

## The Impact of Obstructive Sleep Apnea and Daytime Sleepiness on Work Performance: An Observational Cross-Sectional Study in a North African Population

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### Abstract

**Background:** Obstructive sleep apnea hypopnea syndrome (OSAHS) has been shown to be associated with many serious health conditions. The impact on occupational health is still unclear as it was scarcely studied.

**Purpose:** The aim of this study was to assess the association of work performance with OSAHS and daytime sleepiness.

**Methods:** A cross-transversal study was conducted including Tunisian active adult subjects referred for suspected sleep disordered breathing. All subjects completed the Epworth Sleepiness Scale (ESS), the Work Productivity and Activity Impairment Questionnaire (WPAI), and the Patient Health Questionnaire 9 (PHQ9). They all underwent polygraph testing level 3.

**Result:** One hundred thirty-nine subjects completed the survey, including 107 (77%) blue-collar workers, and 32 (23%) white-collar workers. Participants were classified as following: 50 patients with apnea hypopnea index (AHI)  $\geq 30$  and 89 with AHI  $<30$ . Among the four outcomes of the WPAI scale, only presenteeism was associated with AHI ( $p=0.012$ ). A significant association has been found between daytime sleepiness and three outcomes of WPAI. Sleepy patients with ESS  $\geq 11$  had lower work performance in terms of presenteeism ( $42.46 \pm 28.40$  vs.  $24.71 \pm 24.77$   $p=0.0001$ ), absenteeism ( $12.26 \pm 25.51$  vs.  $6.05 \pm 18.32$ ,  $p=0.101$ ), overall work productivity loss ( $47.43 \pm 31.65$  vs.  $26.58 \pm 28.47$ ,  $p=0.0001$ ), and decline in activity ( $46.67 \pm 30.75$  vs.  $32.14 \pm 27.02$ ,  $p=0.004$ ) in comparison with non-sleepy participants. A strong correlation of presenteeism and overall work productivity loss scores with ESS was demonstrated among white-collar workers ( $r=0.624$ ,  $p=0.0001$ ;  $r=0.602$ ,  $p=0.0001$  respectively). PHQ9 score was significantly higher in sleepy subjects ( $p=0.0001$ ). Near miss accidents in the workplace and work related accidents were significantly more frequent in those with ESS  $\geq 11$  ( $p=0.012$ ,  $p=0.026$ ; respectively).

**Conclusion:** The most relevant finding of this study was the involvement of daytime sleepiness in performance impairment, while the impact of AHI was less clear.

**Keywords:** Sleep apnea syndromes; Work performance; Depression

### Introduction

Obstructive sleep apnea hypopnea syndrome (OSAHS) is a common disease with reported rates of 3-7% in middle age population [1]. It's characterized by repetitive partial or complete collapse of the airway during sleep, resulting in apnea or hypopnea. These episodes cause intermittent hypoxia, repetitive arousal from sleep, which leads to increased sympathetic activity, increased respiratory effort, and sleep fragmentation. Untreated OSAHS is incriminated in increased risk of several co-morbidities including cardiovascular diseases, and metabolic syndrome. Disrupted sleep can also result in tiredness, lack of energy, and a feeling of weakness during the day. Severe forms of the

disease are often associated with excessive daytime sleepiness and micro-sleep episodes. Furthermore, persons with OSAHS may experience decreased quality of life, significant cognitive limitations and mood disorders such as anxiety, irritability, and depression.

Because of these adverse mood changes and neurocognitive dysfunction, it has been suggested that OSAHS may be detrimental to work performance, and associated with greater risk of workplace accidents. However, this hypothesis has been little explored, and even less so among North African population and no solid conclusion could be drawn due to disputed results.

Considering the above findings and rationale, we designed an observational cross-sectional study in order to gain a greater understanding in how OSAHS and daytime sleepiness affect work

productivity and workplace accidents in a sample of subjects referred for suspected sleep-disorders.

## Material and Methods

### Participants

The study was performed during the period of July 2015 to April 2017 on a subset of participants referred to the department of respiratory and sleeps medicine of Hedi Chaker University Hospital in Sfax, Tunisia for suspected sleep-disorders. Only subjects between the age of 18 and 60 years, and actively employed for at least 6 months were included in the study. The exclusion criteria were: another sleep disorder, previous treatment for sleep apnea, medications that could affect sleep and/or vigilance, serious medical conditions, overt psychiatric disorders including alcohol or other drug addiction, and pregnancy. The study was approved by the institutional Human research ethics committee, and consent was obtained from all participants.

### Instruments

**Self-administrated questionnaires:** Consenting participants were given extensive questionnaire regarding their socio-demographics, habits, medical history, and working conditions such as work schedule, shift work, number of worked hours and the kind of work they had over the last 24 months. The following groupings were classified as white-collar workers: clerks, technicians and associate professionals, highly skilled professionals, directors and managers. Otherwise, unskilled workers, production-line/machine workers and drivers, skilled manual workers, farm/horticulture workers, service workers and retailers were classified as blue-collar workers [2]. The survey also included questions aimed at evaluating the number of work-related accidents, the number of sick leave more than 30 days over the last year, as well as somatic symptoms of stress such as epigastralgia, chest tightness, dyspnea and muscle tension.

Elsewhere, participants completed the Work Productivity and Activity Impairment (WPAI) questionnaire, in order measure impairments in work and activities. Daytime sleepiness was assessed by Epworth Sleepiness Scale (ESS), while Patient Health Questionnaire (PHQ9) was used to screen for the presence and severity of depression according to DSM-IV criteria.

**Work productivity and activity impairment (WPAI) questionnaire:** The WPAI [3] is a validated instrument that consists of six questions: Q1=currentlly employed; Q2=hours missed due to health problems; Q3=hours missed due to other reasons; Q4=hours actually worked; Q5=degree health affected productivity while working; and Q6=degree health affected regular activities. According to the questionnaire responses, scores are generated for four main outcomes including absenteeism (work time missed), presenteeism (impaired productivity at work), and overall work productivity loss (absenteeism +presenteeism) in the past 7 days. Impairment in performing daily (non-work) activities, such as work around the house, shopping, child care, exercising, etc. is also assessed.

The different outcomes are expressed as percentage score, with higher scores indicating greater impairment. They are generated as the following:

1. Absenteeism =  $Q2/(Q2+Q4)$  for those who were currently employed;

2. Presenteeism =  $Q5/10$ ;

3. Percent overall work loss due to health=  $Q2/(Q2+Q4)+[(1-Q2/(Q2+Q4)) \times Q5/10]$  for those who were currently employed;

4. Percent activity impairment due to health=  $Q6/10$  for all respondents. For those who missed work and did not actually work in the past seven days, the percent overall work impairment due to health is equal to the percent work time missed due to health.

**Patient health questionnaire (PHQ9):** The PHQ-9 is a validated self-administered tool used in primary care to screen patients for depression and to estimate symptoms severity. By assessing patient's mood over the last 2 weeks, the questionnaire allows scoring each of the 9 DSM-IV criteria for Major Depressive Disorder as '0' (not at all) to '3' (nearly every day). As a severity measure, the PHQ-9 score can range from 0 to 27. PHQ-9 scores of 5, 10, 15, and 20 represented mild, moderate, moderately severe, and severe depression, respectively [4].

**Epworth sleepiness scale (ESS):** Daytime sleepiness was estimated using the Arabic version of the ESS (AESS) [5]. It's an eight self-completed questionnaire assessing the probability of falling asleep in various daytime situations, for a total score ranging from 0 to 24. Depending on their ESS score ( $ESS < 11$ ,  $ESS \geq 11$ ), subjects were divided into two groups of subjective sleepiness severity. Those with an ESS score  $\geq 11$  were considered to have significant daytime sleepiness.

The AESS was created according to the recommendations of the ISPOR Task Force for Translation and Cultural Adaptation with bilingual individuals. It had shown a high internal consistency (Cronbach's alpha 0.76, intra-class correlation coefficient of 0.85 (IC95%: 0.76–0.92), thus it's considered valid instrument for the evaluation of daytime sleepiness in Arabic speaking populations [5].

**Nocturnal polygraph recording:** Nocturnal polygraph recording was performed for all patients using type III polysomnography (PSG) (EmblaTM N7000, ResMed Corp., San Diego, CA, United States) according to standard techniques. Airflow was monitored by an oronasal air pressure transducer (EmblaTM N7000, ResMed Corp., San Diego, CA, United States), thoracic and abdominal respiratory effort and body position by uncalibrated impedance plethysmography belts (EmblaTM N7000, ResMed Corp., San Diego, CA, United States), and arterial oxygen saturation ( $SpO_2$ ) by digital pulse oximetry. Snoring was recorded by a microphone (EmblaTM N7000, ResMed Corp., San Diego, CA, United States) placed on the anterior neck. Prior to sleep study, patients were recommended to avoid caffeinated drinks and foods, alcohol, and drugs that could interfere with sleep architecture.

Scoring respiratory events was performed manually by one doctor according to the standard criteria of the American Academy of Sleep Medicine (AASM) published in 2012 [6]. Obstructive apnea was defined as a 90% decrease in airflow relative to the basal amplitude persisting for at least 10 seconds in the presence of thoracic and abdominal movements. Hypopnea was defined as a 30% decrease in the airflow amplitude relative to the baseline persisting for at least 10 seconds, with an associated 3% oxygen desaturation. Patients having an apnea hypopnea index (AHI)  $< 5$ /hour without any evocative symptoms apart from snoring were classified as controls, while patients with an AHI of 5 or greater and clinical symptoms were considered positive for OSAHS [7].

According to the AHI, subjects were classified into groups. One group included subjects with severe OAHs ( $AHI \geq 30$ ), while a second included subjects without OAHs ( $< 5$  events per hour), mild OAHs ( $5 \leq AHI < 15$ ), and moderate OAHs ( $15 \leq AHI < 30$ ).

Groups							
	Type of work		AHI		ESS		Total n=139
	Blue collar (n=107)	White collar (n=32)	<30 (n=89)	≥ 30 (n=50)	<11 (n=70)	≥ 11 (n=69)	
<b>Age, years</b>	48.4 ± 10.2	45.19 ± 10,7	47.43 ± 11.003	48.1 ± 9.2	47.8 ± 10.6	47.5 ± 10.2	47.6± 10.4
<b>Sex-ratio</b>	2.57*	0.88*	1.28**	5.25**	2.33	1.65	1.96
<b>BMI (Kg/m<sup>2</sup>)</b>	33 ± 5.83	35.23 ± 6.97	32.41 ± 6.44**	35.46 ± 5.1**	32.05±4.99**	34.99 ± 6.87**	33.51 ± 6.16
<b>Education, n (%)</b>							
No studies	7(6.5)	0(0)	6(6.7)	1(2)	4(5.4)	3(4.3)	7(5)
Primary	48(44.9)***	1(3.1)***	34(38.2)	24(34.3)	24(34.3)	25(36.2)	49(35.3)
Secondary	39(36.4)	10(31.3)	29(32.6)	20(40)	23(32.9)	26(37.7)	49(35.3)
Technical training	0(0)***	16 (50)***	9(10.1)	7(14)	13(18.6)	3(4.3)	16(11.5)
University studies	13(12.1)	5(15.6)	11(12.4)	7(14)	6(8.6)	12(17.4)	18(12.9)
<b>Working schedule, n (%)</b>							
Full time	79(73.8)	29(90.6)	72(80.9)	36(72)	56(80)	52(75.4)	108(77.7)
Nocturnal work	7(6.5)	1(3.1)	4(4.5)	4(8)	3(4.3)	5(7.2)	8(5.8)
Shift work	21(19.6)	2(6.3)	13(14.6)	10(20)	11(15.7)	12(17.4)	23(16.5)
<b>Habits, n (%)</b>							
Smoking	36(81.8)	8(18.2)	26(59.1)	18(40.9)	25(56.8)	19(43.2)	44(31.7)
Alcoholism	36(91.3)	1(7.7)	5(38.5)	8(61.5)	7(53.8)	6(46.2)	13(9.4)
<b>Comobidities</b>							
Hypertension	37(72.5)	14(27.5)	29(56.9)	22(43.1)	25(49)	26(51)	51(36.7)
Diabeties	23(85.2)	4(14.8)	19(70.4)	8(29.6)	13(48.1)	14(51.9)	27(19.4)
Dyslipidemia	26(70.3)	11(29.7)	23(62.2)	14(37.8)	21(56.8)	16(43.2)	37(26.6)
Cardiovascular disease	25(86.2)	4(13.8)	20(69)	20(31)	16(55.2)	13(44.8)	29(20.9)
Lung disease	33(84.6)	6(15.4)	27(69.2)	12(30.8)	15(38.5)	24(61.5)	39(28.1)
Endocrine disease	6(46.2)*	7(53.8)*	9(69.2)	4(30.8)	5(38.5)	8(61.5)	13(9.4)
Neurological disease	5 (71.4)	2 (28.6)	6 (85.7)	1 (14.3)	4 (57.1)	3 (42.9)	7 (5)
<b>ESS</b>	11.34 ± 6.25	9.59 ± 5.76	10.57 ± 5.90	11.58 ± 6.61	<11	≥ 11	10.94 ± 6.16
<b>Polygraphy</b>							
AHI (events/hour)	24.86 ± 24.98	26.16 ± 25.46	<30	≥ 30	21.68 ± 18.53	28.67 ± 29.93	25.15 ± 25.01
ODI (events/hour)	23.29 ± 24.68	21.68 ± 24.71	9.17 ± 8.51***	47.38 ± 24.93***	18.24 ± 15.73*	27.66 ± 30.53*	22.92 ± 24.61
Mean SpO <sub>2</sub> (%)	93.08 ± 2.96	92.98 ± 5.67	94.02 ± 2.19***	91.33 ± 5.10***	93.82 ± 2.23*	92.28 ± 4.70*	93.05 ± 3.74
T90% (%)	11.26 ± 19.74	10.29 ± 23.62	5.51 ± 14.18***	20.88 ± 26.1***	8.59 ± 17.34	13.51 ± 23.34	11.03 ± 20.61
<b>AHI:</b> Apnea-hypopnea index. <b>ESS:</b> Epworth sleepiness scale. <b>BMI:</b> Body mass index. <b>ODI:</b> Oxygen desaturation index. <b>SpO<sub>2</sub>:</b> Arterial oxygen saturation. <b>T90%:</b> Total sleep time with arterial oxygen saturation lower than 90%. * 0.01 ≤ p<0.05. ** 0.001 ≤ p<0.01. *** p<0.001.							

**Table 1:** Socio-demographic and clinical characteristics of study participants.

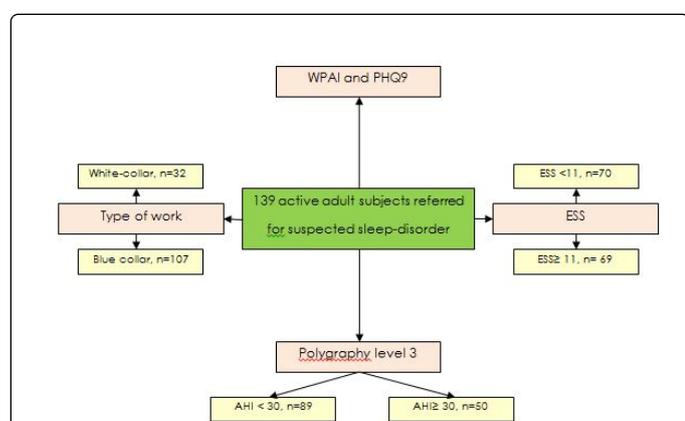
**Depression rates:** Considering the total sample, PHQ9 score was significantly higher in subjects with daytime sleepiness compared with those with normal ESS ( $p=0.0001$ ). The observed difference between

the two groups was significant whatever the AHI was  $<30$  or  $\geq 30$  (Table 2). In contrast, no significant difference was found in PHQ9 score according to AHI, T90%, and IDO.

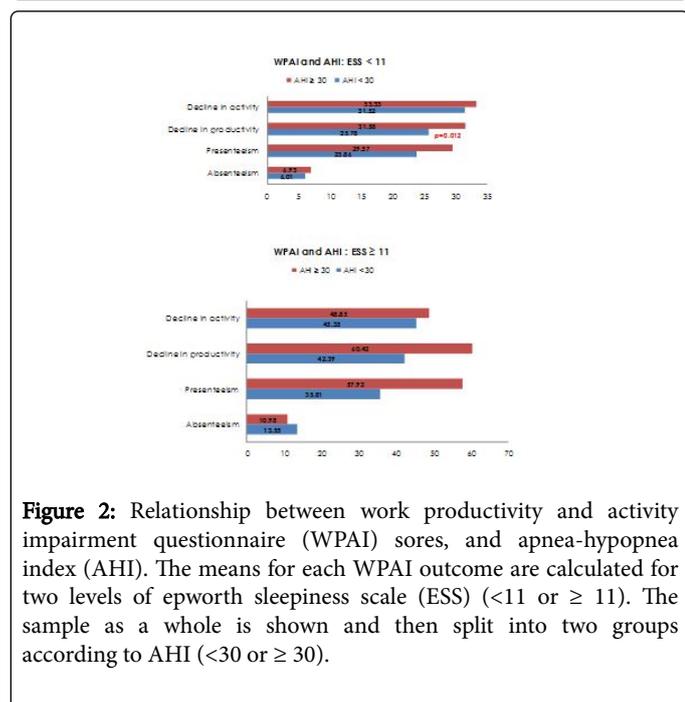
Variables				Groups					
IAH	$<30$ (n=89)		$\geq 30$ (n=50)		Total (n=139)				
ESS	$<11$	$\geq 11$	p	$<11$	$\geq 11$	p	$<11$	$\geq 11$	p
PHQ9	6.56 $\pm$ 5.85	11.72 $\pm$ 4.69	3-Oct	6.46 $\pm$ 4.04	12.38 $\pm$ 5.52	3-Oct	6.46 $\pm$ 4.4	12.38 $\pm$ 5.52	3-Oct

PHQ9: Patient health questionnaire. ESS: Epworth sleepiness scale AHI: Apnea-hypopnea index.

**Table 2:** Assessment of depression severity with patient health questionnaire according to Epworth sleepiness scale.



**Figure 1:** Study schema and a priori sample quota algorithm. WPAI, work productivity and activity impairment questionnaire. AHI, apnea-hypopnea index. ESS, epworth sleepiness scale.



**Figure 2:** Relationship between work productivity and activity impairment questionnaire (WPAI) scores, and apnea-hypopnea index (AHI). The means for each WPAI outcome are calculated for two levels of epworth sleepiness scale (ESS) ( $<11$  or  $\geq 11$ ). The sample as a whole is shown and then split into two groups according to AHI ( $<30$  or  $\geq 30$ ).

**Somatic symptom of stress, and work related accidents:** Somatic symptom of stress, near miss accidents in the workplace, and work related accidents were not associated with any sleep polygraphic parameters including AHI, ODI, and T90% (Figure 1). However, near miss accidents in the workplace and work related accidents were significantly more frequent in sleepy subjects ( $ESS \geq 11$ ), as compared with  $ESS <11$  ( $p=0.012$ ,  $p=0.026$ ; respectively).

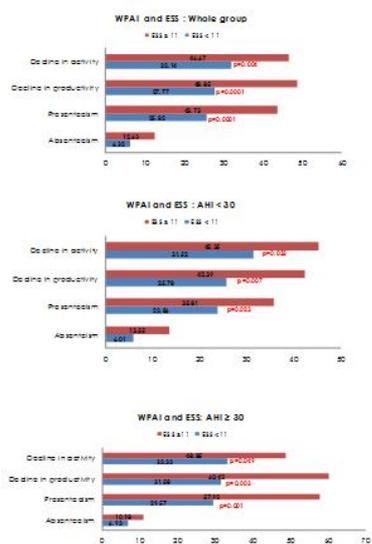
**Work productivity:** Among the four outcomes of the WPAI scale, only presenteeism was associated with AHI. Actually, patients with  $AHI \geq 30$  had a significantly higher score of presenteeism in comparison with those with  $AHI <30$  ( $41.4 \pm 28.07$  vs.  $29.1 \pm 27.12$ ;  $p=0.012$ ). However, this difference was not found when the sample was subdivided into blue-and white-collar workers (Figure 2).

Elsewhere, when most hypoxemic subjects ( $T90\% \geq 30\%$ ) were compared with the least hypoxemic subjects ( $T90\% <30\%$ ), significant higher presenteeism was observed ( $46.67 \pm 28.08$  vs.  $31.57 \pm 27.57$ ;  $p=0.032$ ).

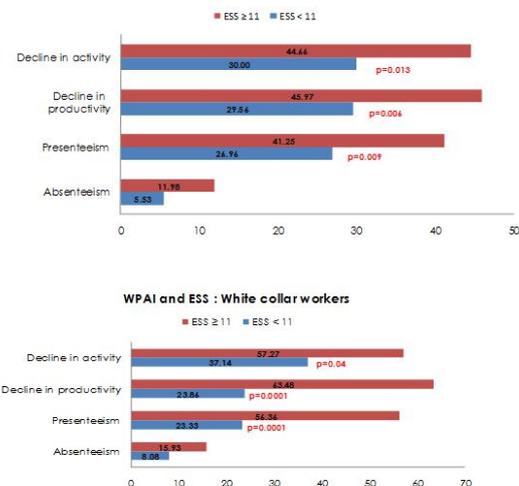
Considering subjective sleepiness, presenteeism, impairment in performing daily activities and overall work productivity loss scores were significantly higher in sleepy subjects when compared with non-sleepy ones. Absenteeism was similar in both groups. These results were observed in the sample as a whole as well as among the two AHI groups (Figure 3).

A similar pattern was observed when subjects were divided into blue and white-collar workers with significant higher scores in sleepy subjects for presenteeism, impairment in performing daily activities and overall work productivity loss, but not for absenteeism. It is interesting to observe, however, that the impact of daytime sleepiness was more marked among white-collar workers (Figure 4).

In the total sample, a weak correlation was found between presenteeism and both AHI ( $r=0.212$ ,  $p=0.012$ ) and T90% ( $r=0.222$ ,  $p=0.009$ ) (Table 3). In addition, the four outcomes of the WPAI scale were weakly correlated with PHQ9 score. Weak correlations were also detected between both presenteeism and overall work productivity loss scores and ESS. This correlation was stronger among white-collar workers ( $r=0.624$ ,  $p=0.0001$ ;  $r=0.602$ ,  $p=0.0001$  respectively). In the same group, presenteeism and overall work productivity loss scores were moderately correlated with AHI ( $r=0.395$ ,  $p=0.025$ ;  $r=0.382$ ,  $p=0.031$  respectively).



**Figure 3:** Relationship between work productivity and activity impairment questionnaire (WPAI) scores, daytime sleepiness, and apnea hyponea index. The means for each WPAI outcome are calculated for two levels of epworth sleepiness scale (ESS) (<11 or ≥ 11). The sample as a whole is shown and then split into two groups according to apnea hyponea index (AHI) (<30 or ≥ 30). Non sleepy participants with ESS <11 are compared with sleepy ones (ESS ≥ 11).



**Figure 4:** Relationship between work productivity and activity impairment questionnaire (WPAI) scores, daytime sleepiness, and type of work. The means for each WPAI outcomes are calculated for two levels of epworth sleepiness scale (ESS) (<11 or ≥ 11). The sample is split into blue and white-collar components. Non sleepy participants with ESS <11 are compared with sleepy ones (ESS ≥ 11).

Variables	Groups					
	Whole sample (n=139)		Blue collar (n=107)		White collar (n=32)	
	r	p	r	p	r	p
<b>With AHI</b>						
Presenteeism	0.212	0.012	0.165	0.09	0.395	0.025
Absenteeism	-0.027	0.754	-0.047	0.627	0.031	0.866
Decline in productivity	0.153	0.071	0.085	0.383	0.382	0.031
Decline in activity	-0.015	0.862	-0.025	0.795	0.016	0.93
<b>With T90%</b>						
Presenteeism	0.222	0.009	0.186	0.055	0.352	0.048
Absenteeism	0.043	0.613	0.111	0.254	-0.127	0.489
Decline in productivity	0.161	0.058	0.131	0.178	0.251	0.165
Decline in activity	-0.007	0.935	-0.036	0.711	0.096	0.601
<b>With PHQ9</b>						
Presenteeism	0.447	0.0001	0.404	0.0001	0.61	0.0001
Absenteeism	0.233	0.006	0.287	0.003	0.089	0.628

Decline in productivity	0.432	0.0001	0.436	0.0001	0.423	0.016
Decline in activity	0.347	0.0001	0.284	0.003	0.574	0.001
<b>With ESS</b>						
Presenteeism	0.296	0.0001	0.226	0.019	0.624	0.0001
Absenteeism	0.096	0.263	0.083	0.395	0.163	0.373
Decline in productivity	0.299	0.0001	0.222	0.022	0.602	0.0001
Decline in activity	0.189	0.026	0.15	0.124	0.421	0.016
<b>AHI:</b> Apnea-hypopnea index. <b>T90%:</b> Total sleep time with arterial oxygen saturation lower than 90%. <b>PHQ9:</b> Patient health questionnaire. <b>ESS:</b> Epworth sleepiness scale						

**Table 3:** Correlations of work productivity and activity impairment scores with apnea hypopnea index, patient health questionnaire and epworth sleepiness scale.

## Discussion

In this study, a decreased work performance (as assessed by a validated scale) was observed in patients with severe OSAHS, but also and most importantly in those with daytime sleepiness. This impact has been found to be more marked in white-color workers as compared with blue-color workers.

Despite the impact of OSAHS on occupational health has been suspected since a long time, only few studies have been performed to evaluate this relationship, showing divergent results. Jurado-Gimez B et al. [8] studied a sample of 259 Spanish individuals referred to the sleep disorders clinic for suspected OAHs. Participants were classified to OAHs group or a non-OAHs according to polysomnography results. Both groups had similar rates of work-related accidents. However, OAHs was significantly associated with higher rate of absenteeism. Psychological distress and OAHs were associated with significantly poorer work productivity as assessed on the Spanish IMPALA (impact of disease on work productivity) index. A diagnostic of OAHs was the variable with the most importance impact on the working lives of patients, while excessive daytime sleepiness and subjective quality of sleep (as assessed using Pittsburgh Sleep Quality index) was not associated with any influence.

For his part, Muglgrew et al. [9] studied a sample of 428 Canadian adults that had undergone overnight polysomnography for sleep-disordered breathing. OAHs severity defined by AHI was not associated with any dimension of work limitation questionnaire (WLQ). In contrast, subjective sleepiness as assessed by ESS was strongly associated with three of the four scales of WLQ.

Similarly in our study, work performance as assessed by WPAI was significantly affected in sleepy patients with  $ESS \geq 11$ , when compared with non-sleepy patients, while the impact of OAHs severity defined by AHI was less clear. The same conclusion was reached by Bean [10] when comparing a group including 1759 subjects with OAHs, depression, narcolepsy, multiple sclerosis, with 1977 subjects without these conditions. In both, group, excessive sleepiness was associated with highly significant impairment in work productivity for all measures, except for absenteeism.

Many other studies had also reached the same conclusion about the negative impact of daytime sleepiness on work performance [11-13] however some of these have limitations. Actually, surveys were almost

always focused on subjects referred for suspected-disordered breathing rather a community-based sample as was the case for Muglgrew et al. [9]. No objective evaluation was performed to better assess the impact of daytime sleepiness on work performance. Some authors did not perform an objective sleep study [11, 13] while others used only polygraph as their sleep study [14].

Yet, despite the above limitations, we could still deduce that daytime sleepiness as a common feature of OAHs could cause greater impairment than AHI on work performance. These findings would support the current controversy about the value of AHI as an indicator of OAHs severity. Actually, several recent studies have suggested that AHI would not be enough to predict adverse safety and health consequences of OAHs, particularly daytime fatigue and sleepiness [15]. This is consists with the results of our study that showed no association between ESS and AHI. Therefore, patients with mild to moderate disease ( $5 \leq AHI < 30$ ) may be more tired and sleepy, and consequently have lower work performance than patients with severe disease ( $AHI \geq 30$ ). This means that AHI would not be appropriate to objectively assess the impact of OAHs on work performance. Thus, a novel parameter such as the recently suggested AHI adjusted should be used to improve the recognition of OAHs patients, as well as accuracy and reliability of disease severity estimates [16].

In our study, depression score was not associated with any polygraphic parameter, but was significantly higher in patients with  $ESS \geq 11$ . This fact may contribute to impair work performance in sleepy patients. Elsewhere, Mulgrew et al. found that the impact of subjective daytime sleepiness as assessed by ESS on work performance was equal between white-color and blue-color workers [17]. As opposed to these findings, white-color workers appeared to be more marked affected in our study. This difference may be explained by the sedentarily nature of white-color work that makes sleepiness harder to fight off.

Some studies have suggested an increased risk of work-related accidents due to OAHs symptoms. However, only very few studies have assessed this relationship in patients with definitive diagnosis of OAHs. Besides, studies did not consistently find that daytime sleepiness and the severity of OAHs were correlated with crash risk [8,17]. Our results showed that Work-related accidents were associated with ESS, but not with AHI. In line with this study, Lindberg et al. [18] showed a 2-fold increase in the risk of work-related accidents in snorer and sleepy subjects when compared with subjects without those

symptoms. Jurado-Gimez B et al. [8] reported that the OAHS group and the control group had similar rates of workplace accidents.

Our study has limitations. First, the sample would not be representative of our target population as it was small in size, and was selected among subjects referred for suspected sleep disordered breathing. This may have introduced a selection bias making our results not representative enough to be extrapolated beyond our referral group. A second limitation may be related to using polygraphy, and not polysomnography, for diagnosing OAHS which may lead to an underestimation of the prevalence and the severity of the disease. Third, work performance was assessed by WPAI scale which has been validated into many languages, but neither in Arabic nor in Tunisian dialect. In addition, despite many confounders were considered when including subjects, it remains still difficult to conclude about the association of work performance with OAHS and daytime sleepiness. The contribution of other unrecognized confounders in this association could not be excluded given the cross-sectional nature of our study. Finally, there was no follow up-analysis of patients post-treatment which would be helpful to have more information about the association in question.

## Conclusion

To our knowledge, this is the first comprehensive study of the burden of OSAHS and daytime sleepiness on occupational health in a Nord African population. Our study demonstrated that daytime sleepiness may lead to low work performance in a population referred for suspected sleep-disordered breathing. This impact was more marked in white-color workers as compared with blue-color workers. In contrast, the relationship between OAHS (as defined by AHI) and work performance was less clear. These results suggest that screening for excessive daytime sleepiness should be considered as a part of occupational health assessment. It would be also interesting to define new instruments other than conventional AHI to more accurately evaluate the impact on the working lives.

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