

Sleep breathing disorders

Introduction



Key points

- Obstructive sleep apnoea syndrome (OSAS) is a major public health problem across Europe.
- Obesity is a major risk factor for OSAS but a significant minority of affected individuals are nonobese.
- The main treatment for OSAS is continuous positive airway pressure – a highly effective and economical intervention.
- Untreated OSAS greatly increases the risk of accidents due to sleepiness.
- Obesity hypoventilation syndrome is an increasing public health issue.

The term 'sleep disordered breathing' encompasses a range of conditions characterised by abnormal breathing during sleep; in many cases this is associated with narrowing or obstruction of the upper airway (pharynx). The disordered breathing ranges from intermittent, partial obstruction of the airway without sleep disturbance (snoring) to, at the other end of the spectrum, frequent apnoeas associated with repetitive hypoxaemia and arousals leading to sleep disruption and daytime sleepiness. The term 'obstructive sleep apnoea' (OSA) refers to intermittent obstruction of the airway, irrespective of the presence of daytime symptoms. If symptoms result, the condition is called obstructive sleep apnoea syndrome (OSAS), also known as obstructive sleep apnoea/hypopnoea syndrome (OSAHS).

Sleep disordered breathing also includes: 1) central sleep apnoea (CSA), in which periodic cessation of breathing occurs without obstruction of the airway and which, in adults, is seen mainly in heart failure; and 2) obesity hypoventilation syndrome (OHS) in which breathing is reduced throughout sleep, with or without accompanying narrowing or obstruction of the upper airway.

Sleep disordered breathing is very common in Europe but no statistics are collected routinely on the associated morbidity or mortality.

This chapter will focus primarily on OSAS, which is a major public health problem in most developed countries.

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In few other conditions is a simple treatment so effective and cost-efficient as continuous positive airway pressure in obstructive sleep apnoea syndrome

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Epidemiology



OSAS is common, underdiagnosed and eminently treatable. In developed countries, it is reported to affect between 3–7% of middle-aged men and 2–5% of women. It is diagnosed on the basis of symptoms (usually daytime sleepiness) plus objective evidence of disordered breathing during sleep. The condition is characterised by frequent obstruction of the upper airway during sleep, resulting in repetitive breathing pauses accompanied by oxygen desaturation (reduced oxygen in the blood) and arousal from sleep. The sleep disruption results in daytime sleepiness and, in the long term, it can lead to cognitive impairment and cardiovascular morbidity. The clinical presentation of, and diagnostic criteria for, sleep disordered breathing are different for adult and paediatric cases. The prevalence of OSAS is higher in certain groups, particularly in the obese, and in various medical conditions, for instance Down syndrome. Many epidemiological studies have focused simply on the prevalence of obstructive breathing pauses at night (OSA) without taking the daytime consequences into account. This has introduced a degree of confusion into the epidemiological literature and contributed to the fluidity of the terminology.

The definition of OSAS

OSAS is characterised by episodes of upper airway occlusion: these are termed apnoeas if the airway is completely occluded and hypopnoeas if the occlusion is partial. An obstructive apnoea is defined pragmatically as the cessation of airflow despite continued breathing efforts for at least 10 s. At their termination, apnoeas/hypopnoeas are often, but not always, associated with a change in the electroencephalographic (EEG) signal indicative of arousal and with a drop in blood oxygen saturation. In most instances, such brief arousals are not accompanied by complete awakening and the patient is usually unaware of them. The definition of hypopnoea is rather variable, depending on the type of equipment used to measure breathing, but the core of the definition, as adopted by the American Academy of Sleep Medicine (AASM), is a 30–50% reduction in thoraco-abdominal movement from the preceding stable baseline for at least 10 s. The current (2012) AASM guidelines add an accompanying 3% desaturation or an arousal. However, in some centres, older definitions of hypopnoea are still in use.

An AASM task force in 1999 defined the severity of OSAS on the basis of two separate components: daytime sleepiness and the degree of breathing disturbance measured by overnight monitoring. The commonly used method of assessing sleepiness is discussed further below. The severity of sleep-related obstructive breathing events is assessed using the apnoea/hypopnoea index (AHI) and is graded as mild (5–15 events per h of sleep), moderate (15–30 events per h of sleep) or severe (more than 30 events per h of sleep). Although a good general working classification, this does not take into account age- or sex-related variations. There are very few normative data on either sleepiness or AHI in the healthy population.

The pathophysiology of OSAS

The pharynx is the site of upper airway obstruction during sleep in OSAS. In general, any pathological change or normal variant that narrows the upper airway when awake will predispose the individual to obstructive apnoea or hypopnoea when asleep. Obesity is the single most common predisposing factor, but patients with OSAS may have other contributory factors that narrow the upper airway, such as a large tongue, enlarged tonsils, increased total soft tissue in the pharynx or a repositioned mandible (receding jaw) (figure 1).

During inspiration, the air pressure in the pharynx is below atmospheric pressure, and the size of the pharyngeal lumen depends on the balance between the narrowing force that results from this suction pressure and the dilating force generated by the small muscles attached to the upper airway, which contract with each inspiration and normally stabilise the

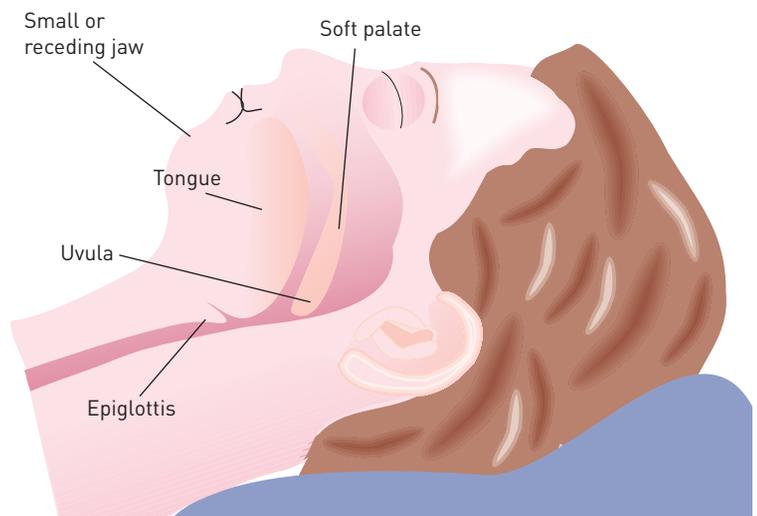


Figure 1 – Cross-section of the back of the pharyngeal area, showing the mechanism of obstruction of the upper airway (in red) during sleep.

floppy walls of the pharynx. At sleep onset, there is a reduction in pharyngeal luminal area and a reduction in upper airway muscle activity, both of which are exaggerated in OSAS. Surface mucosal factors may also influence airway patency, especially in subjects with mucosal inflammation from repetitive trauma and resultant loss of sensation.

Each apnoea or hypopnoea is terminated by an arousal, which is accompanied by a surge in heart rate and blood pressure. In many individuals, the increased blood pressure persists by day, with its attendant risk of developing cardiovascular disease and stroke.

Risk factors for OSAS

The prevalence of OSAS increases with age and reaches a plateau after 60 years of age. However, recent cross-sectional data on more than 5000 subjects have shown significant proportions of people ≥ 70 years of age continuing to present with symptomatic disease.

An association between obesity and OSAS has been noted in many studies, with moderate or severe obesity [body mass index (BMI) $> 30 \text{ kg}\cdot\text{m}^{-2}$] in 60–90% of patients with OSAS. Central obesity, characterised by a high waist-to-hip ratio or large neck circumference, correlates better with OSAS than BMI, even in people with a normal BMI.

OSAS is more common in men than women. This has been attributed to differences in anatomical and functional properties of the upper airway, differences in craniofacial morphology and fat deposition, and different ventilatory responses to arousal from sleep. However, health professionals need to be particularly alert to the possibility of OSAS in women, as male bed partners may be less aware of the symptoms of obstructive breathing during sleep. The disease prevalence is higher in post-menopausal women and hormone replacement therapy is associated with a lower prevalence; the prevalence of OSAS increases during pregnancy, particularly in the third trimester.

First-degree relatives of patients with OSAS have an increased risk of developing the disorder. The genetic determinants of craniofacial features, obesity and regional fat distribution are also relevant. Congenital conditions affecting craniofacial development, such as Marfan syndrome, Down syndrome and the Pierre Robin sequence, predispose to OSAS, as do acromegaly and hypothyroidism.

Smoking is associated with a higher prevalence of snoring and OSAS, and alcohol can increase upper airway collapsibility leading to apnoeas.

Muscle-relaxant medication (sedative hypnotic drugs, opiates), sleep deprivation and supine posture can all exacerbate OSAS, although the degree to which sleep disordered breathing is worsened in the individual may depend on the predominant pathological mechanism in the individual patient and his or her intrinsic physiological responses.

Reduced nasal patency, due to congestion or anatomical defects, as well as respiratory allergy are also potential contributors.

Clinical manifestations and consequences



The symptoms of OSAS can be classified as those manifesting during sleep and those present during wakefulness (table 1). The most common complaint is excessive daytime sleepiness (EDS). However, EDS is not present in all patients with OSA and

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During sleep	While awake
Loud snoring/snorting	Daytime sleepiness
Witnessed apnoeas by bed partner	Non-restorative sleep
Awakening with choking	Lack of concentration
Nocturnal restlessness	Cognitive deficits
Vivid, strange or threatening dreams	Changes in mood
Gastro-oesophageal reflux	Morning headaches
Insomnia with frequent awakenings	Dry mouth
Nocturia (urination at night)	Impotence or decreased libido
Hypersalivation, teeth grinding	
Diaphoresis (sweating)	

Table 1 – Symptoms of obstructive sleep apnoea syndrome. Adapted from RIHA, 2010, with permission from the publisher.

consideration should be given to other causes of diurnal sleepiness, such as shift work, medication and alternative diagnoses – periodic limb movement disorder and narcolepsy, for example.

Nocturnal symptoms of OSAS are generally reported by a bed partner. The most common are snoring (which is almost always a feature), snorting, choking attacks terminating a snore, and witnessed apnoeas. Apnoeic episodes are reported by about 75% of bed partners.

A number of clinical features are associated with OSAS (table 2), but the predictive value of any single one for diagnosis is limited and not all will co-exist in the same patient. History and clinical examination alone (including blood pressure and BMI) can predict the presence of OSAS in only 50% of patients attending a sleep disorders clinic: definitive diagnosis requires overnight investigation.

Obesity (particularly central, BMI >30 kg.m ⁻²)
Large neck circumference (>40 cm)
Small mandible, small maxilla
Retrognathia (back-set jaw)
Dental malocclusion, overbite
Reduced nasal patency
High and narrow hard palate
Elongated and low-lying uvula
Enlarged tonsils and adenoids
Macroglossia (large tongue)

Table 2 – Clinical features of obstructive sleep apnoea syndrome. BMI: body mass index. Adapted from RIHA, 2010, with permission from the publisher.

Recording and measuring sleep and breathing during the night

Previously, the most widely used method for the diagnosis of OSAS was detailed overnight polysomnography (PSG), but simpler diagnostic investigations are increasingly being used and these often take place in the patient's home rather than in hospital. PSG remains the gold standard by which most newer developments in the measurement of breathing during sleep are assessed. PSG simultaneously monitors:

- nasal and/or oral airflow
- thoraco-abdominal movement
- snoring
- electroencephalogram (EEG)
- electro-oculogram (EOG)
- electromyogram (EMG)
- oxygen saturation

Video recording of any abnormal movements may help identify other disorders. For accurate interpretation, manual scoring of the PSG recording is necessary, using guidelines for the interpretation of the EEG (sleep trace) and for the scoring of respiratory and other events.

Simplified recording systems are increasingly used (respiratory PSG or polygraphy). These measure airflow, respiratory effort, oxygen saturation and heart rate, but not EEG. Their advantages are greater capacity of service, lower cost and better portability and convenience to patients, who can set up the equipment in their own homes. Overnight oximetry is sometimes used as a screening test for identifying patients with OSAS but there are significant limitations to using oximetry alone.

Assessing daytime sleepiness

Sleepiness is difficult to define objectively and a wide variety of behavioural, performance-related, electrophysiological and questionnaire-based tests have been used. The most widely used and best validated and pragmatic scale for assessing daytime sleepiness is the Epworth Sleepiness Scale (ESS). This asks the subject to grade the likelihood of falling asleep in each of eight everyday situations (each scored from 0 to 3). An ESS score of greater than 11 out of 24 generally indicates abnormal daytime sleepiness, irrespective of age. However, as with any subjective measurement, the ESS can be prone to misinterpretation by the patient and, of course, a high score may be due to causes other than OSAS.

Consequences

OSAS is an independent risk factor for hypertension and is associated with an increased risk of cardiovascular disease, abnormal glucose metabolism, depression and sleepiness-related accidents.

OSAS is not generally recognised as a specific cause of death and therefore is not routinely reported on death certificates. However, a number of databases are being created to document OSAS – in France and Denmark, for instance. The association with cardiovascular, cerebrovascular and metabolic disorders implies that OSAS contributes to increased morbidity and mortality in the general population.

Untreated OSAS increases the rate of road traffic accidents and work-related and domestic accidents. A recent meta-analysis has shown that most medical conditions

confer an increased risk of a driving accident (between 1.2–2-fold compared to the healthy population). By contrast, OSAS was associated with a large increase in risk of a motor vehicle accident, with a relative risk of 3.7; this was second only to age and sex as a general risk factor.

Undiagnosed OSAS results in higher medical costs than those incurred by age- and sex-matched healthy individuals and the more severe the disease, the greater the medical cost. Even a single road accident due to sleepiness caused by OSAS can incur considerable health costs.

There has been no comprehensive evaluation of the financial burden of OSAS across Europe. However, reports from several countries have evaluated healthcare consumption, cost-effectiveness/utility of treatment and treatment costs. These are summarised in the further reading list. Table 3 illustrates the comparative cost-effectiveness of treating OSAS compared to 'doing nothing' across four different countries.

Prevention



As previously discussed in this chapter, a number of risk factors can predispose to, or exacerbate, OSAS. Targets for primary prevention are already integrated into many public health strategies, including campaigns focused on obesity, smoking and excessive alcohol consumption.

Prior to diagnosis, OSAS is associated with a large number of medical complaints and with annual healthcare costs per person of 50–100% more than those for the general population. In adults, these excess costs are attributable to cardiovascular disease, digestive problems and metabolic disease, while in children they are mainly due to ear, nose and throat (ENT) and respiratory conditions. Therefore, primary care physicians as well as physicians in a variety of specialties need to be aware of OSAS and sleep disordered breathing in order for the problem to be diagnosed and treated as promptly

	UK	Canada	Spain	Canada
Cost-effectiveness#	£1400	US\$3354	€7861	>US\$9792
AHI of patients events-h⁻¹	>30	>15	41.3±14.6	67.6±24.3
ESS of patients¶	12		13.8±5.8	

Table 3 – Cost-effectiveness studies for continuous positive airway pressure treatment of obstructive sleep apnoea syndrome. Parameters are given as mean values ± standard deviation. AHI: apnoea/hypopnoea index; ESS: Epworth Sleepiness Scale. #: cost per quality-adjusted life year; ¶: out of 24. Reproduced and modified from MWENGE and RODENSTEIN (in McNICHOLAS and BONSIGNORE, 2010).

as possible. Secondary prevention therefore includes screening patients with the above conditions for symptoms potentially related to OSAS.

Management



Once OSAS is diagnosed, its treatment is relatively straightforward. Lifestyle measures, such as weight loss, alcohol consumption and smoking should be addressed. However, the commonest and most rapidly effective treatment for moderate-to-severe OSAS is with nocturnal continuous positive airway pressure (CPAP) (figure 2). This is usually delivered through the upper airway using a mask over the nose, or the nose and mouth, attached by a hose to an air compressor that generates a flow of air at positive pressure throughout the breathing cycle, of sufficient magnitude to keep the upper airway open and prevent it from collapsing. CPAP thereby acts as a pneumatic splint for the upper airway. Unfortunately, CPAP does not permanently restore or correct the problems leading to upper airway obstruction; it therefore needs to be applied throughout each night for maximum effect. If well tolerated and used consistently, CPAP has been shown to reverse or ameliorate the somnolence, cognitive deficit, reduced health status, hypertension and metabolic disturbances associated with OSAS.

In snoring or mild OSAS, an alternative therapy may be used: the mandibular repositioning device (MRD) (figure 3). This device may also be useful in patients who cannot or will not tolerate or adhere to CPAP. Although less reliably effective than CPAP, MRDs can be used as adjuncts to CPAP therapy. They should always be constructed by a trained professional.

Other potential treatments include: tonsillectomy, where appropriate and especially in children; upper airway surgery in exceptional cases where significant craniofacial abnormalities are present; and bariatric surgery for those in whom severe obesity is the primary contributor to OSAS. Stimulation of the hypoglossal nerve through implanted



Figure 2 – Continuous positive airway pressure equipment. ©iStockphoto David Cannings-Bushell.

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Waiting lists for assessment and treatment of obstructive sleep apnoea syndrome are a serious problem for both patients and medical staff – facilities need to expand

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Figure 3 – A mandibular advancement device. Reproduced from Tsujiki *et al.*, 2010.

electrodes is increasingly being trialled in patients with OSAS who fail to respond to more conventional modes of therapy, though this treatment remains very much under development. No effective pharmacological therapies are currently available.

As with other forms of long-term treatment, adherence requires application of the specific treatment by trained personnel and long-term follow-up.

In few other chronic medical conditions is a simple treatment so rapidly effective and cost-efficient as CPAP in OSAS.

Prognosis



Once recognised and treated appropriately, the available data suggest that the prognosis for OSAS is very good and reverts to that of the non-OSAS population, particularly in terms of cardiovascular mortality and morbidity. However, because patients with significant sleepiness need symptomatic treatment with CPAP, it is not ethically acceptable to undertake long-term randomised, placebo-controlled trials in the optimal population to determine its effect on cardiovascular morbidity and mortality; rather, the evidence has to be obtained more indirectly from case-controlled or cohort studies with all of their inherent biases.

Obesity hypoventilation syndrome

OHS is increasingly recognised as a significant public health issue, particularly in the context of the obesity epidemic that is occurring in many countries. However, its prevalence in Europe is unknown.

OHS is defined as the combination of obesity (BMI > 30 kg·m⁻²), hypercapnic (type II) respiratory failure (arterial carbon dioxide partial pressure greater than 45 mmHg or 6.5 kPa) and sleep disordered breathing when all other causes of type II respiratory failure have been excluded. This is unlike uncomplicated OSAS, in which the awake arterial carbon dioxide level is normal. The pathophysiology of OHS is complex, resulting from the interaction between OSA, decreased ventilatory drive and reduced compliance of the chest and abdominal walls caused by obesity.

The problem is under-recognised, with the corollary that the severe respiratory and cardio-metabolic consequences are not being adequately treated, which increases health-related costs and the risk of hospitalisation and death. There are very few well-conducted trials in the area, but the best treatment in terms of reducing mortality is noninvasive ventilation (NIV), which, like CPAP, is delivered *via* a face mask. Unlike CPAP, which provides almost constant pressure throughout the respiratory cycle, NIV provides higher inspiratory pressures than expiratory pressures, in order to assist ventilation; frequently, additional oxygen is also required.

Weight loss is an effective treatment for OHS but is often difficult to achieve without additional intervention such as bariatric surgery.

The limited evidence available suggests that early recognition, intervention and treatment saves lives and limits complications and costs to both the patient and society, but that this is occurring in a minority of instances, both in primary and secondary care settings.

Future developments and research needs



There needs to be a continued effort to better define specific populations with OSAS and to learn which of these populations will respond most favourably to the various forms of treatment available.

Future developments should include devoting more resources to targeted prevention and raising awareness of OSAS. Individuals who are sleepy, who snore and, particularly, those who experience sleepiness while driving, should be encouraged to seek medical advice. Secondary prevention needs to be expanded by improved screening of those presenting with suggestive symptoms and those with associated cardio-metabolic comorbidities. And finally, tertiary prevention, *i.e.* the treatment of patients with OSAS, involves expanding facilities to provide timely investigation and treatment of the large number of patients currently undiagnosed or untreated. As the prevalence of OSAS within the community is considerable, and, in many countries, is being further exacerbated by the current obesity epidemic, the resources needed are large and require commitment by national governments.

National health and transport authorities need to recognise the common and potentially severe effects on driving (both privately and commercially) of sleepiness due to OSAS – a phenomenon that puts both the individual and the general public at risk. The problem needs to be formally recognised by appropriate legislation, which is sorely lacking in many European countries.

In most European countries, waiting lists for assessment and treatment of OSAS are a serious problem for both patients and medical staff – facilities need to be expanded. High-priority research needs in OSAS include the following:

- Epidemiological studies of the prevalence of OSAS and OHS across Europe
- Assessment of the impact of OSAS and its severity on mortality, cardiovascular disease and type II diabetes mellitus.
- Analyses of the cost-effectiveness of various management strategies for OSAS patients according to disease severity, including long-term outcomes.
- Comparative cost-benefit analyses of different OSAS treatments (CPAP *versus* MRD *versus* surgery) stratified according to patient characteristics, disease characteristics and comorbidities, and including long-term outcomes, *e.g.* severe OSAS in patients with Down syndrome and elderly patients with mild disease.
- Investigation of: treatment adherence strategies for the various treatment modalities available; financial considerations in implementing treatment; and the role of specialised sleep services in the assessment and management of OSAS, *e.g.* should OSAS remain a secondary/tertiary care problem or be devolved into primary care with referral of only difficult cases?

A number of studies are in progress addressing OSAS in the ageing population and in children. It is important to recognise that some populations, such as the elderly, the very young, the intellectually disabled and those with particular morbidities, may have different treatment needs and responses to treatment.

Although not successful to date, the search for a pharmacological treatment for OSAS that can be used together with current treatment modalities for OSAS should be encouraged.

Further effort is needed to simplify diagnostic approaches while maintaining accuracy, including increasing the use of polygraphy and using new technologies, such as telemedicine, to diagnose and monitor patients. Since publication of the first edition of this book in 2003, these needs have not been adequately addressed and have not been met by the requisite public health and research funding. Funding should also be directed towards greater public awareness of the common risk factors for OSAS such as obesity and relevant craniofacial variants. Orthodontic treatments instituted in early life might come to play a more important role in prevention.

Longitudinal cohort studies of OSAS are few and should be instituted as the significance of this disorder in children and young adults is increasingly recognised.

Further reading



General

- Hedner J, Grote L, Bonsignore M, *et al.* The European Sleep Apnoea Database (ESADA): report from 22 European sleep laboratories. *Eur Respir J* 2011; 38: 635–642.
- Jennum P, Kjellberg J. Health, social and economical consequences of sleep-disordered breathing: a controlled national study. *Thorax* 2011; 66: 560–566.
- Leger D, Bayon V, Laaban JP, *et al.* Impact of sleep apnea on economics. *Sleep Med Rev* 2012; 16: 455–462.
- McNicholas WT, Bonsignore MR, eds. Sleep Apnoea. *Eur Respir Monogr* 2010; 50.
- Riha RL. Clinical assessment of the obstructive sleep apnoea/hypopnoea syndrome. *Thorax* 2010; 4: 83–91.
- Riha RL, Gislason T, Diefenbach K. The phenotype and genotype of adult obstructive sleep apnoea/hypopnoea syndrome. *Eur Respir J* 2009; 33: 646–655.
- Sjösten N, Vahtera J, Salo P, *et al.* Increased risk of lost workdays prior to the diagnosis of sleep apnea. *Chest* 2009; 136: 130–136.

Epidemiology

- Duran J, Esnaola S, Rubio R, *et al.* Obstructive sleep apnea-hypopnea and related clinical features in a population-based sample of subjects aged 30 to 70 yr. *Am J Respir Crit Care Med* 2001; 163: 685–689.
- Jennum P, Riha RL. Epidemiology of sleep apnoea/hypopnoea syndrome and sleep-disordered breathing. *Eur Respir J* 2009; 33: 907–914.

Management

- Brevi BC, Toma L, Magri AS, *et al.* Use of the mandibular distraction technique to treat obstructive sleep apnea syndrome. *J Oral Maxillofac Surg* 2011; 69: 566–571.
- Mar J, Rueda JR, Durán-Cantolla J, *et al.* The cost-effectiveness of nCPAP treatment in patients with moderate-to-severe obstructive sleep apnoea. *Eur Respir J* 2003; 21: 515–522.
- McDaid C, Griffin S, Weatherly H, *et al.* Continuous positive airway pressure devices for the treatment of obstructive sleep apnoea-hypopnoea syndrome: a systematic review and economic analysis. *Health Technol Assess* 2009; 13: 1–274.
- Parati G, Lombardi C, Hedner J. Position paper on the management of patients with obstructive sleep apnea and hypertension: joint recommendations by the European Society of Hypertension, by the European Respiratory Society and by the members of European COST (COoperation in Scientific and Technological research) ACTION B26 on obstructive sleep apnea. *J Hypertens* 2012; 30: 633–646.
- Tsuiki S, Kobayashi M, Namba K, *et al.* Optimal positive airway pressure predicts oral appliance response to sleep apnoea. *Eur Respir J* 2010; 35: 1098–1105.
- Weatherly HL, Griffin SC, Mc Daid C, *et al.* An economic analysis of continuous positive airway pressure for the treatment of obstructive sleep apnea-hypopnea syndrome. *Int J Technol Assess Health Care* 2009; 25: 26–34.

Driving

- Alonderis A, Barbé F, Bonsignore M, *et al.* Medico-legal implications of sleep apnoea syndrome: driving license regulations in Europe. *Sleep Med* 2008; 9: 362–375.
- Rodenstein D, Cost-B26 Action on Sleep Apnoea Syndrome. Driving in Europe: the need of a common policy for drivers with obstructive sleep apnoea syndrome. *J Sleep Res* 2008; 17: 281–284.

Obesity hypoventilation syndrome

- Borel JC, Borel AL, Monneret D, *et al.* Obesity hypoventilation syndrome: from sleep-disordered breathing to systemic comorbidities and the need to offer combined treatment strategies. *Respirology* 2012; 17: 601–610.