Obstructive sleep apnoea in persons with diabesity: A clinical management perspective

Maria Pallayova, Shahrad Taheri

Citation: Pallayova M, Taheri S (2013) Sleep apnoea in persons with diabesity: A clinical management perspective. *Diabesity in Practice* **2**: 62–71

Article points

1. The coexistence of three highly prevalent conditions – obesity, obstructive sleep apnoea and type 2 diabetes – places affected individuals at a significantly increased morbidity and mortality risk.
2. Untreated obstructive sleep apnoea has a negative impact on type 2 diabetes, and the interrelationship between obstructive sleep apnoea and obesity is complex.
3. The diagnosis of obstructive sleep apnoea includes a comprehensive sleep evaluation.
4. Guidelines have been developed to tailor obesity, obstructive sleep apnoea and type 2 diabetes therapies to patients according to the severity of the disorders, comorbid diseases and patient preference.

Key words

- Obesity
- Obstructive sleep apnoea
- Positive airway pressure
- Type 2 diabetes
- Weight loss

Authors

Maria Pallayova, Research Fellow, Shahrad Taheri, Senior Lecturer in Endocrinology, Heart of England NHS Foundation Trust and University of Birmingham, Birmingham.

The coexistence of obesity, obstructive sleep apnoea and type 2 diabetes – three highly prevalent conditions – is a significant risk factor for increased morbidity and mortality. The adverse health and social consequences of this vicious triangle warrant increased clinical awareness and therapeutic attention to raise the standard of practice, and improve clinical outcomes and patient safety. Using a multidisciplinary approach, the present article aims to provide up-to-date discussion on the prevalence and impact of obstructive sleep apnoea in people with coexistent type 2 diabetes and obesity, describe the clinical aspects of management and treatment, and make recommendations to assist healthcare professionals with the management of obese people with type 2 diabetes and obstructive sleep apnoea. In summary, the diagnosis of obstructive sleep apnoea needs to be considered in all obese people with type 2 diabetes. All patients with obesity, obstructive sleep apnoea and type 2 diabetes should have ongoing, long-term management for their chronic disorders. Guidelines have been developed to tailor therapies to patients according to the severity of the disorders, comorbid diseases and patient preference. Successful implementation of these guidelines requires close liaison between primary care and specialist services.

Over the past three decades, the number of people with type 2 diabetes worldwide has more than doubled, largely being driven by the rising prevalence of obesity (Chen et al, 2011). Besides obesity, obstructive sleep apnoea is increasingly being recognised as a potential independent risk factor for the development of type 2 diabetes (Botros et al, 2009; Marshall et al, 2009; Muraki et al, 2010), particularly in obese individuals. The coexistence of the three highly prevalent conditions – obesity, obstructive sleep apnoea and type 2 diabetes – places affected individuals at a significantly increased morbidity and mortality risk. Using a multidisciplinary approach to this modern epidemic, the present article aims to provide up-to-date discussion on the prevalence and impact of obstructive sleep apnoea in people with coexistent type 2 diabetes and obesity, describe the clinical aspects of management and treatment, and make recommendations to assist healthcare professionals with the management of obese people with type 2 diabetes and obstructive sleep apnoea.

Prevalence

Obstructive sleep apnoea is a highly underdiagnosed sleep-related breathing disorder. The prevalence of the condition in the general population varies depending on its definition. Approximately 2–7% of the general adult population (3–7% in men and 2–5% in women) has obstructive sleep apnoea, defined as having an apnoea–hypopnoea index (AHI, defined as the

number of apnoea and hypopnoea events per hour of sleep) of ≥5 events per hour, accompanied by ≥1 symptom that is known to respond to treatment, for example, excessive daytime sleepiness (Lurie, 2011).

In contrast, the prevalence of obstructive sleep apnoea has been found to be much higher in people with type 2 diabetes than in the general population (Einhorn et al, 2007). Using a single-channel screening tool for sleep apnoea, Einhorn et al examined 279 consecutive adults with type 2 diabetes and found that 36% (49% of men and 21% of women) had an AHI of ≥15 events per hour. These results were confirmed by performing gold standard polysomnography on a small subgroup of the cohort. Of importance, the prevalence of obstructive sleep apnoea in obese people is nearly twice that of normal-weight adults, which reflects the fact that obesity is a major risk factor for the development and progression of obstructive sleep apnoea. As well as obesity, other factors such as airway anatomy and control are also important.

The prevalence of obstructive sleep apnoea in obese people with type 2 diabetes has been investigated in the Sleep AHEAD (Action for Health in Diabetes) arm of the Look AHEAD study (Foster et al, 2009). The investigators have found that 86% of the 306 patients with type 2 diabetes and BMI >30 kg/m^2 who underwent polysomnography had obstructive sleep apnoea as indicated by an AHI of ≥5 events per hour, with a mean AHI of 20.5 events per hour (Foster et al, 2009). More importantly, a total of 30.5% of the participants had moderate obstructive sleep apnoea (AHI ≥15 events per hour) and 22.6% had severe obstructive sleep apnoea (AHI ≥30 events per hour). These findings strongly indicate that the coexistence of obesity and type 2 diabetes is linked with an extremely high prevalence of obstructive sleep apnoea and possibly also with the associated risks and sequelae of this sleep disorder.

Characteristics

Obstructive sleep apnoea is characterised by recurrent episodes of upper airway collapse and obstruction during sleep due to defects in pharyngeal structure and neuromuscular control (McGinley et al, 2008). The episodes of apnoea and hypopnoea are associated with recurrent oxyhaemoglobin desaturations and arousals from sleep. If left untreated, obstructive sleep apnoea can lead to a variety of cardiovascular (Mannarino et al, 2012), metabolic (Punjabi et al, 2004), neuroendocrine (Gianotti et al, 2002), inflammatory (Selmi et al, 2007) and other consequences, including an increased occurrence of perioperative complications (Vasu et al, 2012). Given the pathogenic mechanisms underlying the development of the condition and the consequences of untreated disease, obstructive sleep apnoea is no longer considered just a local breathing disorder.

Impact on type 2 diabetes and its complications

The consequences of untreated obstructive sleep apnoea on type 2 diabetes have been explored in a number of studies investigating the impact of the sleep disorder on glucose control and on the development and progression of chronic diabetes complications. The two primary physiological disturbances in obstructive sleep apnoea – acute periods of hypoxic stress and sleep fragmentation – have been shown to potentially impair glucose homeostasis (Oltmanns et al, 2004; Stamatakis and Punjabi, 2010), and the negative impact of obstructive sleep apnoea on glucose control has been suggested by further studies (Aronsohn et al, 2010; Priou et al, 2012).

There is only one meta-analysis that looked at the effect of continuous positive airway pressure (CPAP), the current gold standard treatment of obstructive sleep apnoea, on glucose homeostasis in type 2 diabetes (Iftikhar and Blankfield, 2012). The meta-analysis included eight observational studies and randomised controlled trials with a total of 67 persons with type 2 diabetes. The meta-analysis showed the mean net change in HbA_{1c} was 0.16% (95% CI, –0.26 to 0.58; P=0.45), indicating that CPAP did not reduce HbA_{1c} levels in people with type 2 diabetes when used in the short term. However, it is important to point out that the studies in the meta-analysis included participants with relatively well-controlled type 2 diabetes (average HbA_{1c} 51 mmol/mol [6.8%]) and that there is limited scope for further improvement of HbA_{1c} through CPAP in these people.

Page points

1. The prevalence of obstructive sleep apnoea has been found to be much higher in people with type 2 diabetes, especially those who are obese, than in the general population.
2. Obstructive sleep apnoea is characterised by recurrent episodes of upper airway collapse and obstruction during sleep due to defects in pharyngeal structure and neuromuscular control.
3. The two primary physiological disturbances in obstructive sleep apnoea – acute periods of hypoxic stress and sleep fragmentation – have been shown to potentially impair glucose homeostasis, and the negative impact of obstructive sleep apnoea on glucose control has been suggested by further studies.

Page points

1. Studies have demonstrated that sleeping glucose levels decreased and were more stable after patients were treated with continuous positive airway pressure.
2. Evidence suggests that both obstructive sleep apnoea and type 2 diabetes share common increased susceptibility to oxidative stress; the consequences of obstructive sleep apnoea may thus extend beyond the negative impact on glucose control in type 2 diabetes.
3. Obesity is a well-established risk factor for the development and progression of obstructive sleep apnoea, which may in turn cause weight gain.

Despite the lack of large randomised controlled trials assessing the acute effects of ventilatory treatment on immediate glucose control in type 2 diabetes, two small independent interventional studies based on continuous glucose monitoring and parallel polysomnography have been conducted so far in people with type 2 diabetes. Both studies (Dawson et al, 2008; Pallayova et al, 2008) have demonstrated that sleeping glucose levels decreased and were more stable after patients were treated with CPAP. Of importance, the increased nocturnal glycaemic variability in persons with untreated moderate to severe obstructive sleep apnoea was strongly associated with nocturnal oxyhaemoglobin desaturations and was reversed by CPAP treatment (Pallayova et al, 2008). These findings suggest that hypoxic stress induced by obstructive sleep apnoea could be an independent contributor to dysglycaemia of type 2 diabetes.

With respect to the impact of obstructive sleep apnoea on the development and progression of chronic diabetes complications, the current evidence (though limited by the lack of prospective studies) suggests that both obstructive sleep apnoea and type 2 diabetes share common increased susceptibility to oxidative stress (Brownlee, 2005; Yamauchi et al, 2005). The consequences of obstructive sleep apnoea may thus extend beyond the negative impact on glucose control in type 2 diabetes, while also increasing the risk of damaging vulnerable endothelial cells in the retina, mesangial cells in the renal glomerulus, and neurons and Schwann cells in peripheral nerves.

Relationship with obesity

The interrelationship between obstructive sleep apnoea and obesity is complex. Accumulating evidence provides support to the model of the bidirectional detrimental association between them. Obesity is a well-established risk factor for the development and progression of obstructive sleep apnoea. It has also been suggested that obstructive sleep apnoea may itself cause weight gain (Phillips et al, 2000). Phillips et al prospectively studied 32 obese otherwise healthy men with newly diagnosed obstructive sleep apnoea and 32 similarly obese men without the condition, and demonstrated that plasma leptin levels were significantly elevated in men with obstructive sleep apnoea independent of body fat content. These findings indicate that obstructive sleep apnoea is associated with resistance to the weight-reducing effects of leptin, which could be due to noradrenergic activation of beta(3)-receptors on adipocytes affecting leptin signalling and predisposing to obesity and weight gain in obstructive sleep apnoea (Phillips et al, 2000).

Furthermore, substantial genetic overlap between obstructive sleep apnoea and obesity may influence the susceptibility to these conditions as well as the interrelationship between them. Specifically, Popko et al (2007) have reported that genetic polymorphisms of the leptin receptor are strongly linked to a higher risk of obesity and higher lipid levels in those with obstructive sleep apnoea. In another study, Patel et al (2008) have shown significant genetic correlations between AHI and anthropometric adiposity measures (ranging from 0.57 to 0.61), suggesting that obesity could explain nearly 40% of the genetic variance in obstructive sleep apnoea.

Finally, other factors, including excessive daytime sleepiness, lack of energy, reduced activity levels, increased appetite and insulin resistance, may also contribute to obesity and further weight gain in patients with obstructive sleep apnoea.

Diagnosis

Diagnostic criteria for obstructive sleep apnoea (*Table 1* and *Table 2*) are based on clinical signs and symptoms (*Table 3*) determined during a comprehensive sleep evaluation, which includes a sleep oriented history and physical examination, and findings identified by objective sleep testing (Adult Obstructive Sleep Apnoea Task Force of the American Academy of Sleep Medicine [AASM] Members, 2009).

Sleep history

A comprehensive sleep history in a patient with suspected obstructive sleep apnoea should include a history of snoring, witnessed apnoeas, gasping/choking episodes, excessive daytime sleepiness not explained by other factors, total sleep amount, nocturia, morning headaches, decreased concentration/memory, and presence of

Table 1. Diagnostic criteria for obstructive sleep apnoea (AASM, 2005).*

A. At least one of the following applies:

1. The patient complains of unintentional sleep episodes during wakefulness, daytime sleepiness, unrefreshing sleep, fatigue or insomnia.
2. The patient wakes with breath holding, gasping or choking.
3. The bed partner reports loud snoring, breathing interruptions or both during the patient's sleep.

B. Polysomnographic recording shows the following:

1. Five or more scoreable respiratory events (apnoea, hypopnoea or RERA) per hour of sleep.
2. Evidence of respiratory effort during all or a portion of each respiratory event.

C. Polysomnographic recording shows the following:

1. Fifteen or more scoreable respiratory events (apnoea, hypopnoea or RERA) per hour of sleep.
2. Evidence of respiratory effort during all or a portion of each respiratory event.

D. The disorder is not better explained by another sleep disorder, medical or neurological disorder, medication use or substance use disorder.

*Minimal criteria: A plus B plus D, or C plus D. AASM=American Academy of Sleep Medicine; RERA=respiratory event related arousal.

Table 2. Severity criteria for obstructive sleep apnoea (AASM Task Force, 1999).

Severity	AHI (events per hour)
Mild	5–15
Moderate	15–30
Severe	>30

AASM=American Academy of Sleep Medicine; AHI=apnoea–hypopnoea index.

comorbidities (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). Of importance, occasionally, the patient may be unaware of clinical features that are observed by others.

The following validated sleep questionnaires can be administered to facilitate the obtaining of a relevant sleep history: the Epworth Sleepiness Scale (ESS), the Berlin questionnaire, the STOP (Snoring, Tiredness during daytime, Observed apnoea, and high blood Pressure) questionnaire, the STOP-Bang (STOP with BMI, age, neck circumference, and sex variables) questionnaire, the American Society of Anesthesiologists screening checklist for obstructive sleep apnoea in surgical patients, and the Hawaii sleep questionnaire. Questionnaires, however, are generally unhelpful in making a diagnosis of obstructive sleep apnoea, but the ESS is useful for assessing the degree of sleepiness (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009; Balk et al, 2011).

Physical examination

The physical examination should include the respiratory, cardiovascular, neurologic and endocrine systems with emphasis on the presence of signs of congestive heart failure, atrial fibrillation, pulmonary hypertension, thyroid abnormalities, central obesity, retrognathia, tonsillar hypertrophy, enlarged uvula, signs of upper airway narrowing, nasal abnormalities (polyps, septal deviations, valve abnormalities or turbinate hypertrophy) and macroglossia. Important clinical features suggestive of obstructive sleep apnoea include increased neck circumference (>17 inches in men, >16 inches in women), waist circumference and sagittal-abdominal diameter, high BMI (≥30 kg/m^2), and a modified Mallampati score of 3 or 4 (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009).

Objective sleep testing

Objective sleep testing is based on the two accepted methods: in-laboratory polysomnography

Table 3. Signs and symptoms of obstructive sleep apnoea (adapted from Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009).

Major signs and symptoms	Other common signs and symptoms
Loud heavy chronic snoring	Morning headaches, a dry mouth or sore throat
Witnessed apnoea	Restless/fitful/unrefreshing sleep
Gasping/choking episodes during sleep	Decreased concentration/memory
Nocturnal cardiac arrhythmias	Irritability, changes in mood/behaviour
Nocturia	Anxiety or depression
Unexplained excessive daytime sleepiness	Decreased interest in sex, sexual dysfunction
Increased neck circumference, central obesity	Gastroesophageal reflux

and home testing with portable monitors (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009).

Polysomnography requires recording of the following physiologic signals: electroencephalogram, electrooculogram, chin electromyogram, airflow, oxygen saturation, respiratory effort, electrocardiogram, and – optionally – body position and leg electromyogram. The diagnosis of obstructive sleep apnoea is confirmed if the AHI is greater than 15 events per hour, or greater than 5 events per hour accompanied by more than one of the following symptoms: excessive daytime sleepiness, unintentional sleep episodes during wakefulness, unrefreshing sleep, fatigue, insomnia, waking up breath holding, gasping or choking, or the bed partner describing loud snoring, breathing interruptions or both during the patient's sleep (AASM, 2005).

Polysomnography is expensive and highly labour intensive, and patients may not prefer attending a sleep laboratory. Thus, home testing is generally employed in the UK NHS setting. Home testing with portable monitors should, at a minimum, record airflow, respiratory effort and blood oxygenation. It may be used as an alternative to polysomnography for the diagnosis of obstructive sleep apnoea in patients with a high pretest probability of moderate to severe obstructive sleep apnoea and no comorbid sleep disorder or major comorbid medical disorder including, but not limited to, moderate to severe pulmonary disease, neuromuscular disease or congestive heart failure (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). With respect to alternative devices for diagnosing obstructive sleep apnoea, data from a technology evaluation report indicate that peripheral arterial tonometry devices are adequate for the proposed use; the device based on cardiac signals shows promise, but more study is required because it has not been tested in the home setting (Collop et al, 2011). The devices available for home screening of the condition are highly cost-effective, allowing screening of patients within the primary care setting. Given the prevalence of obstructive sleep apnoea in patients with diabesity, such screening should be carried out on a regular basis and could be incorporated into the annual diabetes review.

Management approach

Current clinical practice guidelines emphasise an evidence-based approach and highlight the needs for prevention, early diagnosis and treatment of diseases. With respect to a high-risk population of obese people with type 2 diabetes and obstructive sleep apnoea, the multidisciplinary approach and timely specialist referral are essential to reduce the burden of significantly increased morbidity and mortality in these people. As the prevalence of diabesity and concurrent obstructive sleep apnoea continues to rise, the need for appropriate evidence-based management is becoming increasingly crucial. The current management recommendations are based on existing national and international guidelines for the management of diabetes, obesity and sleep apnoea (National Institutes of Health [NIH], 1998; NICE, 2006; Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009; Handelsman et al, 2011).

Appropriate and comprehensive ongoing patient education is an essential part of the overall general management of obese people with type 2 diabetes and obstructive sleep apnoea. While such education can improve patient outcomes, it can also become more difficult to accomplish under certain circumstances. The following most common factors have been identified as potential barriers to effective patient education:

age and developmental level, physical limitations, emotional or mental state that interferes with learning, lack of motivation to learn, presence of pain, cultural or ethnic factors, language barrier, dearth or inappropriateness of educational materials, limited time, and lack of specific training and reimbursement for time spent on patient education. Despite increased access to high-quality, affordable healthcare, the attitudinal barriers still exist that hinder obese people with type 2 diabetes and obstructive sleep apnoea from adhering to multiple self-care tasks, and thus impede achieving therapeutic targets. An intensive, individualised therapeutic approach involving patient input and counselling may help to identify and tackle these barriers to successful disease management.

Management of obese people with obstructive sleep apnoea and type 2 diabetes should ideally be approached on a case management basis utilising a multidisciplinary care team that can include both primary and secondary care healthcare professionals. A comprehensive management plan with a multidimensional approach, involving diabetes, obesity, dietetics, physical activity and sleep, should be designed to address the unique needs and circumstances of each patient, taking into account medical history, risk factors, ethnocultural background, and issues of lifestyle, diet, motivation and behaviour change.

Clinical aspects of treatment

Obesity, obstructive sleep apnoea and type 2 diabetes create a vicious triangle leading to further weight gain, progression of obstructive sleep apnoea, and advanced alterations in glucose homeostasis. Lifestyle and pharmacological treatments exist to control glucose levels and insulin action in diabetes. Targeting the obesity-related insulin resistance by reducing intra-abdominal fat undoubtedly remains an equally important therapeutic objective. However, the adverse health and social consequences of untreated obstructive sleep apnoea may be considerably underestimated and neglected in clinical practice, and therefore warrant increased clinical awareness and therapeutic attention to raise the standard of practice and improve clinical outcomes and patient safety.

Once the diagnosis of obstructive sleep apnoea is established in an obese person with type 2 diabetes, the decision process on an appropriate treatment strategy follows. The currently available therapeutic strategies include a primary treatment and alternative therapies. The therapeutic strategy decision depends mainly on the severity of obstructive sleep apnoea and concurrent comorbidities, as well as patient preference. The patient should be an active participant in the therapeutic decision process, while utilising a multidisciplinary care team approach.

Primary treatment

Positive airway pressure (PAP) is the primary (preferred) treatment for obstructive sleep apnoea and should be offered as an option to all patients (NICE, 2006; Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). This treatment provides pneumatic splinting of the upper airway and may be delivered in continuous, bilevel or autotitrating modes. PAP is safe and effective in reducing the AHI (Gay et al, 2006). In particular, PAP is indicated for the treatment of moderate to severe obstructive sleep apnoea (AHI ≥15 events per hour), for reducing self-reported sleepiness, improving quality of life, and as an adjunctive therapy to lower blood pressure in hypertensive patients with obstructive sleep apnoea (Kushida et al, 2006).

Alternative therapies

Adult Obstructive Sleep Apnoea Task Force of the AASM Members (2009) recommends that alternative therapies may be offered depending on the severity of the condition and the patient's anatomy, risk factors and preferences. Alternative therapies include behavioural therapies, oral appliances, surgical treatment, and adjunctive therapies (bariatric surgery, pharmacologic agents and oxygen therapy).

Behavioural therapy is an essential part of the complex treatment process for obstructive sleep apnoea. Behavioural treatments comprise lifestyle changes aimed at achieving desirable weight loss, performing regular physical activity, avoiding smoking and use of alcohol and sedatives before bedtime, and the positional therapy to encourage

Page points

1. Management of patients with obesity, obstructive sleep apnoea and type 2 diabetes should ideally be approached on a case management basis utilising a multidisciplinary care team that can include both primary and secondary care healthcare professionals.
2. The adverse health and social consequences of untreated obstructive sleep apnoea may be considerably underestimated and neglected in clinical practice.
3. Currently available therapeutic strategies for treating obstructive sleep apnoea include a primary treatment and alternative therapies, with the primary treatment being positive airway pressure.

"All obese people with obstructive sleep apnoea and type 2 diabetes should have ongoing, long-term management, preferably in a multidisciplinary integrated service."

sleeping in a non-supine position (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). Behavioural therapy alone might be satisfactory for mild obstructive sleep apnoea. This approach can be given concurrently with diabetes care in diabetes clinics providing an integrated service.

Bariatric surgery is an adjunctive treatment for obstructive sleep apnoea with important additional metabolic implications for patients with diabesity. Bariatric operations beneficially modulate a number of molecular mechanisms, leading to attenuation of oxidative stress, decreased levels of systemic inflammatory markers, and improved endothelial function, glucose tolerance, lipid profiles and hypertension control (Ashrafian et al, 2008). With respect to obstructive sleep apnoea, weight reduction after bariatric procedures has been shown to improve the sleep disorder (Buchwald et al, 2004). Current evidence suggests that massive weight loss after bariatric surgery is associated with decreases in pharyngeal collapsibility and may also lead to concomitant improvements in active neuromuscular control (Schwartz et al, 2010). Charuzi et al (1992) reported 40% remission rate for obstructive sleep apnoea two years after bariatric surgery, which was related to the percentage loss of excessive body weight. The findings suggest that obstructive sleep apnoea is likely to persist in patients who have a substantial amount of excessive body weight despite weight loss or to recur in those who experience weight regain, emphasising the need for ongoing clinical follow-up of these patients (Charuzi et al, 1992).

Long-term follow-up

All obese people with obstructive sleep apnoea and type 2 diabetes should have ongoing, long-term management, preferably in a multidisciplinary integrated service. This is particularly relevant for obstructive sleep apnoea that should be approached as a chronic condition (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). A regular sleep specialist follow-up to monitor tolerance and adherence to treatments, side effects, development and progression of complications (including hypertension, stroke, myocardial infarction, cor pulmonale, erectile dysfunction and decreased daytime alertness), and symptom resolution is recommended.

A follow-up assessment is routinely indicated in people with obstructive sleep apnoea for the assessment of treatment results on PAP after substantial weight loss (≥10% of body weight), substantial weight gain with return of symptoms when clinical response is insufficient, or return of symptoms despite a good initial response to CPAP (Kushida et al, 2005; Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009). Home testing with portable monitors may be indicated to monitor the response to non-PAP treatments.

Those with diabesity and resolved obstructive sleep apnoea should be monitored closely for continued risk factor modification and symptom recurrence. Besides age (a non-modifiable risk factor for obstructive sleep apnoea), systemic and local inflammatory mechanisms, as well as metabolic and neurohumoral factors that promote central adiposity in diabesity, may further aggravate underlying defects in upper airway neuromechanical control and lead to a relapse or worsening of obstructive sleep apnoea over time.

Future perspectives

The identification of obstructive sleep apnoea may be a difficult task for the clinician. Patients may present with less specific signs and symptoms suggestive of the condition, for example, depression, confusion, difficulty in concentration, sexual dysfunction and heart palpitations. The diagnosis of this sleep disorder needs to be considered in all obese people with type 2 diabetes, including those without the typical signs and symptoms. Given the high risk of obstructive sleep apnoea in diabesity, the diagnosis process should ideally be started as early as possible, both in the primary care setting and in specialist services. Screening for obstructive sleep apnoea with portable monitors should become a part of the regular high risk screening in diabetes clinics. Additionally, given the obesity epidemic and an associated risk of metabolic syndrome among children and adolescents, there is an increasing need to start screening and

prevention of obstructive sleep apnoea and type 2 diabetes even in children and young people.

The clinical management of obstructive sleep apnoea cannot be viewed in isolation from the management of the concurrent comorbidities. Those with severe obesity are advised to follow a programme of lifestyle change and behavioural therapy, while being under regular review by a multidisciplinary specialist weight management team. If dieting, exercising and behavioural therapy do not result in sufficient weight loss, bariatric surgery can be considered. Early effective treatment of obesity in type 2 diabetes and obstructive sleep apnoea is important to limit further weight gain and reduce complications of obesity that are likely to develop over time. A high prevalence of pre-diabetes among obese people with obstructive sleep apnoea warrants close monitoring of these individuals for the risk of progression to overt type 2 diabetes. In those with type 2 diabetes, the selection of antidiabetes drugs should prioritise the medications minimising the risk and magnitude of weight gain. The diabetes specialist team should always be consulted if there is uncertainty about treatment selection or if the blood glucose targets are not achieved and maintained.

It is unlikely that the problem of diabesity and concurrent obstructive sleep apnoea can be addressed through primary care management alone. Guidelines have been developed to tailor therapies for obesity (NIH, 1998; NICE, 2006), obstructive sleep apnoea (Adult Obstructive Sleep Apnoea Task Force of the AASM Members, 2009) and type 2 diabetes (Handelsman et al, 2011) to individuals according to the severity of these disorders and comorbid diseases, as well as patient preference. Successful implementation of these guidelines requires close liaison between primary care and specialist services. ■

Funding

The authors are funded by the National Institute for Health Research (NIHR) through the Collaborations for Leadership in Applied Health Research and Care for Birmingham and Black Country (CLAHRC-BBC) programme.

Disclaimer

This paper presents independent research funded by the NIHR. The views expressed are those of the author(s) and not necessarily those of the NHS, NIHR or Department of Health.

Adult Obstructive Sleep Apnea Task Force of the American Academy of Sleep Medicine Members (2009) Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med* **5**: 263–76

American Academy of Sleep Medicine (2005) *International classification of sleep disorders: Diagnostic and coding manual*. 2nd ed. American Academy of Sleep Medicine Westchester, IL

American Academy of Sleep Medicine Task Force (1999) Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep* **22**: 667–89

Aronsohn RS, Whitmore H, Van Cauter E, Tasali E (2010) Impact of untreated obstructive sleep apnea on glucose control in type 2 diabetes. *Am J Respir Crit Care Med* **181**: 507–13

Ashrafian H, le Roux CW, Darzi A et al (2008) Effects of bariatric surgery on cardiovascular function. *Circulation* **118**: 2091–102

Balk EM, Moorthy D, Obadan NO et al (2011). *Diagnosis and Treatment of Obstructive Sleep Apnea in Adults. Comparative Effectiveness Review No. 32*. Available at: http://tiny.cc/t120ww (accessed 13.05.2013)

Botros N, Concato J, Mohsenin V, Selim B (2009) Obstructive sleep apnea as a risk factor for type 2 diabetes. *Am J Med* **122**: 1122–27

Brownlee M (2005) The pathobiology of diabetic complications: a unifying mechanism. *Diabetes* **54**: 1615–25

Buchwald H, Avidor Y, Braunwald E et al (2004) Bariatric surgery: a systematic review and meta-analysis *JAMA* **292**: 1724–37

Charuzi I, Lavie P, Peiser J, Peled R (1992) Bariatric surgery in morbidly obese sleep-apnea patients: short- and long-term follow-up. *Am J Clin Nutr* **55**: 594S–6S

Chen L, Magliano DJ, Zimmet PZ (2011) The worldwide epidemiology of type 2 diabetes mellitus – present and future perspectives. *Nat Rev Endocrinol* **8**: 228–36

Collop NA, Tracy SL, Kapur V et al (2011) Obstructive sleep apnea devices for out-of-center (OOC) testing: technology evaluation. *J Clin Sleep Med* **7**: 531–48

Dawson A, Abel SL, Loving RT et al (2008) CPAP therapy of obstructive sleep apnea in type 2 diabetics improves glycemic control during sleep. *J Clin Sleep Med Dec* **15**: 538–42

"The diagnosis of obstructive sleep apnoea needs to be considered in all obese people with type 2 diabetes, including those without the typical signs and symptoms."

"Obesity, obstructive sleep apnoea and type 2 diabetes create a vicious triangle leading to further weight gain, progression of obstructive sleep apnoea, and advanced alterations in glucose homeostasis."

Einhorn D, Stewart DA, Erman MK et al (2007) Prevalence of sleep apnea in a population of adults with type 2 diabetes mellitus. *Endocr Pract* **13**: 355–62

Foster GD, Sanders MH, Millman R et al for the Sleep AHEAD Research Group (2009) Obstructive sleep apnea among obese patients with type 2 diabetes. *Diabetes Care* **6**: 1017–19

Gay P, Weaver T, Loube D, Iber C (2006) Evaluation of positive airway pressure treatment for sleep related breathing disorders in adults. *Sleep* **29**: 381–401

Gianotti L, Pivetti S, Lanfranco F et al (2002) Concomitant impairment of growth hormone secretion and peripheral sensitivity in obese patients with obstructive sleep apnea syndrome. *J Clin Endocrinol Metab* **87**: 5052–7

Handelsman Y, Mechanick JI, Blonde L et al (2011) American Association of Clinical Endocrinologists Medical Guidelines for clinical practice for developing a diabetes mellitus comprehensive care plan: executive summary. *Endocr Pract* **17**: 287–302

Iftikhar IH, Blankfield RP (2012) Effect of continuous positive airway pressure on hemoglobin A(1c) in patients with obstructive sleep apnea: a systematic review and meta-analysis. *Lung* **190**: 605–11

Kushida CA, Littner MR, Morgenthaler T et al (2005) Practice parameters for the indications for polysomnography and related procedures: an update for 2005. *Sleep* **28**: 499–521

Kushida CA, Littner MR, Hirshkowitz M et al (2006) Practice parameters for the use of continuous and bilevel positive airway pressure devices to treat adult patients with sleep-related breathing disorders. *Sleep* **29**: 375–80

Lurie A (2011) Obstructive sleep apnea in adults: epidemiology, clinical presentation, and treatment options. *Adv Cardiol* **46**: 1–42

Mannarino MR, Di Filippo F, Pirro M (2012) Obstructive sleep apnea syndrome. *Eur J Intern Med* **23**: 586–93

Marshall NS, Wong KK, Phillips CL et al (2009) Is sleep apnea an independent risk factor for prevalent and incident diabetes in the Busselton Health Study? *J Clin Sleep Med* **5**: 15–20

McGinley BM, Schwartz AR, Schneider H et al (2008) Upper airway neuromuscular compensation during sleep is defective in obstructive sleep apnea. *J Appl Physiol* **105**: 197–205

Muraki I, Tanigawa T, Yamagishi K et al (2010) Nocturnal intermittent hypoxia and the development of type 2 diabetes: the Circulatory Risk in Communities Study (CIRCS). *Diabetologia* **53**: 481–8

National Institutes of Health (1998) Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. *Obes Res* **6**: 51S–209S.

NICE (2006) *Clinical guideline 43. Obesity: Guidance on the Prevention, Identification, Assessment and Management of Overweight and Obesity in Adults and Children*. NICE, London

Oltmanns KM, Gehring H, Rudolf S et al (2004) Hypoxia causes glucose intolerance in humans. *Am J Respir Crit Care Med* **169**: 1231–7

Pallayova M, Donic V, Tomori Z (2008) Beneficial effects of severe sleep apnea therapy on nocturnal glucose control in persons with type 2 diabetes mellitus. *Diab Res Clin Pract* **81**: e8–e11

Patel SR, Larkin EK, Redline S (2008) Shared genetic basis for obstructive sleep apnea and adiposity measures. *Int J Obes* **32**: 795–800

Phillips BG, Kato M, Narkiewicz K et al (2000) Increases in leptin levels, sympathetic drive, and weight gain in obstructive sleep apnea. *Am J Physiol Heart Circ Physiol* **279**: H234–7

Popko K, Gorska E, Wasik M et al (2007) Frequency of distribution of leptin gene polymorphism in obstructive sleep apnea patients. *J Physiol Pharmacol* **58**: 551–61

Priou P, Le Vaillant M, Meslier N et al (2012) IRSR Sleep Cohort Group. Independent association between obstructive sleep apnea severity and glycated hemoglobin in adults without diabetes. *Diabetes Care* **35**: 1902–6

Punjabi NM, Shahar E, Redline S et al (2004) Sleep-disordered breathing, glucose intolerance, and insulin resistance: The Sleep Heart Health Study. *Am J Epidemiol* **160**: 521–30

Schwartz AR, Patil SP, Squier S et al (2010) Obesity and upper airway control during sleep. *J Appl Physiol* **108**: 430–5

Selmi C, Montano N, Furlan R et al (2007) Inflammation and oxidative stress in obstructive sleep apnea syndrome. *Exp Biol Med* **232**: 1409–13

Stamatakis KA, Punjabi NM (2010) Effects of sleep fragmentation on glucose metabolism in normal subjects. *Chest* **137**: 95–101

Vasu TS, Grewal R, Doghramji K (2012) Obstructive sleep apnea syndrome and perioperative complications: a systematic review of the literature. *J Clin Sleep Med* **8**: 199–207

Yamauchi M, Nakano H, Maekawa J et al (2005) Oxidative stress in obstructive sleep apnea. *Chest* **127**: 1674–9

Online CPD activity

Visit www.diabetesonthenet.com/cpd to record your answers and gain a certificate of participation

Participants should read the preceding article before answering the multiple choice questions below. There is ONE correct answer to each question. After submitting your answers online, you will be immediately notified of your score. A pass mark of 70% is required to obtain a certificate of successful participation; however, it is possible to take the test a maximum of three times. A short explanation of the correct answer is provided. Before accessing your certificate, you will be given the opportunity to evaluate the activity and reflect on the module, stating how you will use what you have learnt in practice. The CPD centre keeps a record of your CPD activities and provides the option to add items to an action plan, which will help you to collate evidence for your annual appraisal.

1. Which ONE of the following is recognised as a MAJOR symptom of obstructive sleep apnoea?
Select ONE option only.

A. Decreased memory
B. Depression
C. Morning headache
D. Nocturnal cardiac arrhythmia
E. Unrefreshing sleep

2. Which ONE of the following is recognised as a COMMON symptom of obstructive sleep apnoea?
Select ONE option only.

A. Altered bowel habit
B. Daytime urinary frequency
C. Increased intraocular pressure
D. Reduced libido
E. Tinnitus

3. Which ONE of the following is recognised as a potential independent risk factor for the development of type 2 diabetes?
Select ONE option only.

A. Asbestosis
B. Benign prostatic hypertrophy
C. Obstructive sleep apnoea
D. Osteoporosis
E. Parkinson's disease

4. Which APPROXIMATE percentage of the general adult population has obstructive sleep apnoea?
Select ONE option only.

A. <1%
B. 5%
C. 10%
D. 15%
E. 20%

5. Which of the following is NOT a potential barrier to effective patient education in obese people with type 2 diabetes and obstructive sleep apnoea?
Select ONE option only.

A. Emotional or mental state that interferes with learning
B. High BMI
C. Lack of reimbursement for time spent on education
D. Lack of motivation to learn
E. Presence of pain

6. A 53-year-old man with type 2 diabetes and obstructive sleep apnoea is finding CPAP has improved his quality of life. Which is the most appropriate statement regarding the evidence base for short-term CPAP and HbA_{1c} levels?
Select ONE option only.

A. CPAP does not have beneficial effects on HbA_{1c} levels
B. CPAP has beneficial effects on HbA_{1c} levels
C. CPAP has detrimental effects on HbA_{1c} levels
D. The evidence is based on several large meta-analyses

7. Which of the following urinary symptoms should be specifically included when asking a comprehensive sleep history in a person suspected of having obstructive sleep apnoea?
Select ONE option only.

A. Daytime frequency
B. End-stream dribbling
C. Incontinence
D. Nocturia
E. Urgency of micturition

8. Which one of the following, if any, is the single most appropriate questionnaire to use in order to make a diagnosis of obstructive sleep apnoea?
Select ONE option only.

A. American Society Anesthesiologists checklist
B. Berlin questionnaire
C. Epworth Sleepiness Scale
D. Hawaii sleep questionnaire
E. STOP-bang questionnaire
F. None of the above

9. Which one, if any, of the following clinical findings is more suggestive of obstructive sleep apnoea in a woman?
Select ONE option only.

A. BMI >27 kg/m^2
B. Mallampati score of 2
C. Neck circumference >16 inches
D. Waist circumference >72 cm
E. None of the above

10. Which single one of the following apnoea–hypopnoea index (AHI) scores best fits a level of adult obstructive sleep apnoea described as "mild"?
Select ONE option only.

A. AHI <1 event/hour
B. AHI 1–4 events/hour
C. AHI 5–14 events/hour
D. AHI 15–29 events/hour
E. AHI 30–40 events/hour