DUDEK, Aleksandra, SADOWSKA, Aleksandra, WELKIER, Aleksandra, SOBIŃSKI, Adam, MIŚKIEWICZ, Joanna, PIETRUSIŃSKA, Patrycja, MODER, Jakub, DZIEWIERZ, Anna, KWAŚNIEWSKA, Paula, and ŚLIWA-TYTKO, Patrycja. Obstructive Sleep Apnea – Current State of Knowledge, Impact on Work and Productivity and Treatment Methods. Quality in Sport. 2025;39:59131. eISSN 2450-3118.
https://dx.doi.org/10.12775/QS.2025.39.59131
https://apcz.umk.pl/QS/article/view/59131

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 02.03.2025. Revised: 11.03.2025. Accepted: 19.03.2025. Published: 21.03.2025.

Obstructive Sleep Apnea – Current State of Knowledge, Impact on Work Productivity and Treatment Methods

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ABSTRACT

Introduction: Obstructive sleep apnea (OSA) is a condition characterized by repetitive episodes of narrowing or complete closure of the upper respiratory tract during sleep, leading to sleep disruption and lowering of blood oxygen levels. OSA is the most common sleep breathing disorder that impacts many facets of health-related quality of life and increases risk of comorbidities. At a societal level, OSA leads to a reduced productivity levels caused by impaired cognitive functions and absenteeism and an increased risk of motor vehicle accidents.

Purpose of research: This review provides a comprehensive overview on current state of knowledge regarding OSA, its impact on work economics and available treatment.

Materials and methods: A comprehensive literature review based on publicly available Google Scholar, Scopus and PubMed databases from 2010 to 2024 using the following phases: "obstructive sleep apnea", "daytime sleepiness", "absenteeism in obstructive sleep apnea", "economic costs of obstructive sleep apnea", "treatment of obstructive sleep apnea".

Results and conclusions: Obstructive sleep apnea is becoming an increasingly common disorder contributing to a number of comorbidities, as well as negatively affecting work productivity and economics. The link between OSA and motor vehicle accidents highlights the importance of screening tests for OSA, especially among the population of professional drivers. Existing treatment methods, especially CPAP treatment, help alleviate OSA symptoms as well as its negative impact on work productivity, which makes it crucial for improving quality of life of patients suffering from OSA.

Keywords: obstructive sleep apnea, excessive daytime sleepiness, epidemiology, etiology, diagnosis, absenteeism, work productivity, motor vehicle accidents, treatment.

1. Introduction

As quality sleep became recognized as the foundation of human health and wellbeing, sleep disorders and the impact they have on neurological, endocrine and metabolic functions of the body became a subject of increased interest among researchers. Among diseases affecting sleep quality obstructive sleep apnea (OSA) appears to be deserving of special attention as it is the most common of sleep breathing disorders. It is characterized by repeating apnea and hypopnea episodes during sleep resulting in increased stimulation of sympathetic nervous system and, consequently – awakenings. As a result of increased sympathetic stimulation OSA patients suffer from frequent cardiovascular comorbidities, while excessive sleepiness leads to deterioration of their cognitive functions affecting their professional life and making them more likely to be at risk of traffic accidents. These factors contribute to making OS an important issue on both individual and societal level.

2. Obstructive sleep apnea – current state of knowledge

2.2. Epidemiology and etiology of obstructive sleep apnea

Obstructive sleep apnea (OSA) is a condition characterized by repetitive episodes of narrowing or complete closure of the upper respiratory tract during sleep, co-occurring with intensification of respiratory effort. The consequence of narrowing the upper respiratory tract is hypopnea, while the consequence of their complete closure is apnea. Apneas and hypopneas cause a decrease in blood oxygenation level, which causes stimulation of the sympathetic nervous system, which in turn lead to awakening. Awakenings, most often unconscious, cause sleep fragmentation. Most apnea/hypopnea episodes last 10-30 seconds, although they can last even more than a minute. During awakenings, the throat opens suddenly, and the resulting soft tissue vibrations cause loud snoring when breathing is restored[1]. The disorder can occur in all stages of sleep, most often during REM sleep[2].

Obstructive sleep apnea is the most common sleep breathing disorder. It is estimated that mild obstructive sleep apnea (5-15 episodes per hour) may affect every 5th adult, while moderate (14-30 episodes per hour) may affect as many as every 15th adult. The prevalence of OSA resulting in daytime sleepiness in the population is estimated at about 3-7% in men and 2-5% in women. Obstructive sleep apnea is more common in overweight and obese people, as well as elderly[3]. Population studies indicate an increased risk of obstructive sleep apnea in African-American population, especially among children. African-American

children are 3-6 times more likely to develop OSA in comparison to their Caucasian peers. This disparity seems to decrease with age until senectitude, when it once more reaches similar values[4]. Men suffer from OSA 2-3 times more often than women[5]. Pregnant women have an increased risk of developing obstructive sleep apnea, seemingly due to narrowing of the upper airways caused by increased fluid retention and weight gain associated with pregnancy[6].

Apneas and hypopneas occurring in patients diagnosed with OSA are caused by periodic narrowing or complete closure of the upper respiratory tract at the level of throat, as it is the only section of upper airways devoid of bone or cartilaginous walls, built entirely out of muscle. During sleep, the tone of muscular walls of the respiratory tract is decreased, which leads to decreasing airway lumen and subsequently – apneas. The apneas lead to hypercapnia, hypoxemia and an increased respiratory effort, resulting in awakening. During REM sleep, these factors are less likely to cause an awakening, which is why apneas during REM sleep are longer and in turn lead to greater hypoxia levels[7].

Another seemingly important aspect in developing OSA are anatomical features. Studies have shown that people suffering from OSA showed lower patency of the posterior palatine section of the pharynx compared to the healthy population, not only during sleep, but also during periods of wakefulness. This can possibly be caused by anomalies in bone and cartilage structures, such as underdevelopment of the mandible, lowering of the hyoid bone, or soft tissue structural anomalies such as tongue hypertrophy[8]. Another factor contributing to reduced patency of the respiratory tract is obesity – an increased amount of subcutaneous adipose tissue in the area of the pharynx and larynx exerts pressure on the muscular walls of the respiratory tract, which increases the risk of their collapse. Another important etiological factor of OSA are neuromuscular and neurohormonal regulation disorders. Hypotonia of the throat opening muscles during sleep predisposes to airway obstruction. It is believed that neuromuscular regulation is responsible for the difference in the severity of sleep apneas between REM and NREM sleep, especially in women and children. In turn, disturbances in neurohormonal modulation may partially explain the differences in the frequency of OSA between male and female patients[9].

2.2. Symptoms of obstructive sleep apnea

Among specialists dealing with obstructive sleep apnea, it is considered practical to divide the symptoms of this condition into nocturnal and daytime symptoms. Some of the

symptoms can only be observed during sleep, so the patient may not be aware of their occurrence. Therefore, information obtained from people closest to the patient is a vital part of the interview[10]. The most commonly reported nocturnal symptom is snoring. It occurs alternately with apneas, in every phase of sleep, regardless of body position. It appears every night. The effect of apnea and the resulting hypoxia is also the stimulation of the sympathetic nervous system, leading to an increase in blood pressure and an accelerated heart rate during awakenings, experienced by the patient as bothersome palpitations. The effect of apneas and the accompanying excessive respiratory effort is increased motor activity and sweating. Awakenings and the accompanying problems with falling asleep again affect the patient's activity levels during the day. The above-mentioned sleep disturbances lead to daytime symptoms. The most commonly reported is daytime sleepiness – caused by a lack of deep sleep and hypoxia. Its intensity is correlated with the intensity of OSA. Patients with moderate obstructive sleep apnea often fall asleep in passive situations, such as watching TV or reading. In the case of patients with severe OSA, it is common to fall asleep during activities that require concentration, such as eating a meal or driving a car. Changes in the partial pressures of respiratory gases in the blood cause morning headaches. Sleep deprivation contributes to impaired cognitive abilities, depression and other emotional disorders[11].

2.3. Diagnosis

A wide plethora of conditions can result in a diminished sleep quality, which makes differential diagnosis crucial in determining further treatment. The interview should include questions about the occurrence and level of intensity of daytime and nighttime symptoms. It is also important to identify the conditions that the patient suffers from that are risk factors for OSA, such as: endocrine diseases, especially hypothyroidism, heart failure or abnormalities in the craniofacial morphology. Attention should also be paid to conditions that may be a result of untreated sleep-related breathing disorders, such as hypertension, metabolic disorders or cardiac conduction defects[12].

A properly conducted physical examination is also an important component in OSA diagnosis, as it enables recognizing risk factors, such as obesity. A neck circumference measurement also proves to be a valuable tool in obstructive sleep apnea diagnosis. A value above 43 centimeters in men and 40 centimeters in women is considered a risk factor for sleep-related breathing disorders, while a neck circumference above 48 centimeters

increases the risk of OBS by as much as 20 times[13]. The patient should undergo an ENT examination, and particular attention should be paid to such abnormalities as a drooping soft palate and uvula, a nasal septum deviation or nasal turbinate hypertrophy. The occurrence of these abnormalities does not allow for the diagnosis of OSA, although it does increase the probability of the diagnosis, while their absence does not allow for it exclusion[14].

In order to diagnose OSA, a sleep study is required to monitor physiological parameters during sleep. The gold standard for diagnosis is polysomnography. The American Academy of Sleep Disorders (AASM) has identified four types of sleep diagnostic devices. The first type of examination is stationary polysomnography – a night-long measurement of at least 7 parameters necessary to assess sleep and breathing: pulse oximetry, encephalography, electrooculogram, encelomyograph, electrocardiogram and measurement of airflow through the upper respiratory tract. This type of examination is conducted in a sleep laboratory. The second type of examination is portable polysomnography. The same 7 parameters as in the first type of examination are measured, however, unlike stationary PSG, it is performed in the patient's home. It allows to avoid the so-called first night effect, i.e. deterioration of sleep quality associated with falling asleep in a new place. The third type of examination mentioned by the AASM – polygraphy involves overnight recording of at least 4 physiological parameters – respiratory movements of the chest and abdomen, airflow through the upper respiratory tract, blood oxygenation level, as well as heart rate or ECG. Sleep structure is not assessed, which means that this type of examination is burdened with the risk of false negative results and is not recommended in diagnosing patients suffering from serious comorbidities. The last type of examination are tests during which no more than two parameters are measured, most often the level of blood oxygenation and nasal airflow or heart rate[15]. Only tests of types I and II allow for a certain diagnosis of OBS. Diagnosis is made based on the criteria of the International Classification of Sleep Disorders[16,17].

2.4. Consequences of untreated obstructive sleep apnea

Untreated obstructive sleep apnea results not only in fatigue, but also in a number of other complications. The most common cause of death in the population of people suffering from OSA are cardiovascular diseases. The sympathetic system, stimulated during apnea-induced awakenings, remains in a state of increased activity also during the day, as a result

of which patients with OSA usually suffer from tachycardia, hypertension, rhythm or conduction disorders. Oxidative stress and increased proinflammatory cytokine concentration caused by apnea also lead to the earlier development of atherosclerosis, consequently contributing to an increased risk of myocardial infarction[18]. Patients with obstructive sleep apnea often struggle with metabolic syndrome, which is obesity coexisting with hypertension, insulin resistance and lipid metabolism disorders. It is worth noting that obesity can be both a risk factor for sleep breathing disorders as well as their effect. Fragmentation and sleep deprivation lead to a decrease in ghrelin concentration and an increase in leptin concentration, and consequently to increased appetite[19]. Sleep apneas can also lead to abnormalities in the secretion of neurotransmitters, and depression and anxiety are also common disorders in patients with OSA, especially in the female population. Introducing antidepressant therapy may be beneficial, as they shorten the duration of REM sleep, which may have a beneficial effect on the quality of sleep in patients who experience apneas particularly often in this phase of sleep[20].

3. Impact of obstructive sleep apnea on work productivity

3.1. Absenteeism

An important ramification of OSA is the tendency to fall asleep during tasks requiring being alert. Obstructive sleep apnea is considered an important factor contributing to work-related injuries and accidents, as well as work disability. Numerous studies have shown a link between OSA and absenteeism – an amount of time of work missed by employed people. Studies comparing absenteeism between population suffering from obstructive sleep apnea and control groups demonstrated, that patients with OSA are prone to take an illness-caused leave of absence in 5 years prior to the diagnosis[21]. A research conducted by Sagherian et al. analyzing a link between acute fatigue and absenteeism in pediatric hospital nursing staff concluded, that nurses suffering from obstructive sleep apnea were twice more likely to take a leave of absence than those not affected by this condition[22]. A recent study conducted by G.E. Silva et al. proves an existence of link between suffering from OSA and involuntary job loss – patients with mild OSA appear to be twice more likely to experience multiple job losses, while those burdened with moderate to severe OSA – thrice more likely[23]. A Swedish study aiming to analyze OSA impact on workability of the Swedish population found that up to 13% of men and 21% of women received disability pensions in 10 years following the diagnosis[24].

3.2. Work performance

As obstructive sleep apnea is associated with a deterioration of cognitive functions, it also contributes to a decreased work performance. In a study performed by Waldman et al. as much as 90% of participants experienced work difficulties they believe to be caused by OSA, with about half of participants reporting difficulty with detail-oriented tasks and 45% reporting difficulty staying awake at work[25]. A Greek study authored by Nena et al. assessing work productivity among otherwise healthy patients burdened with OSA using Endicott Work Productivity Scale showed, that daytime sleepiness caused by OSA impairs their work productivity[26]. A recent meta-analysis conducted by Guglielmi et al. showcases OSA having a negative impact on concentration, attention span, time management and ability to master new tasks among the population of patients suffering from OSA, while suggesting that further research must be conducted in order to determine clear effect of obstructive sleep apnea on work-related cognitive functions[27]. Another research, also authored by Guglielmi et al. found, that patients suffering from OSA are at higher risk of developing burnout compared to those not burdened by this condition[28].

3.3. Motor vehicular accidents

Obstructive sleep apnea is also becoming widely recognized as a considerable risk factor contributing to an increased risk of road traffic accidents. A recent nationwide Danish study regarding this topic demonstrated, that OSA patients are more likely to suffer in a motor traffic accident, and that severity of OSA patients' accidents is increased comparing to matched references[29]. Another study, conducted by Ward et al. found, that patients burdened with OSA are three times more likely to suffer a motor vehicle accident and five times more likely to nearly miss such an accident[30]. Given this information, obstructive sleep apnea is an especially dangerous condition for commercial drivers. A study authored by Garbarino et al. investigating a link between OSA and traffic accidents among truck drivers found, that drivers suffering from OSA have severely increased risk of both motor vehicular accidents and near miss accidents[31]. A study focusing on Malaysian commercial vehicle drivers found that as much as 44,3% express bus drivers had polysomnography results indicating OSA, highlighting importance of screening test for OSA among this population[32].

3.4. Economic burden of obstructive sleep apnea

Obstructive sleep apnea as a condition is associated not only with a diminished quality of life, but also with increasing health care costs. A study authored by Ronksley et al. aiming to analyze economic burden of OSA found that excessive daytime sleepiness contributed to an increased number of outpatient physician visits, as well as increased usage of sleep medication. As OSA patients are often burdened with comorbidities such as diabetes, and cardiovascular diseases, it is also associated with an increased number of all-cause hospitalizations[33]. A recent systematic review authored by Borsoi et al. estimated that OSA contributes to an economic burden of €10,7- €32 billion a year in Italy, most of it being costs of undiagnosed OSA[34]. Another systematic review, conducted by Alakörkkö et al. states, that healthcare costs associated with OSA vary significantly across geographical regions, with annual costs per patient ranging from €236 in New Zealand up to €28,267 in United States[35]. A research by Hoffman et al. estimating cost benefit of obstructive sleep apnea treatment among commercial motor vehicle drivers population showcases, that OSA patients receiving treatment exhibited fewer missed workdays and lower late of disability claims, which resulted in approximately over $6000 cost savings per patient, highlighting the importance of screening tests and treatment in managing the economic burden of OSA[36].

4. Treatment of obstructive sleep apnea

The goal of obstructive sleep apnea therapy is to restore patency of the throat during sleep. In the case of mild OSA, improvement can be achieved through patient education and lifestyle changes, while moderate and severe sleep apnea may require more complex and invasive therapy.

4.1. Weight loss

Obesity plays a significant role in the etiopathogenesis of OSA, which makes weight loss an important therapeutic goal in the treatment of this disease. The methods of treating obesity in OSA do not differ from those recommended for people not affected by it[37]. A 10% weight loss allows for a decrease in the Apnea Hypopnea Index (AHI) by about 26%[38]. An official American Thoracic Society Clinical Practice Guideline recommends a comprehensive lifestyle change program including increased physical activity, reduced-

calorie diet and behavioral counseling, while also suggesting an evaluation for potential weight-loss pharmacotherapy[37].

4.2. Positional therapy

Positional therapy is an effective treatment for positional obstructive sleep apnea (POSA). This is a subtype of OSA characterized by a twofold increase in AHI during sleep in the supine position compared to sleep in other positions. The factor causing the change in anatomical conditions in the upper respiratory tract and the occurrence of POSA is gravity. The goal of positional therapy is to force sleep in the side position using mechanical obstacles that prevent sleeping on the back, devices signaling the body position or devices with a vibrating alarm, the so-called sleep position trainers[39]. Positional therapy effectiveness in alleviating symptoms of POSA is similar to the effectiveness of CPAP treatment[40].

4.3. Continuous positive airway pressure

The method of choice in the treatment of obstructive sleep apnea is treatment with positive airway pressure. CPAP (continuous positive airway pressure) devices are used to ensure constant positive airway pressure. This device works as a pump that draws air from the environment and delivers it to the patient under positive pressure through a mask connected to the device by a tube and a mask tightly fitting the patient’s face. Upon entering, the air stream maintains the patency of the patient's upper respiratory tract during sleep. CPAP therapy eliminates or reduces the severity of the OSA symptoms, bringing remarkable relief to the patients[41]. The air prosthesis should be used throughout the duration of sleep every night. The minimum time of its use necessary to achieve a therapeutic effect is 4 hours for at least 70% of the observed nights[42].CPAP treatment can lead to a decrease in insulin resistance in patients with OSA[43]. It also helps alleviate symptoms of depression[20]. CPAP treatment also proved to be a valuable tool improving work performance among OSA patients. Research conducted by Jurado-Gamez et al. comparing work productivity and burnout in OSA patients before and after CPAP therapy found, that CPAP treatment contributed to respectively increasing work productivity and decreasing burnout[44]. A systematic review authored by Tregear et al. indicates, that

CPAP treatment also helps to reduce the risk of motor vehicular accidents among drivers suffering from OSA[45].

4.4. Intraoral appliances

In the population of patients not tolerating CPAP treatment and in patients whose OBS is caused by anatomical conditions of the maxillofacial region, intraoral appliances are recommended. Their task is to keep the mandible in a protruding position, which prevents the upper airway from collapsing. Treatment with intraoral appliances should be performed under the care of both a sleep medicine physician and an experienced dentist[46]. Usage of intraoral appliances is an effective treatment strategy in adults suffering from OSA. It appears to be more commonly used in mild to moderate OSA in patients not adhering to the CPAP treatment, as CPAP is considered to be more effective[47].

4.5. Surgical interventions

If conservative treatment fails to produce satisfactory results, surgical treatment of OSA is possible. It focuses on removing obstruction in three anatomical areas – the nasal cavity, the oropharynx and the hypopharynx. The effectiveness of surgical interventions in the treatment of obstructive sleep apnea and recommendations for the selection of patients who will benefit from this treatment method are still a subject of research[48]. As OSA is also often a result of narrowing the upper respiratory tract in several areas, a combination of surgical procedures may bear better result than a single one. In order to address anatomical abnormalities in multiple areas of the upper respiratory tract, staged surgery protocols have been developed. Before the procedures, individual risks and potential complications are taken into consideration. As a rule, the safest procedure carrying less risks is performed earliest.[49].

5. Conclusions

Obstructive sleep apnea is becoming an increasingly common disorder, that negatively impacts many facets of patient's life. Untreated OSA contributes to a number of comorbidities, including diabetes and cardiovascular diseases. Untreated OSA symptoms are negatively affecting work productivity and economics. All of aforementioned difficulties have severe impact on the quality of life of an OSA patients. Keeping in mind

the costs of untreated OSA it may be reasonable to implement screening tests for obstructive sleep apnea. The link between OSA and motor vehicle accidents highlights the importance of screening tests for OSA, especially among the population of professional drivers. Existing treatment methods, especially CPAP treatment, help alleviate OSA symptoms as well as its negative impact on work productivity, which makes it crucial for improving quality of life of patients suffering from OSA both from individual and societal point of view.

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Received funding – The study did not receive funding.

All authors have read and agreed with the published version of the manuscript.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable

Conflict of interest: The authors declare no conflicts of interest.

Acknowledgements: Not applicable.

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