REVIEW

An obstructive sleep apnoea - a novel public health threat

Sona Gresova[1*], Martina Gaborova[1], Judita Stimmelova[1], Igor Peregrim[1], Pavol Svorc[1], Viliam Donic[1], Maria Pallayova[1]

Department of Human Physiology, Pavol Jozef Safarik University Faculty of Medicine, Trieda SNP 1, Kosice, Slovak Republic.

***Corresponding author:**
Sona Gresova, Dr. PhD.
Department of Physiology, Faculty of Medicine, University PJ Safarika,
Tr. SNP 1, 04001 Kosice, Slovak Republic.
Email: sona.gresova@upjs.sk
Telephone: 00421903678666

Summary
In patients with obstructive sleep apnoea (OSA) during obstructive events, episodes of hypoxia and hypercapnia may modulate the autonomic nervous system (ANS) by increasing sympathetic tone and irritability, which contributes to sympathovagal imbalance and ultimately dysautonomia. Because OSA can alter ANS function through biochemical changes, we can assume that heart rate variability (HRV) will be altered in patients with OSA. Most studies show that in both the time and frequency domains, patients with OSA have higher sympathetic components and lower parasympathetic dominance than healthy controls. These results confirm autonomic dysfunction in these patients, but also provide new therapeutic directions. Respiratory methods that modulate ANS, e.g., cardiorespiratory biofeedback, could be beneficial for these patients. Heart rate variability assessment can be used as a tool to evaluate the effectiveness of OSA treatment due to its association with autonomic impairment.

Keywords: autonomic nervous system, heart rate variability, obstructive sleep apnoea, sleep

Introduction

Obstructive sleep apnoea (OSA) is defined as the absence of ventilation lasting for at least 10 seconds, during which the activity of the respiratory centre is maintained so the respiratory effort remains. This phenomenon is caused by the paradoxical movement of the chest and diaphragm that occurs during an obstructive sleep apnoea episode. This is a recurrent collapse of the upper airways during sleep, when transient obstruction during snoring is caused by weakening and "sucking" of the oropharyngeal walls with the interruption or restriction of air permeability and a consequent decrease in blood oxygen saturation. Thus, transient hypoxaemia occurs with sleep disturbance and fragmentation, resulting in excessive daytime sleepiness. Due to vagal activity, the heart rate and blood pressure decrease during the apnoea pause. A decrease in pO_2 and increase in pCO_2 activate chemoreceptors in the carotid sinus, aortic arch and spinal cord. This activation leads to a reflex increase in ventilation, causing microarousals and increased muscle tone of the upper respiratory tract, which subsequently opens. As a result of sympathetic activation, persons with OSA hyperventilate, have tachycardia and their blood pressure increases. Increased sympathetic activity leads to vasoconstriction and increased peripheral vascular resistance in the systemic and pulmonary systems. After falling asleep again, this

whole cycle is repeated. These periods are accompanied by snoring of varying intensity (snoring can also be a predictor of OSA).
Heart rate variability (HRV) can be used to evaluate the integrity of the autonomic nervous system (ANS) in these patients. A lower HRV is observed in several cardiovascular and respiratory diseases, such as hypertension and chronic obstructive pulmonary disease (2), indicating the abnormal adaptability of ANS in these patients. As OSA can alter the ANS function through biochemical changes, we can assume that HRV will be altered in patients with obstructive sleep apnoea (3).
Previous studies have yielded promising results showing that heart rate variability analysis can be a predictor of sleep apnoea, reaching a sensitivity and specificity of approximately 70–90% [1]. However, it should be emphasised that these studies were limited to small groups of patients and were primarily based on qualitative rather than quantitative analyses. The primary goal of the present review was to describe changes in the autonomic nervous system in patients with OSA.

Obstructive sleep apnoea

Obstructive sleep apnoea is the most common type of sleep apnoea, accounting for up to 80% of all cases of sleep apnoea syndrome. According to a 2016 study [2], the overall prevalence of OSA (defined by an apnoea-hypopnoea index/AHI ≥5 respiratory events/h) ranged from 9–38% in the general population and was higher in men. The OSA prevalence increased with age, reaching up to 90% in men aged 60–85 years and 78% in women of a similar age [2]. When defined by the AHI ≥15 respiratory events/h, the prevalence of OSA ranged from 6–17% in the adult population (49% were elderly) [2]. The awareness of doctors about OSA and its complications plays a key role in providing necessary healthcare. In places where these disorders are given increased attention, patients are sent for examinations for suspected OSA much more often [2]. This leads to a locally increased percentage of diagnosed patients [2]. Obstructive sleep apnoea occurs in all age categories, but the most common period of symptoms is in the 4th and 5th decade of life. During this period, the symptoms are also the most significant [2].
The incidence of OSA is higher in obese patients, in type 2 diabetes mellitus and in other cardiovascular disorders which include coronary artery disease, heart failure, cardiac arrhythmias, stroke, atherosclerosis and myocardial infarction. Research by the Seventh Join National Committee shows that OSA is the cause of secondary hypertension in 37–56% of cases and the prevalence rate of OSA in patients with resistant hypertension is estimated at 70–83% [3]. In the paediatric population, the incidence of OSA ranges from 1.2–5.7% and the risk of developing OSA in obese children is estimated at 36% [4]. It is reported that in more than 85% of patients with OSA, the symptoms have never been clinically diagnosed [5]. The incidence of snoring itself is much higher, affecting one in three adults, but it is a habitual snoring that is not accompanied by clinical signs of the disease. We also refer to this type of snoring as simple benign snoring [6].

Pathogenesis of obstructive sleep apnoea

Obstructive sleep apnoea is characterised by recurrent episodes of upper airway collapse and obstruction during sleep due to defects in the pharyngeal structure and neuromuscular control [7]. Important components include abnormalities in the upper airway anatomy, the ability of the upper airway dilator muscles to respond to the challenge of breathing during sleep, the tendency to wake up after increased respiratory effort, the stability of the respiratory centre and the potential for lung volume changes to influence these factors. Also, OSA is often associated with changes in upper airway anatomy; structural changes, including tonsil hypertrophy, retrognation and variations in craniofacial structures are all associated with an increased risk of sleep apnoea as they contribute to increased upper airway collapse. Ethnic differences in craniofacial traits are one of the potential explanations for the observed differences in the prevalence and severity of OSA for a given level of obesity. Studies in awake patients using CT and MRI have shown increased adipose tissue deposition and submucosal oedema in the lateral walls of the pharynx, both of which contribute to narrowing of the pharyngeal

lumen and may predispose these individuals to obstruction during sleep [8]. Based on the presence of anatomical changes in the upper airways in patients with OSA, structural or mechanical changes are considered to be the primary determinant of upper airway obstruction during sleep [8]. Studies have shown that structural changes in the lateral walls of the pharynx and tongue arise on a family basis, suggesting a role for genetics in the development of OSA. In addition, experimental data obtained in the absence of neuromuscular activity show narrowing of the pharyngeal space and increased Pcrit (passive pharyngeal critical closing pressure) values in individuals with OSA. In addition, obesity, jaw position, acromegaly, tonsillar hypertrophy and the smaller bone envelope surrounding the pharynx have been shown to increase pharyngeal collapse [8]. Upper airway structural differences differentiate OSA patients from healthy subjects. In addition, when neuromuscular mechanisms weaken during sleep, they may predispose them to upper airway obstruction [8].

Obesity is another serious risk factor for OSA. It is associated with an increased neck circumference and increased amounts of peripheral fat, which can narrow and compress the upper airways. Increased parapharyngeal fat also correlates with the increasing severity of sleep apnoea. Studies examining resected uvular tissue have revealed greater amounts of submucosal adipose tissue in patients with OSA. The compressive effects of adipose tissue deposited around the pharynx may therefore increase the collapse of the upper airways and possibly antagonise the effects of the expansion muscles that maintain their patency. Obesity also increases pharyngeal collapse through a reduction in lung volumes, especially by reducing functional residual capacity (FRC), which deepens with the onset of sleep. Decreased FRC increases pharyngeal collapse by reducing tracheal traction on the pharyngeal segment. Conversely, an increase in lung volumes leads to an increase in tracheal traction and stabilisation of the upper airways during inspiration. In patients with OSA, an increase in lung volumes has been shown to reduce continuous positive airway pressure (CPAP) requirements and the severity of OSA [9].

Neuromuscular factors

Anatomical mechanical loads on the upper airways may not always lead to pharyngeal collapse during sleep. Women have a smaller pharynx and oropharyngeal junction than men, but still have a lower prevalence of OSA. In addition, measurements of Pcrit under low neuromuscular activity conditions, which reflect the mechanical loads on the upper airways, show significant overlap between OSA patients and controls. Thus, non-structural (i.e., neuromuscular) factors must also play a role in upper airway protection. Changes in upper airway neuromuscular activity during sleep were originally described by Remmers et al., who showed that genioglossal electromyogram (EMGgg) activity was reduced at the onset of apnoea and increased at arousal when airway patency was restored. Subsequently, upper airway obstruction has been found to trigger various neuromuscular responses that restore upper airway patency by activating muscles that dilate and lengthen the airways. During the respiratory cycle, various pharyngeal muscle groups are important, which ensure stabilisation (tonic activity, e.g., m. tensor palatini) and airway dilatation during inspiration (phase activity, e.g., m. genioglossus). The resulting pharyngeal motility is modulated by a number of factors, which include waking and sleep-dependent mechanisms, local mechanoreceptor responses to vacuum and respiratory control mechanisms [10]. During wakefulness, an increased activity of m. genioglossus and m. tensor palatini was observed in patients with OSA, which can be significantly reduced by applying positive pressure. On the contrary, the control group of healthy individuals showed lower activity of these muscles, which did not decrease further after the application of CPAP. These findings suggest that the increased upper airway dilatation muscle activity compensates for anatomically narrower upper airways in patients with OSA. Decreased upper airway muscle activity with the onset of serotonergic, cholinergic, noradrenergic and histaminergic pathways may lead to their obstruction [11].

Pressure-sensing mechanisms play an important role in modulating upper airway neuromuscular activity during wakefulness and sleep. The negative pressure in the upper respiratory tract serves to stabilise them during inhalation. The vacuum reflex is primarily mediated by mechanoreceptors in the pharynx. This argument is supported by the fact that there is a relationship between EMGgg (m.

genioglossus electromyography) and pharyngeal pressure independent of the central respiration generated in the brainstem. Local anaesthesia on the pharyngeal mucosa weakens this relationship, leading to increased obstructive apnoea and hypopnoea, loud snoring and/or prolonged apnoea episodes in healthy subjects, implying that the pharyngeal vacuum stabilises upper airway patency during inhalation [11].

Microarousals

Waking from sleep at the end of hypopnoea or apnoea has long been considered an important protective mechanism for reopening the airways [12]. However, work by Younes [12] provided insights into the functional role of waking from sleep in OSA and questioned the notion that it was a necessary mechanism for reopening the airways. When examining the response to experimentally-induced transient airway depression (CPAP) in patients with OSA, Younes noted that inspiratory flow increased in 22% of cases before awakening and resumed in 17% of cases without awakening [12]. Jordan et al. conducted a study on the mechanisms underlying the resumption of airflow without awakening patients [13]. A transient decrease in pressure for up to 5 minutes resulted in an increase in genioglossus muscle activity and changes in the work cycle. These compensatory responses were similar between OSA patients and healthy individuals. However, compared to healthy patients receiving stimuli of a similar magnitude, patients with OSA without increased cortical activity had a lower ability to restore ventilation [10]. Findings that patients with OSA are able to restore ventilation at respiratory loads without cortical arousal for at least some time increase the likelihood that some patients are able to maintain clear airways during sleep if they remain in sleep long enough to restore compensatory mechanisms [10]. Combinations of stimuli, such as carbon dioxide and vacuum, can activate the dilatation muscles of the upper respiratory tract [10]. Delaying the awakening, which would allow for the sufficient accumulation of respiratory stimuli to restore pharyngeal patency, could thus be beneficial for patients. Procedures to prevent awakenings from sleep (increasing the individual awakening threshold) are likely to be the most effective in patients who wake up easily during sleep after sleep exercise. However, raising the awakening threshold in patients who already have a high value may be detrimental due to the possible worsening of blood gas abnormalities [10]. Most of the available evidence suggests that the level of pleural pressure generated by respiratory effort regardless of stimulus (e.g., hypoxia, hypercapnia and respiratory load) is likely to be a key trigger to induce non-REM sleep awakening [10]. Experimentally, the awakening threshold is measured as the minimum oesophageal pressure (or pressure at the level of the epiglottis that is thought to be similar during airway occlusion) generated by the breath before awakening during respiratory load or occlusion. Although there is considerable interindividual variability, patients with OSA tend to have a worsened response to micro-arousal (greater negative pressure or higher awakening threshold is required) than controls. CPAP treatment tends to lower the awakening threshold [10]. These findings suggest that OSA itself (e.g., sleep fragmentation, hypoxia and recurrent airway obstruction) is responsible for impaired awakening responses in OSA patients and not an inherent abnormality of the awakening threshold. Awakening from sleep is associated with increased upper airway dilator activity at an equivalent level of negative pharyngeal pressure during sleep and with a rapid ventilatory response. Although these changes are beneficial in rapidly restoring airflow and reversing oxygen desaturation/hypercapnia, they can also destabilise respiration and contribute to the severity of apnoea [10].

Besides epigenetic factors, genetic predisposition may play an important role in the pathogenesis of OSA. Studies have clearly shown a familial occurrence in the development of obstructive sleep apnoea [14]. This finding applies to both obese and non-obese patients with OSA. Studies using linkage analysis have provided an initial insight into the possible linkages between specific regions of the genome and the pathogenesis of OSA. Anatomy (obesity, craniofacial structure) clearly has a genetic basis [14]. In addition, features such as upper airway soft tissue structure size, respiratory control abnormalities and respiratory responses to sleep resistance may also have a genetic background [14].

Heart rate variability in obstructive sleep apnoea

Recurrent episodes of obstructive sleep apnoea lead to periodic hypoxaemia, hypercapnia and arousal from sleep, which stimulates peripheral and central chemoreceptors. They cause cyclic oscillations in the activity of the sympathetic and parasympathetic nervous systems, which cause oscillations in blood pressure and heart rate with each apnoea-hyperpnoea cycle. Autonomic regulation is related to baroreceptors and chemoreceptors, which can perceive biochemical modifications in pCO2 and pH. Hypoxia and hypercapnia during recurrent obstructive episodes are therefore considered to be a major cause of altered ANS. During obstructive events, these episodes of hypoxia and hypercapnia may modulate the ANS of patients with OSA by increasing sympathetic tone and irritability, which may contribute to sympathovagal imbalance and ultimately dysautonomia [15].

Several physiological factors derived from recurrent upper airway obstruction can lead to autonomic dysfunction and the cardiovascular comorbidities of OSA. Obstructive events increase negative intrathoracic pressure and hypoxia, which has adverse haemodynamic consequences, such as excessive sympathetic activity, enhanced reactive oxygen species (ROS) and vasoactive compensatory mechanisms [16]. Sympathetic activity and blood pressure are also determined by the duration of the obstructive episode and the severity of oxygen desaturation [17].

HRV assessment can be used as a tool to evaluate the effectiveness of treatment of patients with OSA due to its association with autonomic damage. In frequency domain analysis, VLF and ULF are mainly influenced by SF circadian differences and therefore cannot be estimated by short-term analysis, only by a 24-hour Holter [18]. Elevated VLF levels may be associated with the increased sympathetic activity observed in OSA patients in some studies. Both components account for 95% of total performance and the literature suggests that they have the highest predictive value because they are more strongly associated with overall health than the high-frequency components. There are several limitations in studies looking at HRV changes in patients with OSA. In HRV research, the effect of the menstrual cycle on autonomic cardiac modulation is less studied in women. Although OSA is more common in men than in women, further investigation of sex differences in HRV in these patients could clarify whether hormones are also involved in this sleep-related breathing disorder [19]. Several studies also include participants with associated comorbidities and patients taking medications that may affect HRV outcomes. Additional limitations include different data length, device and record status. These differences between the studies affect the accuracy of HRV analysis and especially the comparison of their results [20].

The values measured in the low-frequency LF band are mainly derived from sympathetic activity, but they also reflect the activity of the parasympathetic nervous system to a lesser extent. The vast majority of studies have shown that healthy control groups have significantly lower LF values than patients with OSA. However, the results in the literature vary. There are several studies that did not confirm statistically significant differences in the LF parameter and one study in which the control group had significantly higher LF values than the observed group of patients with OSA [17].

The HF high frequency band is a component of HRV that represents vagal cardiac activity. High HF levels are considered a predictor of good health. Studies have shown that patients with OSA have significantly lower HF levels than healthy controls, indicating a lower parasympathetic predominance and an increased risk of cardiovascular problems. Increased HF performance in patients with severe OSA may be associated with an increase in vagal tone, presumably due to more frequent and intensive Mueller manoeuvres. A large change in the respiratory model of sick patients may affect HF performance, as the high frequency band is also known to be affected by respiration itself [17].

The low frequency to high frequency ratio HRV (LF/HF) represents the sympathovagal balance index. High LF/HF values indicate a predominance of sympathetic activity and dysautonomia. Most studies have shown elevated LF/HF levels in OSA patients compared to healthy controls. A higher proportion of sympathetic tone is probably related to recurrent apnoea events. Relative hypoxaemia acts on central chemoreceptors and thus increases sympathetic activity. Repeated arousal from sleep can also cause relatively high sympathetic activity and decreased vagal tone. A retrospective study of patients

with varying severities of obstructive sleep apnoea found that the arousal index is a stronger contributing factor to cardiac autonomic dysfunction in patients with OSA than the apnoea-hypopnoea index (AHI) [21]. Elevated values of the LF/HF standard deviation indicate that the changes in sympathetic and parasympathetic activity during the night are not identical. This may be due to less common apnoea events.

Changes in the stage of sleep are also an important factor. REM sleep, which usually occurs at 90-minute intervals, is associated with a significantly higher number of apnoea episodes in patients with OSA. The long 24-hour data collection is considered the "gold standard" because it involves changes in the body's metabolism and circadian rhythm. All of these selected studies also used AHI as a classification of the severity of sleep apnoea, but this index does not fully correlate with cardiovascular risk in adults. The coherent study [22] showed that the prediction of cardiovascular outcomes can be independent of AHI. AHI represents only the number of apnoea and hypopnoea events per hour of sleep [22], which documents the frequency of these events, but not, for example, the duration or magnitude of each event. The study by Hietakoste et al., in 2020 [23], provides valuable insight into the cardiovascular stress associated with apnoea and hypopnoea. The results show that higher ultrashort HRV and greater variation between RR intervals within and after a respiratory episode are more strongly associated with longer respiratory event duration, apnoea and male gender. Although some of these selected studies compare data between AHI and HRV, more studies are needed to clarify whether the current definition of hypopnoea and sleep apnoea severity classification still apply as a predictor of cardiovascular risk in patients with OSA [17]. On the other hand, HRV can be used as a predictor of morbidity and mortality, especially SDNN, which is considered the "gold standard" for medical stratification in 24-hour recordings [24].

Heart rate variability as an obstructive sleep apnoea novel diagnostic tool

At the beginning of the investigation of obstructive sleep apnoea, it was found that the events of apnoea and hypopnoea are accompanied by concomitant cyclical changes in heart rate. The bradycardia/tachycardia pattern is closely related to the time course of apnoea events. As a result, this model has been successfully used to detect sleep apnoea in patients with clinical symptoms. Over the last 15 years, special devices have been developed to detect sleep apnoea in the early stages of the disease by recording heart rate, snoring, oxygen saturation and body position. These devices have been successfully used to stratify the individual risk of patients suffering from sleep-disordered breathing before being referred for cardiorespiratory polysomnography. The sensitivity and specificity of these simplified four-channel recording systems have been evaluated in many studies providing results for specific systems. A recent systematic review summarised the results of these studies in a comparative review [25]. This review revealed the value and limitations of the systems with respect to the accepted criteria for the diagnosis of sleep apnoea. It should be noted that satisfactory standardisation of terms and diagnostic criteria for a transmissible diagnosis of sleep apnoea has not been achieved.

In parallel with efforts to define evidence-based criteria for the simplified diagnosis of sleep apnoea, the physiology causing cyclical changes in heart rate has been investigated. Studies of sympathetic nerve activity during sleep apnoea have shown that sympathetic activation increases during apnoea [26]. It is not entirely clear to what extent nerve activity reflects the sympathetic activation of the heart during apnoea with effects on the heart rate itself. Sympathetic nerve activation in patients with sleep apnoea even persists during the day and may contribute to an increased cardiovascular risk in these patients [27]. The study was validated in 2020, in which HRV served as a supplement to well-known cardiovascular risk factors such as aging, adiposity and sleep disorders during sleep, with an overall accuracy of 75.3%. This suggests that adding heart rate variability to the severity classification may predict a real impact on physiological parameters that later lead to pathological changes [28].

Several studies have examined heart rate and HRV before [29] and during sleep apnoea in order to improve the means for a simplified diagnosis of sleep-disordered breathing. At the same time, the

work suggests that changes in HRV are caused by sleep apnoea [30]. One of these studies uses sympathetic activity derived from the spectral components of HRV. A standard technique is introduced to derive sympathetic and parasympathetic tone indicators from HRV by calculating the spectral power in defined frequency bands. This technique has been shown to have some prediction of hypertension and myocardial infarction and is therefore currently used in many cardiovascular disorders. The low frequency component of HRV is usually associated with sympathetic activity. This study examined the spectral components in short 2-minute time segments in patients with OSA and compares them to undisturbed sleep in healthy controls. The study concluded that there was an increased sympathetic tone in respiratory disorders [30]. However, sleep-associated respiration represents a complex interaction between regular changes in the autonomic nervous system during sleep and specific changes associated with apnoea. From a physical point of view, spectral analysis requires stationary signals. This means that the mean and standard deviation and moments of the higher order of the analysed signal must remain the same for the entire investigation period. Sleep apnoea with a highly dynamic HRV pattern is by no means a stationary process; therefore, the use of spectral analysis is limited. Due to these limitations, other authors are trying to use new techniques developed specifically for non-stationary data analysis. Time-frequency wave analysis is a sophisticated technique superior to spectral analysis because it is not restricted to limiting stationary requirements [1]. The problem with wave analysis is that the results are less intuitive, so another method needs to be used to select the best wave to detect sleep apnoea. In a research study by Roche et al. from 2003, (1) they used the wave method on a large sample of patients and developed an optimal algorithm in order to identify the most suitable waves. The presented results prove that this method is effective in recognising cyclic HRV specific for sleep apnoea, because the pattern is not strictly periodic. The application of this method can improve the recognition of sleep apnoea based on non-invasive simple electrocardiography (ECG) and heart rate recording [31]. Both studies confirm the finding that new methods can detect sleep apnoea only from HRV changes to a good extent [31]. Thus, it seems that simplified recording techniques can be used in combination with sophisticated analysis techniques to detect sleep disorders. The 2021 review study provides, among other things, an overview of the physiological basis for measuring heart rate and heart rate variability in wearable devices and summarises some of the strengths and limitations of consumer devices [32]. The latest pacemakers already offer an optional indication of sleep apnoea based on an analysis of past heart rate records stored in their memory. As a result, more cardiologists using long-term ECG recordings and using pacemaker heart rate extracts can identify patients with suspected sleep apnoea [33]. The physiology behind the HRV changes is remarkable and several aspects of heart-lung interactions have been elucidated to date. Therefore, it is interesting to investigate the time course of sympathetic and parasympathetic activation during apnoea and subsequent breaths [26]. The time course of activation of the autonomic nervous system has been described by sympathetic nerve activity, but the time course of parasympathetic activity has not been determined. It is quite likely that both sympathetic and parasympathetic activity increase at the end of each period of apnoea and then decrease over a short period of compensatory hyperventilation. However, volumetric hyperventilation in healthy subjects was associated with a predominance of sympathetic disease, but changes in haemodynamics and sympathovagal balance were smaller in patients with heart failure and arterial hypertension [34]. In a 2019 study, Festic et al. (35) observed changes in HRV and nocturnal pulse oximetry in subjects with an oxygen desaturation index of less than 5 events/h and found that the episodic increase in HRV occurring with minimal oxygen desaturation in normal nocturnal oximetry is a strong independent predictor of OSA, despite the increased use of drugs to control the heart rate in patients with OSA. It is possible that some quantifiable methods such as nocturnal pulse oximetry and pulse monitoring may provide better predictive power given the severity of OSA [35].

Impact of obstructive sleep apnoea treatment on heart rate variability

CPAP is still the gold standard treatment for moderate to severe obstructive sleep apnoea. CPAP treatment affected changes in heart rate variability in patients with OSA; these changes are more significant using frequency analysis compared to time analysis and they are also noticeable in medium

and long periods of treatment with significant modifications in terms of decreased sympathovagal imbalance and increased vagal component (HF) [36]. In a meta-analysis by Guo et al. [37], the researchers point out that CPAP treatment for at least 1 month in patients with obstructive sleep apnoea is likely to improve sympathovagal imbalance, which may be one mechanism by which CPAP could reduce the risk of cardiovascular disease in patients with OSA.
Kufoy et al. [38] emphasise that heart rate variability parameters acutely improve regardless of gender and weight on the first night of CPAP use in patients with severe OSA and therefore CPAP treatment should not be delayed; conversely, patients with severe OSA should be informed that even a single night without CPAP results in changes in HRV that are adjusted by CPAP treatment.

Conclusion

In conclusion, OSA is a highly prevalent but also largely underdiagnosed condition. Early diagnosis and satisfactory treatment are critical to prevent numerous OSA sequalae. In order to improve the healthcare process in the public health sector, the liaison between primary care physicians and sleep specialists is needed. Considering the continually increasing prevalence of obesity and diabetes worldwide, we can expect the epidemic of OSA to become exacerbated in the near future.

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