mental and social aspects six months after undergoing PAP treatment (22). Lee et al. (23) and Kuhn et al. (24) reported that treatment with PAP enhanced the vitality domain of the Short Form 36 (SF-36). Intention-to-treat analysis revealed that PAP treatment also ameliorated the role-physical domain and physical component scores of the SF36. Furthermore, a per-protocol analysis indicated that PAP treatment improved the vitality and social functioning domains of the SF36, as well as the mental component score. It is important to note, however, that while the SF36 showed improvements in several domain scores, it is a generic questionnaire that is not specifically tailored to OSA. In a study conducted by Jurádo-Gámez et al., the impact of continuous positive airway pressure (CPAP) on work productivity and burnout symptoms was assessed in patients with moderate-to-severe OSA using validated questionnaires. Their findings indicate that CPAP therapy positively contributes to work productivity and alleviates burnout symptoms (25). Our study aligns with these findings, further emphasizing the benefits of CPAP use for OSA patients in their professional lives. In another study using the WLQ, Mulgrew et al. demonstrated that CPAP treatment improved perceived work limitations in the areas of time management, social relationships, and work productivity (26). These results are consistent with our study, which discovered that the work limitations of patients with OSA who are employed significantly improved in terms of work efficiency after using PAP, as quantified by the WLQ. The key distinction between our study and that of Mulgrew et al. (26) is that we specifically examined employed patients with OSA, considering the complications and consequences of this condition in working individuals, especially in safety-sensitive jobs. This is important, as it affects not only the individual but also the people to whom they provide services.

Patients with OSA typically exhibit low physical activity levels. This is because OSA significantly disrupts aerobic exercise capacity, often leads to extensive chronic pain, and can result in various health conditions. The impact of PAP on physical activity has been explored in numerous studies, using a variety of objective and subjective measures (27). Jean et al., utilizing the International Physical Activity Questionnaire (IPAQ) and a pedometer to measure actual physical activity, found that PAP usage over a three- to eight-month period led to a gradual enhancement in physical activity (28). In addition, a study conducted by Chasens et al. demonstrated that treating OSA results in an average improvement in activity among individuals with type 2 diabetes (29). Stevens et al. found that PAP treatment positively influenced the participants' self-reported physical activity levels in cardiovascular disease and OSA over 3.7 years (30). Research conducted by Yue Liu et al. revealed a significant

inverse correlation between total physical activity and OSA incidence (31). In this context, the results of the current study demonstrated a significant improvement in the physical activity scores of patients after PAP therapy. An additional research endeavor sought to explore the correlation between physical activity and the risk of OSA among Chinese adults. Interestingly, the study found no association between OSA risk and leisure-time physical activity (LTPA), occupational activity, or transport activity after accounting for potential confounding factors (32). While a general link between OSA and reduced levels of physical activity may exist, the specifics of this relationship can fluctuate based on the type of physical activity and demographic group under study. It is crucial to highlight that these findings are based on observational studies, indicating the need for further research to fully comprehend the precise relationship between physical activity and OSA.

The findings of the current study indicate that PAP treatment significantly enhances mental domain scores related to interpersonal relationships and time management in patients with OSA. Research by Eda et al. revealed that OSA severity negatively affects long-term memory, sustained attention, and verbal fluency. However, they also observed significant improvements in all cognitive domains following PAP treatment (33). Similarly, Costa et al. (34) and Mulgrew et al. (26) found that PAP treatment leads to a significant improvement in mental-interpersonal relationships and time management. In contrast, a meta-analysis reported minimal improvements in cognitive domains in patients with OSA after post-PAP treatment (35). Generally, these score outcomes vary depending on an individual's job type, societal relationships, and psychological state. Therefore, further research is necessary to fully comprehend the precise relationship between mental-interpersonal relationships, time management, and OSA.

Mitigation of symptoms related to OSA is dependent on the duration of CPAP therapy. Studies have demonstrated a direct correlation between the duration of treatment adherence and the effectiveness of CPAP therapy in alleviating OSA symptoms (36). It has been suggested that a minimum of four hours of therapy adherence each night is crucial for achieving clinical efficacy. Research further indicates that maintaining the therapy for over four hours can lead to improvements in sleep quality and a reduction in daytime sleepiness, fatigue, and depressive symptoms (37, 38). Botokeky et al. observed that the AHI of patients was significantly improved with the use of CPAP at 8 per hour compared with 4 per hour (22). Interestingly, a longer duration of CPAP use has been associated with a significant decrease in the baseline score of the excessive sleepiness scale (ESS) (39). Lo Bue et al. reported significant improvements in all symptoms, except energy levels, among patients who adhered to treatment for more than 5 h compared with those who received inadequate treatment. Furthermore, the study results indicated that individuals who used PAP for more than 4 hours transitioned from symptomatic to asymptomatic, and nearly 30% of individuals who used PAP for less than 4 hours also demonstrated improvement in each category (40). A systematic review suggests that the optimal duration of PAP usage is individually defined, and previous notions about optimal sleep hours should be replaced with a focus on improving clinical indicators and using PAP as a percentage of total sleep time (41). The findings of the current study revealed that the mean change in WLQ was significantly higher in the group of patients with OSA who used PAP for a mean of more than four hours a night than in the group that used PAP for less than four hours a night. However, focusing on improving job performance appears to be a more appropriate approach.

The results of the current study show that a weak and negative correlation exists between AHI and both the mean initial score of work limitation and the mean change in the work limitation score. The results also revealed a weak negative correlation between the mean initial score of work limitation and the mean change in the work limitation score. These findings suggest that AHI is not a reliable

predictor of work limitations. In a related study conducted on drivers, AHI provided minimal insight into impaired driving performance (42). While AHI plays a pivotal role in diagnosing and evaluating the severity of sleep apnea, it may not be a direct indicator of work limitations. Elements such as daytime lethargy, fatigue, and cognitive functioning, which can be affected by OSA, could have a more immediate effect on work performance (19). Some studies have highlighted the constraints of AHI in specific demographics, including children and young adults with neuromuscular disorders. These studies proposed that while AHI is a significant metric, it should not be the exclusive determinant for clinical decision-making, including the prediction of work limitations. Other aspects, such as anomalies in overnight gas exchange and clinical symptoms, should also be considered (43). Consequently, it is crucial to acknowledge that the correlation between AHI and work limitations can be complex and influenced by numerous factors.

Our study, which used a valid criterion to assess work limitations, had several strengths, including the translation of the WLQ into Farsi due to its unavailability in Iran and the objective evaluation of PAP. However, owing to high treatment costs and lack of insurance coverage, many patients diagnosed with OSA were discouraged from continuing treatment and were excluded from the study. Ideally, the study included only patients with sufficient PAP compliance; however, due to the small sample size, patients with less-than-ideal PAP usage were also included. Future studies should focus more on the impact of effective factors on results and conduct studies with larger sample sizes and in a multicenter manner.

CONCLUSION

Based on the findings of this study, the use of PAP enhanced job performance in all areas assessed by WLQ. This includes time management, physical activity, mental-interpersonal relationships, and work efficiency in patients with OSA. Despite contradictory findings regarding the effects of PAP in other studies, our results confirmed the beneficial therapeutic effects of PAP. This underscores the need for increased attention from doctors and patients towards early diagnosis of the disease, prevention of its complications and consequences, and maximization of the benefits from its treatment.

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Conflicts of interest

The authors declare no conflicts of interest related to the present study.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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