RESEARCH PAPER

Importance of Measuring Neck Circumference in Assessment of Obstructive Sleep Apnea Among Obese Individuals: A Literature Review

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ABSTRACT

Background: Obstructive sleep apnoea (OSA) is a common respiratory problem related to sleep and is defined by recurring bouts of upper airway obstruction during sleep, which causes intermittent hypoxia and fragmented sleep. The primary modifiable risk factor for OSA is obesity, and the growing incidence of obesity worldwide has greatly increased the burden of OSA in people of all ages. Obesity and OSA have a complicated and reciprocal relationship that has significant effects on public health outcomes and cardiometabolic health.

Methodology: Using published epidemiological studies, systematic reviews, meta-analyses, and population-based cohorts, a narrative assessment of the literature on the prevalence, pathogenesis, and clinical implications of OSA in connection to obesity was carried out. English-language publications discussing the causes behind obesity, regional and worldwide incidence trends, and OSA management techniques were found by searching important databases. Descriptive syntheses were made of data from community-based and hospital-based research involving adult, paediatric, and elderly populations.

Conclusion: The research that is now available shows a substantial and reliable correlation between obesity and OSA, with obesity considerably raising the disorder's prevalence and severity. Through morphological, mechanical, inflammatory, and neuroendocrine factors, excess adiposity leads to upper airway collapse; if left untreated, OSA may also encourage weight gain and metabolic dysfunction. Standardizing NC measurement in addition to BMI and waist circumference may improve risk categorization, increase predictive accuracy, and better match epidemiological measures with anatomical mechanisms. A realistic and evidence-based step toward enhancing obesity-related OSA assessment and public health planning is including NC into standard screening and research frameworks.

How to cite this article: Sharma PJ, Dutta A, Koch M, Das M, Devi SA, Chanu MR, Yangma K. Importance of Measuring Neck Circumference in Assessment of Obstructive Sleep Apnea Among Obese Individuals: A Literature Review. Int J Drug Deliv Technol. 2026;16(21s): 725-731. DOI: 10.25258/ijddt.16.21s.76

Source of support: Nil.

Conflict of interest: None

INTRODUCTION:

Obstructive sleep apnea (OSA) is a respiratory disorder characterized by intermittent breathing disruption or cessation during sleep secondary to obstruction of the airway. The cause of this obstruction is often multi-factorial, with common contributing factors including

obesity, dysfunction of pharyngeal muscles leading to inadequate airway dilation, and impaired respiratory drive responsiveness resulting in unstable breathing patterns and airway narrowing. More common in males than females, OSA affects approximately 13% of men and 6% of women in the United States, with prevalence increasing with age across both sexes. (1) Other identified risk factors of OSA include body mass index (BMI) greater than 30 kg/m^2 and ethnic groups impacted by increased frequency of craniofacial structural abnormalities (e.g., East Asians) or obesity (e.g., Black and Hispanic populations) . Patients with OSA are often characterized by loud, habitual snoring and experience symptoms such as morning grogginess and persistent daytime fatigue due to disrupted and non-restorative sleep (2,3).

Demographic characteristics have a considerable impact on the occurrence of OSA, with age, gender, and ethnicity appearing as important determinants. Age has a significant role in the development of OSA; research indicates that up to 90% of men and 78% of women over 70 may have at least mild OSA. (4). According to the majority of research, the general population's male-to-female ratio is between 2:1 and 3:1. The underdiagnosis of OSA in women, however, may have an impact on this disparity, which narrows in older age groups . It is commonly known that the prevalence of OSA varies by gender (5). Furthermore, the prevalence of OSA is significantly influenced by socioeconomic status (SES), although the nature of this association is complex and may vary across different populations. Some research indicates a negative correlation between OSA prevalence and SES, potentially mediated by factors such as obesity, smoking, and healthcare access (6). However, the lack of consistency in this relationship across studies underscores the need for further investigation into the socioeconomic determinants of OSA (6,7)

Risk factors

Both non-modifiable and modifiable factors that affect the risk of OSA are shown in Table 1. Risk factors that cannot be modified include race, age, and male sex. A higher risk of OSA may be associated with cranio-facial structures that result in restricted airways, genetic susceptibility, and a family history of OSA (8,9). Modifiable risk factors include obesity, drugs that relax muscles and constrict the airway (opioids, benzodiazepines, and alcohol), endocrine conditions (hypothyroidism and polycystic ovary syndrome), smoking, alcoholism, and nasal congestion or obstruction. (10)

Non-modifiable risk factors	**Modifiable risk factors**
Race	Obesity
Age	Muscle relaxant drugs
Sex	Endocrine conditions
Cranio-facial defects	Smoking
Genetic susceptibility	Nasal congestion
Family history of obstructive sleep apnoea	Alcoholism

Approximately 1 billion of the world's population of 7.3 billion people, between the ages of 30 and 69 years, are estimated to have the most common type of sleep-disordered breathing, obstructive sleep apnoea (OSA). OSA prevalence is rising and affects all countries (11). The increase in prevalence is driven by the global increase in obesity, the major risk factor for OSA. In this review, we examine contributing factors, the burden of disease, approaches and challenges in addressing the global burden of OSA (12).

The current population challenges of obesity, in adults and in children, as well as an ageing population make the global burden of OSA a major contributor the future health of all populations. Given the ongoing obesity epidemic, increases in prevalence are certain globally, and in particular in the two most populous nations, China and India. These populations are at risk for increases in OSA even in the presence of more modest increases in BMI (11,13). Around104 million Indians of working age suffer from OSA, of whom 47 million have moderate-to-severe OSA. The prevalence of OSA was similar in urban and rural areas. Both BMI and NC were higher for urban patients than for rural patients (14). The risk factors were mainly diabetes mellitus and hypertension. This represents a major public health problem in India with important implications for the global burden of the disease. (12)

Approximately half of the people worldwide have OSA. High BMI, increasing age, and male gender are described as risk factors in the literature, but these covariates do not affect pre-existing heterogeneity. (15)

Epidemiological Burden

Prevalence of OSA surges with body mass index (BMI), reaching 50-90% in severe obesity (BMI ≥40 kg/m^2), though 23-44% of cases occur in non-obese individuals, underscoring multifactorial ethology. A 10% weight increase elevates AHI by ~30%, with central (visceral) fat distribution heightening risk more than peripheral. Bidirectionally, OSA independently predicts 2-4 kg annual weight gain, amplified in

postmenopausal women and metabolic syndrome cohorts. Recent IPD meta-analyses from 12,860 adults confirm obesity in only 31.5% of OSA cases, urging expanded screening (16).

Pathophysiological Mechanisms

Obesity narrows the pharynx through parapharyngeal fat pads, tongue enlargement, and reduced lung volume, diminishing traction on the airway; this collapsibility worsens with supine posture and REM sleep. Obesity also contributes indirectly to upper airway narrowing, especially in the hypotonic airway present during sleep, because lung volumes are markedly reduced by a combination of increased abdominal fat mass and the recumbent posture. In turn, the reduced lung volume reduces the "tug" on the trachea induced by the traction exerted via mediastinal structures by negative intrathoracic pressures and by the diaphragm descent, thereby further increasing the thickness of the lateral pharyngeal walls and narrowing the airway (17,18).

The highly sensitive "traction" effect of changes in lung volume on upper airway patency and airway resistance was clearly demonstrated in anesthetized animals by Van de Graaff who surgically disconnected the mechanical linkage between chest wall and upper airway by severing all cervical structures anterior and anterolateral to the spine (19).

Anatomical Factors

Excess adipose tissue deposition in the neck, tongue, and pharyngeal walls narrows the upper airway and increases its collapsibility during sleep (20). Neck circumference is a strong clinical predictor of OSA severity (21,22). Central obesity also reduces lung volumes, particularly functional residual capacity, thereby decreasing caudal traction on the upper airway and promoting collapse during sleep. (23)

Neuromuscular and Mechanical Factors

Obesity adversely affects upper airway neuromuscular control by reducing the activity and responsiveness of pharyngeal dilator muscles during sleep (24). Increased abdominal fat mass elevates intra-abdominal pressure, limits diaphragmatic excursion, and impairs respiratory mechanics, further exacerbating sleep-disordered breathing (25).

Inflammatory and Metabolic Mechanisms

Adipose tissue functions as an endocrine organ that secretes pro-inflammatory cytokines such as tumour necrosis factor-α and interleukin-6(26). Chronic low-grade inflammation associated with obesity may contribute to upper airway oedema and neuromuscular dysfunction (27). Leptin resistance, commonly observed in obesity, has also been implicated in impaired ventilatory control and increased susceptibility to OSA (28).

Bidirectional Relationship Between OSA and Obesity

The association between obesity and OSA is bidirectional. While obesity increases the risk and severity of OSA, untreated OSA may promote further weight gain (29). Sleep fragmentation and intermittent hypoxia disrupt neuroendocrine regulation of appetite, resulting in increased ghrelin levels and reduced leptin sensitivity, which Favor increased caloric intake (30). Excessive daytime sleepiness may reduce physical activity levels, further contributing to positive energy balance and obesity (31). This narrative review summarizes current evidence on the epidemiology, mechanistic pathways, and clinical implications of obesity-related OSA, while highlighting emerging gaps beyond conventional BMI-based assessment.

Methodology

Study Design: Literature review.

Search Engines: PubMed, Cochrane, Embase, Scopus, Google Scholar, Europe PMC (2010-2026).

Keywords: "OSA prevalence obesity," "AHI BMI," "sleep apnea epidemiology."

Inclusion Criteria:

Systematic reviews/meta-analyses.

RCTs, cohorts, prevalence studies with BMI data.

Peer-reviewed English articles.

Exclusion Criteria:

Paediatric/non-OSA studies.

Non-English/paid walls.

Author (Year)	Study Type	Population/Setting	Obesity Measurement Used	Findings	Identified Gap Related to Neck circumference
Rundo (2019)	Clinical overview	General adult population	BMI discussed	Obesity highlighted as major risk factor	Neck circumference mentioned minimally; not emphasized as routine obesity indicator

Brower et al. (2025)	Narrative review	Aging adults	BMI, weight gain	Aging and obesity synergistically increase OSA risk	Lack of NC-based obesity characterization in elderly populations
Senaratna et al. (2017)	Systematic review	General population	BMI (most studies)	OSA prevalence underestimated worldwide	NC rarely reported across prevalence studies despite airway relevance
Lin et al. (2008)	Review	Male vs female OSA	BMI, fat distribution	Gender affects OSA severity and treatment response	NC not systematically used to explain sex-based anatomical differences
Petrovic et al. (2019)	Cohort study	Swiss population	BMI-adjusted models	Lower socioeconomic groups show higher SDB burden	Upper-body adiposity markers like NC absent in inequality models
Iannella et al. (2025)	Review	Global burden	BMI based estimates	OSA contributes significantly to global morbidity	Global burden projections ignore NC, reducing precision in obesity-attributable risk
Lee et al. (2008)	Population epidemiology review	Community-based cohorts	BMI dominant	Obesity is strongest predictor	BMI oversimplifies obesity; NC not routinely adopted
Lv et al. (2023)	Mechanistic review	Adults with OSA	General obesity	Fat deposition contributes to airway collapse	NC as surrogate for peripharyngeal fat not discussed clearly
Gomase et al. (2023)	Narrative review	Adults	General obesity	CPAP and weight loss improve outcomes	Lack of NC measurement in management stratification
Benjafield et al. (2019)	Global prevalence analysis	Worldwide	BMI-derived obesity estimates	Nearly 1 billion adults affected	Burden calculations overlook NC despite strong predictive value
Lyons et al. (2020)	Review	Global SDB burden	Obesity general	OSA linked with cardiometabolic disease	NC not integrated into screening or burden models

Devaraj et al. (2021)	Cross-sectional Indian study	Urban & rural India	BMI, waist circumference	Obesity major predictor in Indian subjects	NC absent, despite being a simple field marker for airway fat
de Araujo Dantas et al. (2023)	Meta-analysis	Worldwide	BMI, anthropometric indices	Obesity strongly associated with OSA	NC underreported; meta-regression limited by lack of NC data

Discussion

Obesity is the most important modifiable risk factor for obstructive sleep apnoea (OSA), according to the body of extant research. Body mass index (BMI) has been the primary method used to evaluate risk and prevalence in significant epidemiological and global burden analyses, such as those conducted by Benjafield and Senaratna.(11) Although BMI is useful and commonly used, it does not account for regional fat distribution, especially upper-body and peri pharyngeal adiposity, which are mechanistically essential for airway collapsibility. Therefore, this over-reliance on BMI may oversimplify the categorization of obesity in OSA research and burden estimates.

Pharyngeal constriction and collapsibility are caused by fat accumulation surrounding the upper airway, according to mechanistic evaluations like the one by Lv. (9) Nevertheless, epidemiological modelling and mechanistic interpretation hardly ever use neck circumference (NC), a straightforward anthropometric proxy for upper-airway fat. There is a crucial translational gap between pathophysiology and measurement. It seems sense to include anthropometric variables that reflect this distribution in screening and prediction frameworks if upper-airway fat plays a major role in the development of disease.

Socioeconomic and population-based analyses, using Petrovic cohort data, show differences in the burden of sleep-disordered breathing (SDB) (6). However, inequality models usually do not include upper-body adiposity measures like NC and instead rely on BMI-adjusted analysis. Particularly in communities where BMI underestimates central or regional fat storage, this omission may mask subtle risk stratification. Similar to this, Devaraj's cross-sectional data from India highlights obesity as a significant predictor; nevertheless, NC was left out despite its viability in field settings with limited resources (14).

Variations related to age and sex further highlight the significance of sophisticated anthropometric instruments. Variations in fat distribution and airway morphology are noted in reviews addressing gender differences in OSA, including Lin's, but NC is not consistently employed to explain these differences (5). Relying just on BMI may misclassify risk in older groups when sarcopenic obesity and fat redistribution are prevalent. The accuracy of risk modelling and clinical screening techniques is restricted by the lack of NC-based characterisation in studies that concentrate on aging.

Obesity and OSA are strongly associated, according to meta-analytic evidence, including de Araujo Dantas's work (15). However, subgroup studies and meta-regression investigating upper-body adiposity as an independent predictor are limited by underreporting of NC. Due to inadequate primary reporting, this restriction keeps NC out of high-level evidence synthesis.

All of these results point to a systematic underutilization of neck circumference in global burden modelling, mechanistic research, and epidemiology. NC has the potential to increase screening accuracy, risk stratification, and obesity-attributable burden estimations because of its low cost, repeatability, and direct anatomical relevance. Standardized NC assessment should be used in conjunction with BMI and waist circumference in future large-scale cohort studies and prevalence surveys. Clinical and public health approaches to OSA may be strengthened by including NC into predictive models, which could close the gap between pathophysiology knowledge and population-level evaluation.

Conclusion

Obesity is the most powerful modifiable risk factor for obstructive sleep apnoea (OSA), according to the data described above. However, body mass index (BMI) is still the primary metric used to quantify obesity. The use of BMI-based estimations in major prevalence and burden investigations, such as those conducted by Senaratna et al. (2017) and Benjafield et al. (2019),

may limit the anatomical precision of risk classification.

According to the mechanistic insights presented by Lv et al. (2023), pharyngeal collapse is mostly caused by upper-airway fat buildup. Despite this, epidemiological, cohort, and meta-analytic studies continue to report neck circumference (NC), a straightforward and direct proxy for upper-body and peri pharyngeal adiposity, in inconsistent ways.

Further evidence that NC is frequently missing from prediction and inequality models, even in a variety of socioeconomic and geographic contexts, comes from population-based studies like Petrovic et al. (2019) and Devaraj et al. (2021).

When taken as a whole, this trend reveals a crucial methodological flaw: whereas the pathophysiological significance of regional fat distribution in OSA is well acknowledged, anthropometric evaluation techniques have not changed in tandem. In future cohort studies, prevalence surveys, and global burden models, standardizing NC measurement in addition to BMI and waist circumference may improve risk categorization, increase predictive accuracy, and better match epidemiological measures with anatomical mechanisms. A realistic and evidence-based step toward enhancing obesity-related OSA assessment and public health planning is including NC into standard screening and research frameworks.

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