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RESEARCH PAPER

Are disease severity, sleep-related problems, and anxiety associated with work functioning in patients with obstructive sleep apnoea?

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ABSTRACT

Purpose: To examine whether Obstructive Sleep Apnoea severity, sleep-related problems, and anxiety are associated with work functioning in Obstructive Sleep Apnoea patients, when controlled for age, gender and type of occupation. To investigate whether anxiety moderates the associations between sleep-related problems and work functioning.

Materials and methods: We included 105 Obstructive Sleep Apnoea patients (70% male; mean age 46.62 ± 9.79 years). All patients completed the Pittsburgh Sleep Quality Index, the Epworth Sleepiness Scale, the Beck Anxiety Inventory, and the Work Role Functioning Questionnaire-2.0.

Results: Obstructive Sleep Apnoea-severity, poor nighttime sleep quality, and anxiety were univariately associated with impaired work functioning. Multivariate analyzes revealed that poor perceived sleep quality was more strongly associated with work functioning than sleep efficiency and daily disturbances. Anxiety was strongly associated with impaired work functioning. After adding anxiety, the explained variance in work functioning increased from 20% to 25%. Anxiety moderated the association between low and medium levels of nighttime sleep quality problems and work functioning.

Conclusions: Poor perceived sleep quality and anxiety were strongly associated with impaired work functioning in Obstructive Sleep Apnoea patients. These findings may help to optimize management, standard treatment, and work functioning in people with Obstructive Sleep Apnoea when confirmed in longitudinal studies.

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Sleep apnea; work functioning; anxiety; nighttime sleep quality; daytime sleepiness

➤ IMPLICATIONS FOR REHABILITATION

- Studies show an impairment of functional status, including work functioning, in obstructive sleep apnea patients.
- Aside from physical disorders, obstructive sleep apnea patients often experience mental problems, such as anxiety.
- As many people with obstructive sleep apnea are undiagnosed, our results demonstrate to employers and healthcare professionals the need to encourage patients for obstructive sleep apnea screening, especially in the situation of impaired work functioning, increased anxiety, and poor sleep quality.
- The associations between obstructive sleep apnea, sleep and anxiety might *increase* the awareness of health professionals towards *optimizing* diagnostic accuracy and standard treatment.

Introduction

Obstructive Sleep Apnoea (OSA) is an incapacitating chronic disease caused by pharyngeal collapse during sleep [1]. OSA is considered to be one of the most prevalent sleep disorders [1], with an estimated prevalence of 2–10% among the adult population [2]. The disease is characterized by repeated breathing pauses (apnoeas) which cause frequent awakenings, fragmented sleep, and, consequently, excessive sleepiness and fatigue [3]. Besides physical disorders, OSA patients may also have substantial mental health problems, such as depression, anxiety [4–8], post-traumatic stress syndrome [5], or panic attacks [9]. OSA has a substantial economic impact on healthcare systems as well as on individuals and their households. Studies show a significant impairment of functional status, including work functioning, in these patients; i.e., undiagnosed OSA is associated with notable increases in healthcare costs [10,11] but also with a reduced work capacity and work disability [2,12,13].

Earlier studies report an impairment of work functioning in OSA patients [12–14]. Tregear et al. [15] described the occurrence of microsleeps and accidents, while Sivertsen et al. [13] showed that self-reported OSA symptoms were an independent risk factor for subsequent long-term sick leave and permanent work disability.

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Supplemental data for this article can be accessed here.

The association between OSA severity and the individual experience of work limitations was dependent on job type [12]; i.e., OSA severity did not affect work performance (time management, physical, mental-interpersonal, and output demands) in white-collar workers, while it did in blue-collar workers. Most of the previous research on work correlates in OSA patients has quantified the outcomes using objective variables, such as absenteeism [13] or occupational accidents [16,17], which may be lower-incidence events when compared to work functioning impairment. Others have assessed the economic impact of OSA on public health systems [10,11]. Furthermore, some older studies on work functioning in OSA patients did not use polysomnography (PSG) to diagnose OSA [13,18], nor did they use validated measures of work role performance [18,19]. Thus, more studies are needed in which OSA is diagnosed with reliable methods and occupational variables are assessed with standardized and validated questionnaires [20].

Moreover, despite the acceptance of continuous positive airway pressure as the standard OSA treatment, there is a lack of consensus regarding the positive evidence of continuous positive airway pressure treatment effect on functional status [3,21,22]. Furthermore, a large proportion of the population is at risk of experiencing a sleep disorder [23]; thus, it is important to quantify work-related outcomes in these persons. Sleep-related OSA symptoms were also found to contribute to decreased employee productivity [24,25] and are related to high costs for employers [24]. According to Swanson et al. [26], sleep disorders adversely affect work performance, while mood and affective symptoms impact relationships with coworkers and presenteeism.

Many OSA patients suffer from anxiety symptoms [4,8,27–29], but these are rarely studied systematically [8,29]. The omission of anxiety associated with OSA symptomatology may contribute to poor treatment acceptance and adherence [30], and consequently, to an overall worsening of OSA symptoms and increased risk of morbidity [29]. Although previous research on OSA patients suggests that there may be a considerable association between sleep-related problems and anxiety [4], these may also occur separately from each other [8]. Anxiety can have a major impact on functional status and may interfere with work productivity [31]. However, the findings are inconclusive; e.g. Mughal et al. [32] found that employees with high trait anxiety exerted greater work effort than those with low trait anxiety, which resulted in better work performance.

We sought to address several gaps in the existing literature, because to the best of our knowledge, no studies have investigated the associations between nighttime sleep quality, anxiety and work functioning in OSA patients. Increased awareness of the associations between OSA and affective problems might improve diagnostic accuracy as well as treatment outcomes [8,33]. Insight into which specific OSA symptomatology, such as sleep-related and mental health problems, are associated with impaired work functioning, may provide opportunities for preventive strategies for productivity-loss among workers with OSA. Therefore, the present research and clinical practice should focus not only on the standard treatment of OSA but also on ensuring that symptoms such as sleep-related problems or mental health impairment are managed. To do that, we first need to understand how these symptoms relate to functioning in OSA untreated patients. Thus, the aims of this study were (1) to examine whether OSA severity, sleep-related problems, and anxiety are associated with work functioning in OSA patients, and (2) to investigate whether anxiety moderates the associations between sleep-related problems and work functioning.

Materials and methods

Sample and procedure

This cross-sectional study was conducted at the Department of Pneumology and Phtiseology, L. Pasteur University Hospital and the Medical Faculty of PJ Safarik University in Kosice, Slovak Republic. All patients who visited the Department for one-night polysomnography (PSG) from July 2013 to April 2016 and underwent PSG were eligible for the study. Indication for PSG was based on a general practitioner referral form. OSA was diagnosed based on an overnight sleep examination. PSG was used to determine whether the diagnosis of OSA was present and to identify the severity of the disorder. PSG consists of a simultaneous recording of multiple physiological parameters related to sleep and wakefulness, which directly monitor and quantify the number of respiratory events, related hypoxemia, and arousals. PSG comprised the overnight recording of left and right electrooculograms, standard central and occipital electroencephalogram, submental electromyogram (EMG), bilateral tibialis EMG, nasal, and oral airflow using a thermistor and thoracic and abdominal excursions using respiratory inductive plethysmography.

The study sample consisted of working patients with an Apnoea Hypopnoea Index (AHI; number of apnoeas + hypopnoeas per hour of sleep) score of 5 or more [34] who had not undergone any continuous positive airway pressure therapy or other OSA treatment, were Slovak-speaking and had no major comorbidities. Patients with non-respiratory sleep-related complaints (e.g., circadian rhythm sleep disorder, insomnia) were routinely referred to another group of clinical specialists and were therefore not represented in our sample. Only OSA patients between 18 and 65 years of age were included due to possible functional changes, increased vulnerability and a decline in abilities and performance related to age.

Out of $N = 152$ eligible OSA patients, a total of $N = 33$ were excluded because of major comorbidities (a coexisting major sleep disorder such as insomnia, narcolepsy, or circadian rhythm sleep disorder; major cardiovascular diseases, primary pulmonary hypertension, chronic obstructive pulmonary disease, diabetes, Pickwick syndrome, a history of cancer in the past 12 months, neurological deficit, a major psychiatric diagnosis in the medical record, and/or current usage of psychiatric medications which may affect cognitive functions (e.g., antipsychotics, benzodiazepines, or antidepressants), or drug abuse in the past 6 months and regular shift work in the past 6 months. Screening for comorbidities was based on medical data and an initial clinical interview prior to data collection. The clinical diagnoses of the comorbidities were established according to the standard International Classification of Diseases, 10 Revision codes. Medical examinations of patients were conducted by a pulmonologist specialized in sleep-disordered breathing. Another $N = 14$ patients refused to participate in the study (response rate 89%). A total of $N = 105$ OSA patients (70% male; mean age 46.62 ± 9.79 years) constituted the final study sample.

The invitation letter, the informed consent, and the self-reporting questionnaires were sent to participants by postal mail 3 weeks before the medical examination. One week before the medical examination, patients were reminded about the questionnaires by a phone call. Patients filled in the questionnaires at home. Each patient completed and signed an informed consent form prior to their participation in the study, which was fully voluntary and included no incentives for participation. The study was approved by the Ethics Committee of PJ Safarik University (approval no. 115/2011).

Measures

Sociodemographic and clinical data

Information on age, gender, and marital status were obtained from patient records. Patients were asked to identify the one industry that best characterized their current employment (over the last 24 months) from a list of International Standard Classification of Occupations [35]. Patients were also asked to specify their occupation to reduce the obtaining of incorrect or inconsistent information. OSA patients in the following industries were classified as blue-collar workers: primary resource industry, construction industry, manufacturing industry, warehousing, trade, and transportation. Patients employed in public administration, armed forces, government, and the service sector (including tourism, business services, education, healthcare, legislators, managerial occupations, professional, and utilities) were classified as white-collar workers. Body Mass Index (height and weight) was assessed by a physician. BMI was used to sort patients into categories: underweight (<18.5), normal (18.5–24.99), overweight (25.0–29.99), and obese (30+). The diagnosis of OSA was determined using PSG and was based on the Apnoea Hypopnoea Index (AHI; number of apnoeas + hypopnoeas per hour of sleep) starting with a score of 5 or more according to the standard criteria [34]. According to this, OSA severity is mild ($AHI \geq 5 \leq 15$), moderate ($AHI > 15 \leq 30$), or severe ($AHI > 30$). An obstructive apnea or hypopnea can be defined as an event that lasts for ≥10 s and is characterized by an absence or a decrease from baseline in the amplitude of a valid measure of breathing during sleep that either reaches ≥50% with an oxygen desaturation of 3% or an arousal (alternatively a 30% reduction with 4% desaturation) [34].

Sleep-related problems

Sleep-related problems concerned nighttime sleep quality and daytime sleepiness. *Night-time sleep quality* was measured using the Pittsburgh Sleep Quality Index (PSQI) [36]. The PSQI is a self-rated questionnaire to assess sleep quality and disturbances over a 1-month time interval. The PSQI consists of 19 self-reported questions which cover seven domains: sleep latency, subjective sleep quality, sleep duration, sleep disturbances, habitual sleep efficiency, daytime dysfunction, and use of sleep medication. The score ranges from 0 to 21, with higher scores reflecting poor nighttime sleep quality. A cutoff score of 5 separates well from poor sleepers [36]. The results of some previous studies suggested that the seven PSQI domains are best represented by three latent factors [37,38]. An empirical examination of the factor structure of the PSQI identified three distinct factors: perceived sleep quality, sleep efficiency, and daily disturbances. The PSQI subscales for subjective sleep quality, sleep medications, and sleep latency were loaded onto the latent variable *perceived sleep quality*; the PSQI subscales for sleep duration and habitual sleep efficiency were loaded onto the latent variable *sleep efficiency*; and the PSQI subscales for sleep disturbances and daytime dysfunction were loaded onto the latent variable *daily disturbances* [37]. *Sleep efficiency* is defined as closely related to sleep quantity [38], while the *daily disturbances* factor reflects sleep-related daytime impairment (i.e., trouble performing daytime activities) and interruptions in sleep due to physical or psychological symptoms [38]. In our sample, Cronbach's alpha was 0.85 for the total PSQI scale.

Daytime sleepiness was measured using the self-report Epworth Sleepiness Scale (ESS), an eight-item questionnaire assessing the tendency to fall asleep in various daytime scenarios [39]. The score ranges from 0 to 24, with higher scores indicating greater daytime sleepiness. An ESS total score greater than 10 indicates excessive daytime sleepiness [39]. Cronbach's alpha for ESS in our sample was 0.87.

Anxiety

Anxiety was measured using the Beck Anxiety Inventory (BAI), which consists of 21 items defining the most common anxiety symptoms [40]. The BAI is a brief measure of anxiety with a focus on somatic symptoms and was developed as a measure adept at discriminating between anxiety and depression [41]. Scores range from 0 to 63, with higher scores indicating a higher anxiety level. The following categories were defined: no anxiety symptoms (score 0–9), mild anxiety (score 10–18), severe anxiety (score 19–29), and very severe anxiety (score 30–63) [40]. Cronbach's alpha in our sample was 0.90.

Work functioning

Work functioning was assessed with the Work Role Functioning Questionnaire (WRFQ 2.0) [42]. The WRFQ measures the perceived difficulties in performing work demands among workers, given their emotional or physical health problems. The WRFQ consists of 27 items divided into subscales: work scheduling demands and output demands, physical demands, mental and social demands, and flexibility demands. In addition, a total score can be calculated. Items are answered on a five-point scale: 0 = difficult all the time (100%), 1 = difficult most of the time (75%), 2 = difficult half of the time (50%), 3 = difficult some of the time (25%), and 4 = difficult none of the time (0%). There is also a response option "Does not apply to my job". The total score is calculated by adding all answers and dividing by the number of items and then multiplying by 25 to obtain percentages between 0 and 100. Higher scores indicate better work functioning. The scores on "Does not apply to my job" are transformed into missing values [42]. To identify the prevalence of impaired work functioning, we used the cutoff value (<90) for patients with a chronic disease according to Amick et al. [43]. In our sample, Cronbach's alpha was 0.98 for the total scale, 0.97 for the work scheduling and output demands, 0.90 for the physical demands, 0.90 for the flexibility demands, and 0.94 for the mental and social demands subscale.

Statistical analyzes

All analyzes were performed using the Statistical Package for the Social Sciences (IBM SPSS 23) and Modgraph. We started with a description of the background characteristics of the sample and determined the prevalence of OSA severity, nighttime sleep quality (PSQI), daytime sleepiness (ESS), anxiety (BAI), and impaired work functioning (WRFQ). Descriptive analyzes included frequencies and percentages for categorical variables and mean values and standard deviations (SD) for continuous variables. Next, we investigated the correlations between all variables. Then, we examined the associations between OSA severity, nighttime sleep quality, daytime sleepiness, anxiety, and work functioning in crude and adjusted linear regression analyzes, including interactions between sleep-related problems and anxiety. We applied the enter method in a linear regression to identify the factors associated with summary scores of work functioning for the total scale and the subscales. For each factor, unstandardized beta coefficients represent the mean variation of work functioning. The first model of the variables included sociodemographic data (age, gender). The second model included a clinical variable (OSA severity – measured by AHI); the third model included the nighttime sleep quality total scale. In addition, each of the three subscales of sleep

quality was analyzed separately. In the fourth model, anxiety was included to assess the increase in the explained amount of total variance in work functioning. Multicollinearity was assessed using the variance inflation factor (VIF < 2.0). Finally, we used moderation analyzes to examine whether the associations between nighttime sleep quality total scale as well as the three subscales and work functioning were moderated by anxiety. A p value of <0.05 was considered to be statistically significant. Power analysis revealed that the statistical power for multivariate analysis exceeds 86% with medium effect size at $\alpha = 0.05$. The statistical power for univariate analyzes was 93% with medium effect size at $\alpha = 0.05$ [44].

Results

Patient characteristics

Most of the patients were male (70%) and had secondary education (60%). A total of 55% were obese, with severe OSA (47%). Poor nighttime sleep quality was present in 84% of the OSA patients, and the prevalence of daytime sleepiness was 59%. The majority (80%) of OSA patients were anxious and reported mild to very severe anxiety. Impaired work functioning was present among 82% of OSA patients. Participants worked 39.5 ± 7.8 h and 5.3 ± 1.1 days a week (Table 1).

Correlations between OSA severity, sleep-related problems, anxiety, and work functioning

Table 2 displays the correlations between the study variables. High OSA severity, poor overall nighttime sleep quality, poor perceived sleep quality, poor sleep efficiency, high level of daily disturbances, and severe anxiety were significantly correlated with impaired work functioning. Daytime sleepiness was not correlated with work functioning.

Associations between OSA severity, sleep-related problems, anxiety, and work functioning (total scale)

A crude effect on work functioning was found for all variables, except for age (B: −0.22; 95%CI = −0.79; 0.36; $p = 0.46$), type of occupation (B: −4.03; 95%CI = −15.40; 7.34; $p = 0.49$) and daytime sleepiness (B: −0.61; 95%CI = −1.70; 0.48; $p = 0.27$) (Table 3). A small association between OSA severity (B: −0.27; 95%CI = −0.53; −0.01; $p \leq 0.05$) and poor work functioning was found in crude analyzes, but was no longer significant (B: −0.18; 95%CI = −0.45; 0.08; $p = 0.17$) in the subsequent multivariate models (Model 2–Model 5). Poor nighttime sleep quality total scale (B: −2.63; 95%CI = −3.85; −1.42; $p \leq 0.001$) was significantly associated with impaired work functioning (Model 3). The association between poor nighttime sleep quality total scale and work functioning attenuated (B: −1.64; 95%CI = −3.07; −0.23; $p \leq 0.05$) when anxiety (B: −0.61; 95%CI = −1.10; −0.15; $p \leq 0.01$) was added to the

Table 1. Baseline characteristics of the OSA patients (AHI ≥ 5).

Characteristics	$N = 105$
Age in years; mean, SD	46.62 ± 9.79
Gender; *N*, % male	73 (70%)
Education; *N*, %	
Elementary	4 (4%)
Secondary	63 (60%)
University	38 (36%)
Occupation type; *N*, % white-collar	51 (49%)
Marital status; *N*, % single	21 (20%)
Body Mass Index; *N*, %	31.27 ± 7.04
Underweight (<18.5)	0 (0%)
Normal (18.5–24.99)	23 (22%)
Overweight (25.0–29.99)	24 (23%)
Obese (30+)	58 (55%)
Apnoea-hypopnea index; mean, SD	37.03 ± 22.75
OSA severity; *N*, %	
Mild (AHI ≥ 5 ≤ 15)	16 (15%)
Moderate (AHI > 15 ≤ 30)	40 (38%)
Severe (AHI > 30)	49 (47%)
Night-time sleep quality (PSQI); mean, SD (0–21)	10.31 ± 4.31
Perceived sleep quality; mean, SD	4.78 ± 2.36
Sleep efficiency; mean, SD	1.81 ± 1.83
Daily disturbances; mean, SD	3.74 ± 1.32
Prevalence of nighttime sleep quality disturbance; *N*, % (cutoff score >5)	88 (85%)
Excessive daytime sleepiness (ESS); mean, SD (0–24)	11.09 ± 5.29
Prevalence of increased daytime sleepiness; *N*, % (cutoff score >10)	62 (59%)
Anxiety (BAI); mean, SD (0–63)	32.99 ± 13.03
Prevalence of anxiety; *N*, % (cutoff score >9)	84 (80%)
Prevalence of mild anxiety (10–18)	31 (30%)
Prevalence of severe anxiety (19–29)	35 (33%)
Prevalence of very severe anxiety (30–63)	18 (17%)
Work functioning (WRFQ) total scale; mean, SD (0–100%)	52.58 ± 28.76 28,758632
Work Scheduling and Output demands	49.19 ± 31.69
Physical demands	57.43 ± 31.57
Mental and Social demands	52.74 ± 31.15
Flexibility demands	56.25 ± 30.04
Impaired Work functioning; *N*, % (cutoff score <90)	82 (82%)
Work days per week; mean, SD	5.32 ± 1.10
Work hours per week; mean, SD	39.73 ± 7.82

AHI: Apnoea–hypopnoea index; OSA: obstructive sleep apnoea; PSQI: Pittsburgh sleep quality index; ESS: Epworth sleepiness scale; BAI: Beck anxiety inventory; WRFQ: work role functioning questionnaire; Missing data: Occupation type: 1%; PSQI: 1%, WRFQ: 4%.

Table 2. Correlation coefficients between OSA severity, nighttime sleep quality the total scale and its three subscales, daytime sleepiness, anxiety, and work functioning.

	OSA severity	Night-time sleep quality	Perceived sleep quality	Sleep efficiency	Daily disturbances	Daytime sleepiness	Anxiety
Night-time sleep quality	0.23*	–	–	–	–	–	–
Perceived sleep quality	0.26**	0.68***	–	–	–	–	–
Sleep efficiency	0.14	0.65***	0.43***	–	–	–	–
Daily disturbances	0.33***	0.62***	0.62***	0.20*	–	–	–
Daytime sleepiness	0.34***	0.20*	0.14	0.04	0.49***	–	–
Anxiety	0.18	0.58***	0.34***	0.32***	0.44***	0.31**	–
Work role functioning	−0.20*	−0.41***	−0.47***	−0.23*	−0.36***	−0.09	−0.45***

OSA: Obstructive sleep apnoea.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

model (Model 4). After adding anxiety (Model 4), the explained variance in work functioning increased from 20% to 25% (Table 3).

A crude effect on work functioning was found for all of the three nighttime sleep quality subscales. Multivariate analyzes of the three subscales revealed that perceived sleep quality (B: −5.28; 95%CI = −7.48; −3.08; $p \leq 0.001$) was more strongly associated with work functioning (Model 3, Supplementary Table S1) than sleep efficiency and daily disturbances (Model 3, Supplementary Tables S2 and S3). The associations between sleep efficiency (B: −3.31; 95%CI = −6.35; −0.27; $p \leq 0.05$), daily disturbances (B: −6.45; 95%CI = −10.92; −1.99; $p \leq 0.01$) and work functioning (Model 3, Supplementary Tables S2 and S3) were no longer significant when anxiety was added to the model (Model 4, Supplementary Tables S2 and S3). The explained amount of total variance in work functioning varied from 22% for models with sleep efficiency and daily disturbances included to 27% for the model with sleep efficiency included.

Associations between OSA severity, sleep-related problems, anxiety, and work functioning by subscale

A crude effect on work functioning subscales was found for all variables, except for age, type of occupation, and daytime sleepiness. OSA severity was associated with physical demands only. Overall nighttime sleep quality and anxiety were significantly associated with all work functioning subscales. Multivariate analyzes showed that nighttime sleep quality and anxiety were significantly associated with the work scheduling-output demands and physical demands in the final models (with an explained total variance of 26% for work scheduling and output demands, and 16% for physical demands) (Supplementary Table S4).

Moderation analyzes

To test the moderation effects, the interaction terms between anxiety and overall nighttime sleep quality were added into the equation (Model 5). The interaction of overall nighttime sleep quality and anxiety was statistically significant (B: 0.12; 95%CI =0.03; 0.22; $p \leq 0.05$) (Table 3). Anxiety moderated the association between low and medium nighttime sleep quality problems and work functioning. The impact of anxiety on the association between nighttime sleep quality and work functioning was negligible in the case of high nighttime sleep quality problems (Figure 1).

Separate analyzes of the three nighttime sleep quality subscales showed that the interactions of perceived sleep quality (B: 0.18; 95%CI =0.10; 0.35; $p \leq 0.05$) and daily disturbances (B: 0.56; 95%CI =0.22; 0.90; $p \leq 0.01$) with anxiety were statistically significant (Model 5, Supplementary Tables S1 and S3). The interaction of sleep efficiency and anxiety was not significant (B: 0.09; 95%CI = −0.14; 0.32 $p = 0.45$) (Model 5, Supplementary Table S2). The moderating effect of anxiety in the association between perceived sleep quality, daily disturbances, and work functioning was especially profound in the case of low and medium perceived sleep quality problems and low and medium levels of daily disturbances (Figures 2 and 3).

Discussion

The aims of this study were (1) to examine whether OSA severity, sleep-related problems, and anxiety are associated with work functioning in OSA patients, when controlled for age, gender, and type of occupation, and (2) to investigate whether anxiety moderates the associations between sleep-related problems and work functioning. Our results provided suggestive evidence that poor nighttime sleep quality and increased anxiety were associated with impaired work functioning. Further, the moderating effect of anxiety on the association between nighttime sleep quality and work functioning was especially profound in patients with better sleep quality, while the effect of anxiety on the association between work functioning and nighttime sleep quality was negligible in the case of high nighttime sleep quality problems.

Separate analyzes of the three nighttime sleep quality subscales showed that perceived sleep quality was more strongly associated with work functioning than sleep efficiency and daily disturbances. The associations between sleep efficiency, daily disturbances and work functioning were weak and no longer significant when anxiety was added to the models. Additionally, the moderating effect of anxiety on the association between perceived sleep quality, daily disturbances, and work functioning was especially present in OSA patients with better-perceived sleep quality and a lower level of daily disturbances. No moderating role of anxiety in the association between sleep efficiency and work functioning was found.

We found a weak association between OSA severity and impaired work functioning; only significant in crude analyzes. In the study by Mulgrew et al. [12], patients with the lowest apnea–-hypopnea index (AHI) scores exhibited an even more significant level of work limitation, and this association was dependent on the type of occupation and particular subscale of the Work Limitation Questionnaire. In contrast, no association between the type of occupation and work functioning for the total scale, not even for subscales was found in our study. An explanation for the lack of clear association between OSA severity and work functioning could be the use of polysomnography (PSG) to determine the diagnosis of OSA. Although a one-night PSG is sufficient for a diagnosis of OSA [45,46], current techniques to measure OSA are a matter of some controversy; i.e., PSG-based AHI has been

Table 3. Multiple linear regression analysis: associations of OSA severity, nighttime sleep quality, daytime sleepiness, and anxiety with work functioning.

	Work functioning (WRFQ)					
	Crude B (95%CI)	Model 1 B (95%CI)	Model 2 B (95%CI)	Model 3 B (95%CI)	Model 4 B (95%CI)	Model 5 B (95%CI)
Age	−0.22 (−0.79; 0.36)	−0.06 (−0.62; 0.51)	−0.01 (−0.56; 0.58)	−0.02 (−0.55; 0.50)	−0.14 (−0.66; 0.39)	−0.17 (−0.68; 0.34)
Gender	**14.70 (2.56; 26.84)***	**16.11 (3.67; 28.59)***	**14.41 (1.76; 27.05)***	9.83 (−2.03; 21.60)	7.20 (−4.54; 18.85)	3.82 (−7.87; 15.44)
Occupation	−4.03 (−15.40; 7.34)					
OSA severity	**−0.27 (−0.53; −0.01)***	–	−0.18 (−0.45; 0.08)	−0.08 (−0.33; 0.17)	−0.08 (−0.32; 0.16)	−0.08 (−0.32; 0.15)
Night-time sleep quality	**−2.95 (−4.12; −1.79)*****	–	–	**−2.63 (−3.85; −1.42)*****	**−1.64 (−3.07; −0.23)***	**−6.10 (−9.80; −2.40)****
Daytime sleepiness	−0.61 (−1.70; 0.48)	–	–	–	–	–
Anxiety	**−1.02 (−1.40; −0.63)*****	–	–	–	**−0.61 (−1.10; −0.15)****	**−1.93 (−3.05; −0.81)****
Nighttime sleep quality × Anxiety	**−0.05 (−0.07; −0.03)*****	–	–	–	–	0.12 (0.03; 0.22)*
F Change	–	**3.55**	**1.88**	**18.45*****	**6.25***	**6.61***
Adjusted R^2	–	**0.05**	**0.06**	**0.20**	**0.25**	**0.29**

Crude effects: effect of each variable separately on work functioning; Model 1: effect of age and gender on work functioning; Model 2: effect of age, gender, and OSA severity on work functioning; Model 3: effect of age, gender, OSA severity, and nighttime-sleep quality on work functioning; Model 4: effect of age, gender, OSA severity, nighttime-sleep quality, and anxiety on work functioning; Model 5: interaction between nighttime sleep quality and anxiety; B: unstandardized regression coefficient; CI: confidence interval; Gender: male gender was set as the reference; Blue-white collar: white collar was set as the reference; OSA: Obstructive Sleep Apnoea; F Change: significance of prediction improvement in the model fit; Adjusted R^2: explained variance adjusted for the number of predictors in the model.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

discussed as being inadequate to detect OSA severity [47,48]. Moreover, the presence of OSA in our study, diagnosed primarily based on AHI values following Macey et al. [49], was associated with abnormally high levels of anxious symptoms and poor sleep quality. Our findings confirm the suggestion of Macey et al. [49] that mechanisms other than the AHI may contribute to adverse health effects in OSA patients.

Our study revealed an association between poor nighttime sleep quality and impaired work functioning, whereas daytime sleepiness was not related to work functioning. Contrary to this finding, previous studies in patients referred for OSA described an association between excessive sleepiness (measured by ESS) and work limitation [12,18,19]. There are a variety of potential explanations for the lack of clear association between daytime sleepiness and work functioning. The study of Ulfberg et al. [18] did not use PSG to diagnose OSA, and measures of work limitation and daytime sleepiness were combined into a single questionnaire, making interpretation difficult. Similarly, Grunstein et al. [19] did not use validated measures of work role performance. Furthermore, the concepts used by Ulfberg et al. [18] and Omachi et al. [14], such as recent work disability and longer-term work duty modification, do not fully capture the scope or nature of subjective work functioning impairment measured in our study. Another possible explanation for these discrepancies could be that daytime sleepiness, measured by ESS, is assessed predominantly in a setting of decreased activity level (e.g., watching TV, sitting, reading etc.) compared with the higher mental or physical activity level usually expected in the working environment. The lack of association between daytime sleepiness and work functioning can be explained based on the hypothesized pathophysiology of insomnia; i.e., the symptoms of poor sleep quality and anxiety might be linked to each other by some form of underlying "hyperarousal" [50]. Anxiety in OSA patients may develop into a chronic state of hypervigilance [8], which refers to the predisposition to be on high alert much more than is considered normal. This arousal ultimately leads to a state of chronic anxiety and eventually sleeplessness. All these cases epitomize the related phenomenon of an anxiety process that may obliterate natural sleepiness [8,50]. In line with the delineated hyperarousal theory, we found that anxiety was more strongly associated with poor overall nighttime sleep quality and its three separate factors than with daytime sleepiness.

The fact that the association between nighttime sleep quality and work functioning was greatly attenuated after anxiety was added to the model is not surprising. Sleep disturbances are closely related to anxiety symptoms, as sleep disturbances are both a precursor and a symptom of anxiety [51]. Moreover, we found a moderating effect of anxiety on the association between low and medium nighttime sleep quality problems and work functioning. Based on our results, it can be hypothesized that work functioning in OSA patients may be impacted by anxiety more significantly than by poor nighttime sleep quality. However, the moderating role of anxiety in the association between work functioning and sleep quality was weakened in patients with the highest levels of sleep quality problems. Thus, high nighttime sleep quality problems may become more significant in the association with poor work functioning than anxiety, while the moderating effect of anxiety on work functioning was especially profound in patients with better sleep quality. In line with the evidence that poor perceived sleep quality is more predictive of negative affectivity and impaired physical health than sleep efficiency, i.e., sleep quantity [52], we found that perceived sleep quality was more strongly associated with work functioning than sleep efficiency and daily disturbances. The association between sleep efficiency

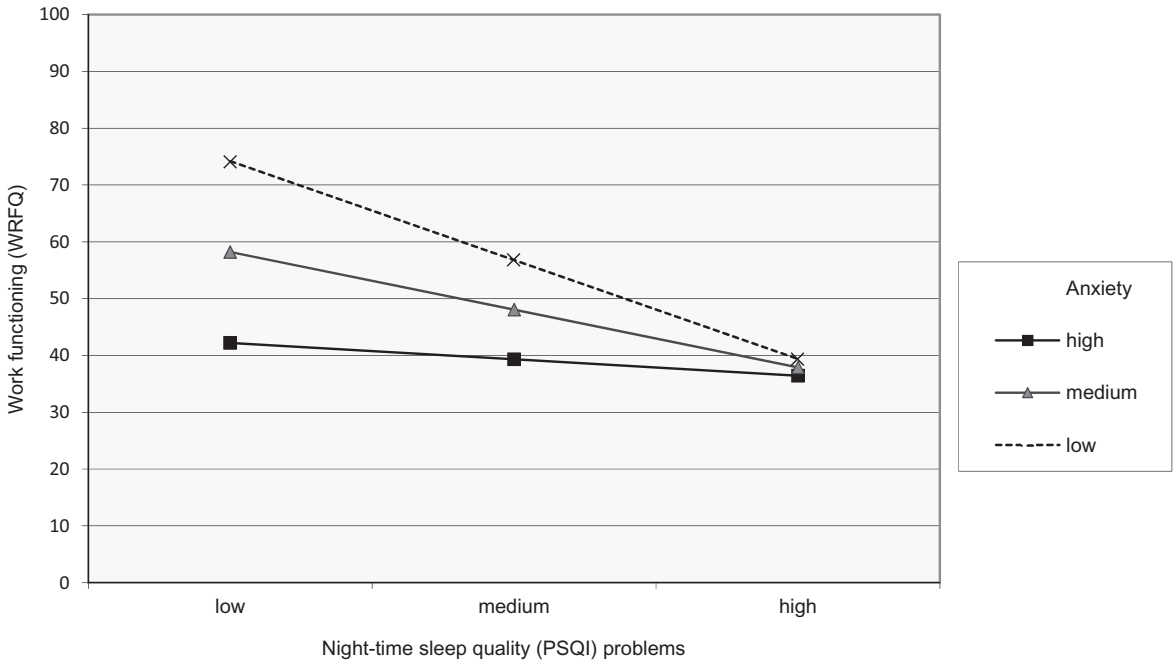

Figure 1. Anxiety as a moderator of the association between nighttime sleep quality and work functioning. PSQI: Pittsburgh Sleep Quality Index; BAI – Beck Anxiety Inventory; WRFQ: Work Role Functioning Questionnaire; Higher WRFQ scores indicated better work functioning.

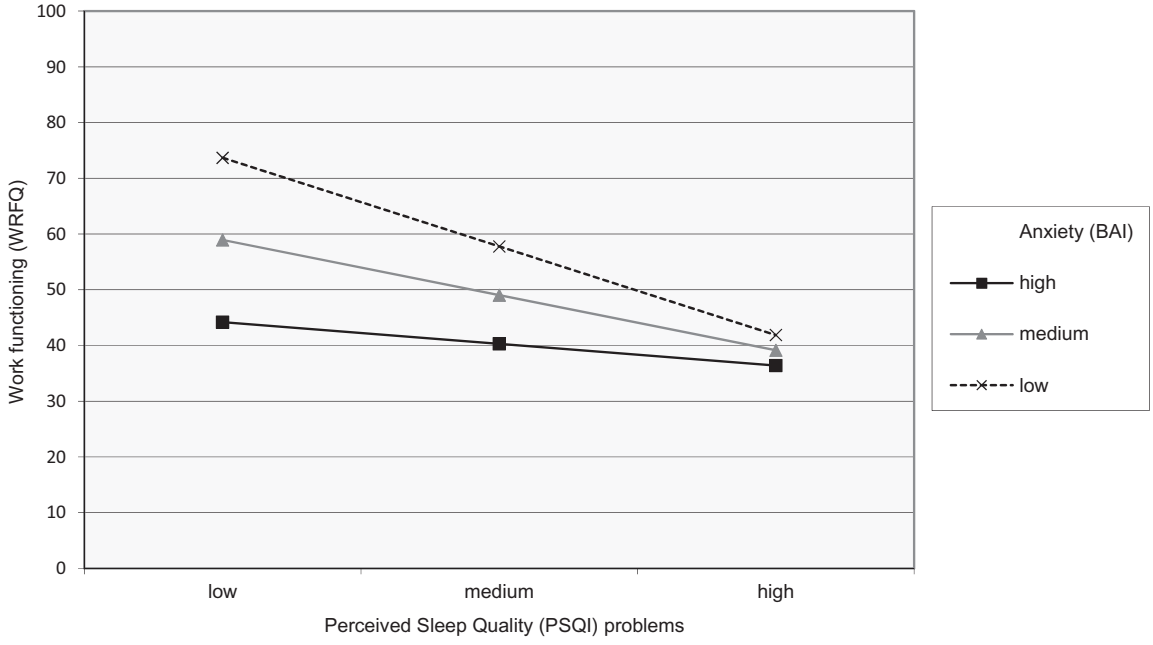

Figure 2. Anxiety as a moderator of the association between perceived sleep quality and work functioning. PSQI: Pittsburgh Sleep Quality Index; BAI – Beck Anxiety Inventory; WRFQ: Work Role Functioning Questionnaire; Higher WRFQ scores indicated better work functioning.

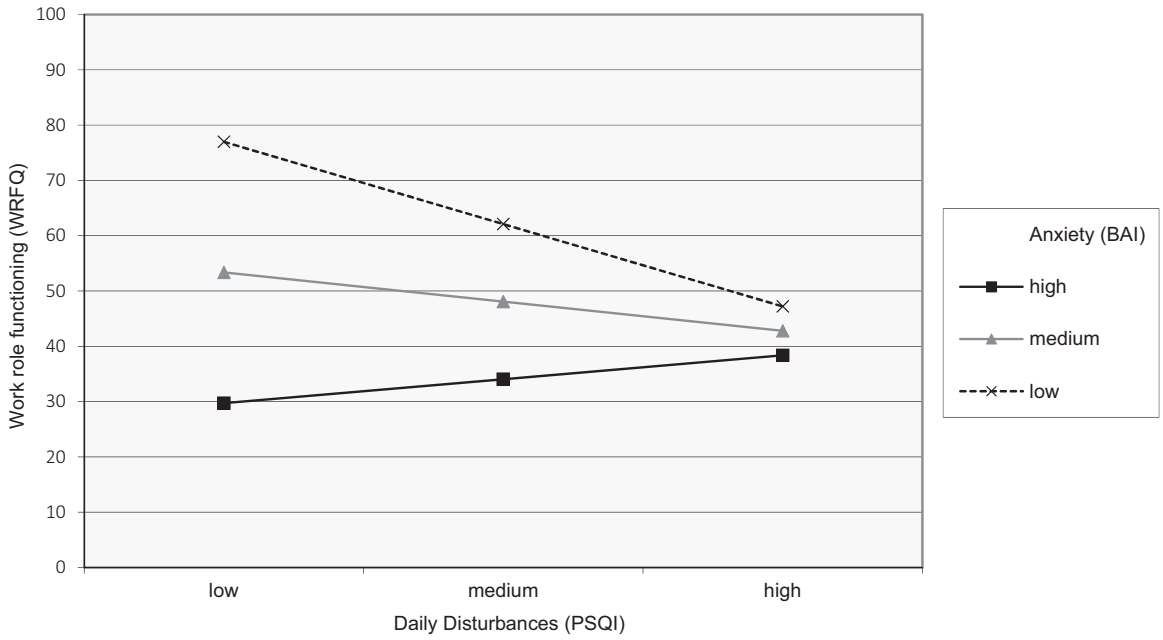

Figure 3. Anxiety as a moderator of the association between daily disturbances and work functioning. PSQI: Pittsburgh Sleep Quality Index; BAI – Beck Anxiety Inventory; WRFQ: Work Role Functioning Questionnaire; Higher WRFQ scores indicated better work functioning.

and work functioning was only weak and no longer significant when anxiety was added to the model.

Regarding the role of sociodemographic variables, we identified a higher impairment of work functioning in male when compared with female OSA patients. In contrast to our study, general functional status was found to be more impaired in female OSA patients when compared with males in some previous studies [53–55]. A potential explanation for these discrepancies can be that men more often than women work in jobs that are incompatible with increased sleep-related symptoms. Hence, male OSA patients may more often than females face demands in their jobs that cannot be dealt with when sleep-related problems are above a certain level [56]. Furthermore, in our sample, 70% of OSA patients were men; thus, our results may be less generalizable to the female population of OSA patients.

Although, it may be assumed that some OSA symptoms, such as sleep-related problems, may be more difficult to overcome due to the sedentary nature of work in the group of white-collar OSA patients, we found no significant difference regarding work functioning impairment in blue- and white-collar workers. However, the fact that white-collar workers, in particular, may have modified and more flexible work options or benefits enabling those with more severe OSA symptoms to continue to work without a significant impairment should be considered [12].

Strengths and limitations

The strengths of this study are that we shed light on several novel aspects of work functioning among OSA patients. Patients in our study were diagnosed using PSG, which is an asset of the study. To the best of our knowledge, this is the first time that the PSQI factor structure has been used in a sample of OSA patients. It is also the first study using the Work Role Functioning Questionnaire in an OSA population. Some limitations should also be noted. Due to the cross-sectional design of the study, causal inferences cannot be made. Next, work functioning has not been objectively evaluated. Nevertheless, the used instrument has been found to be appropriate to measure health-related work functioning in the occupational health care practice or in the rehabilitation process of disabled workers [57]. We can also assume that anxiety symptoms assessed in our study may be associated with panic disorder, rather than with anxiety in general. Although the Beck Anxiety Inventory (BAI) may be used as an indicator of anxiety in primary care patients with different anxiety disorders [58], it has been disputed for its focus on psychophysiological symptoms linked to panic disorder [59,60], such as a racing heart or dizziness [61]. The associations identified in our study may also occur due to latent mental health problems or somatic disease; i.e., sleep disturbances have also been identified to be both a precursor and a consequence of depression [62]. Nevertheless, the measure of anxiety used in our study was found to be suitable to distinguish an overlap between anxiety and depressive symptoms [41]. Furthermore, considering that patients with any major somatic or mental health comorbidity in the medical record were excluded from our study, this bias is rather unlikely. Previous study showed that OSA patients had difficulties to complete the work tasks and they subjectively felt a lack of trust from coworkers, which consequently caused subsequent embarrassment related to this [63]. Thus, it should be considered that increased anxiety may also be work (e.g., working environment, cutting down jobs) and not only OSA-related.

Implications for practice and future research

This study shows that poor nighttime sleep quality and anxiety were strongly associated with impaired work functioning in OSA patients. In many chronic diseases, the costs associated with presenteeism may greatly exceed the combined costs of absenteeism and medical treatment [64]. Thus, employee assessment of their work functioning may be an important proxy for the economic burden of OSA [12]. Although patients with any major somatic or mental health comorbidity in the medical record were excluded, we found that 80% of OSA patients experienced increased symptoms of anxiety, which varied from mild (30%) to severe (17%).

Thus, the study suggests that early detection and treatment of OSA and anxiety should be one of the priorities on the stakeholders' agenda. Furthermore, identifying patients with overlapping diagnoses of mental health problems and OSA in clinical care may help to improve their treatment outcomes through careful dosing of pharmacotherapy and use of continuous positive airway pressure treatment [65]. Compared with sleep efficiency, perceived sleep quality was more strongly associated with work functioning. These results indicate that health care professionals, in their efforts to understand the role of sleep in the daily life of patients with OSA, should rather focus on sleep quality than on sleep quantity. In clinical and research settings, these qualitative aspects of sleep may be captured by clinical interviews and specific patient-reported outcomes. There is a need for workplace strategies that encourage behaviors and practices that may be helpful in reducing OSA-related symptoms and improve work functioning in OSA patients. Employers can play a role in educating employees about effective management of sleep loss through a variety of proven strategies, including better-managed work demands, regular exercise, duty hour considerations, and instructing them on the basics of sleep hygiene [66]. Some recent evidence shows that workplace flexibility (allowing more flexible work start and end times) may contribute to positive health-related behaviors and may play an important role in effective workplace health promotion programs [67]. Previous studies have also shown that enabling "unwinding" time between work and home may improve sleep patterns; as reduced work-to-home interference has the potential to decrease the risk of poor nighttime sleep quality [68].

As boundaries between work and private life become more blurry, there is a real need to examine the associations between work habits, sleep, and other related aspects, especially in common diseases such as OSA. Further research should identify risk groups of patients with impaired work functioning and increased anxiety levels and tailor the counseling and interventions suitable for these patients. Although PSG is considered to be a gold standard for making a diagnosis of OSA, it is not easily applicable in large population-based studies due to its intrusiveness and high costs [13]. Therefore, screening instruments based on self-reported symptoms of OSA have been important in order to gain information on the prevalence, comorbid conditions of OSA or continuous positive airway pressure treatment effectiveness, which would be difficult to obtain without using scale surveys [13]. As BAI does not assess other symptoms of anxiety, such cognitive aspects, further research may be accompanied by additional anxiety measures to distinguish between panic symptoms and other anxiety disorders (e.g., generalized anxiety disorder). Moreover, the possibility that anxiety may mask a certain amount of daytime sleepiness in OSA patients [8] should be examined in the future studies. Further prospective, longitudinal research is needed to elucidate the pathways from OSA, sleep-related problems and anxiety to impaired work functioning. As perceived sleep quality and sleep efficiency are influenced by a range of factors related to age or health [69], there is a need for further studies examining the factor structure of the PSQI in OSA patients. Finally, we studied OSA patients without major comorbidities, as these are assumed to influence sleep and effective OSA symptoms [49]. As a group with minimal comorbidities and recent diagnosis is not fully representative of the general OSA population, it may be assumed that work functioning and other health-related outcomes would be even more significantly impaired in a sample of OSA patients with comorbid diseases [49].

Conclusion

Poor sleep quality and anxiety were significantly associated with impaired work functioning in OSA patients. We also found that perceived sleep quality was more strongly associated with work functioning than sleep efficiency; i.e., sleep quantity. Further, the moderating effect of anxiety on work functioning was especially strong in patients with better sleep quality. The role of anxiety in the association between sleep quality and work functioning was weakened in the case of poor nighttime sleep quality. Impaired work functioning in OSA patients may represent a possible cause of disability, which may be improved by workplace strategies focused on decreasing poor sleep quality and anxiety when confirmed in longitudinal studies. As many people with OSA are undiagnosed, our results demonstrate to employers and healthcare professionals the need to encourage patients for OSA screening, especially in the situation of impaired work functioning, increased anxiety and poor sleep quality.

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Disclosure statement

The authors report no conflicts of interest.

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