Predictors of swallowing disorders in Obstructive Sleep Apnea Syndrome: a case-control and cross-sectional study

Original Article

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Abstract

Introduction: Obstructive sleep apnea syndrome (OSAS) is a prevalent sleep disorder characterized by recurrent upper airway collapse, leading to intermittent hypoxia and sleep fragmentation. While OSAS is associated with multiple systemic comorbidities, its impact on swallowing function remains underrecognized. This study aims to compare swallowing characteristics between OSAS patients and controls and identify risk factors and predictors of swallowing disorders severity.

Methods: A case-control and cross-sectional study was conducted with people with moderate to severe OSAS (PwOSAS) and age- and sex-matched controls. Swallowing function was assessed using the Fiberoptic Endoscopic Evaluation of Swallowing, Dysphagia Outcome and Severity Scale (DOSS), and Dysphagia Handicap Index (DHI). Descriptive statistics, normality tests, group comparisons (t-test, Mann-Whitney U test, Chi-square, Fisher's exact test) and an ordinal regression were applied, with significance set at $p \leq 0.05$.

Results: Fifty individuals (PwOSAS n = 25 and controls n = 25) were included, with a mean age of 50 ± 1.55 years. Swallowing impairments were identified in 60% of PwOSAS compared to 28% of controls ($p = 0.023$). The most frequent impairments were pharyngeal residue accumulation (52% in PwOSAS vs. 24% in controls; $p = 0.041$), followed by premature spillage (12% vs. 4%; $p = 0.297$). PwOSAS had significantly higher DHI scores than controls ($p = 0.024$). The percentage of recording time with SpO_2 below 90% (T90) is a negative predictor of the severity of swallowing disorders.

Conclusion: Swallowing impairments are common in PwOSAS, with significantly higher pharyngeal residue accumulation and greater impact on daily life compared to controls. These findings highlight the importance of swallowing assessment in this population.

Keywords: Obstructive sleep apnea syndrome; dysphagia; deglutition handicap index

Introdução

Obstructive sleep apnea syndrome (OSAS) is a common sleep disorder characterized by repetitive pharyngeal collapse, leading to complete (apnea) or partial (hypopnea) airway obstruction. These events cause oxygen desaturation, hypercapnia, and sleep fragmentation, contributing to its consequences.[1,2] It is estimated that OSAS affects around 1 billion people worldwide[3], and the condition is proven to be associated with multiple comorbidities, including hypertension, type 2 diabetes mellitus, dyslipidemia, gastroesophageal reflux disease, acute myocardial infarction, and stroke[4].

The link between OSAS and swallowing disorders remains poorly understood, despite reported prevalence rates ranging from 16% to 76%.[5] Previous studies indicate that swallowing disorders in OSAS patients are generally subclinical, with endoscopic findings most commonly revealing premature spillage of the food bolus and residue retention after swallowing.[6] Swallowing disorders can impact physical and mental health leading to increased fear of eating, prolonged loss of appetite, malnutrition, and serious complications such as aspiration, pneumonia and airway obstruction.[7] Therefore, it's mandatory to identify patients at risk of swallowing disorders, to prevent potential complications and improve their quality of life. This study aims to compare the characteristics of swallowing between people with OSAS (PwOSAS) and a matched control group and identify risk factors and predictors of severity of swallowing disorders in patients with OSAS.

Material e Métodos

2. Study design

A cross-sectional case-control study was conducted, including a group of PwOSAS and a control group of people without OSAS. The study was approved by the Health Care Ethics Committee of Unidade Local de Saúde de Lisboa Ocidental (ULSLO), Lisbon, Portugal (20170700050) and was carried out in accordance with the principles of the revised Declaration of Helsinki (2013) [8]. All patients provided written informed consent.

2.2. Participants

Participants aged between 18 and 65 years, diagnosed with moderate to severe OSAS and without prior treatment with Continuous Positive Airway Pressure (CPAP) were included in the study through convenience sampling. The control group was matched to individuals with PwOSAS based on sex and age (± 2 years), with no history of snoring, as confirmed through clinical history. The exclusion criteria applied to both groups included: diagnosis of psychiatric, neuromuscular, or neurodegenerative diseases, stroke in the past year or presence of neurological sequelae post-stroke, diagnosis of gastroesophageal reflux disease, history of head and neck tumors, palatopharyngoplasty or tonsillectomy in adulthood, treatment with continuous positive airway pressure (CPAP) in the last three months and lack of cooperation during evaluation.

2.3. Data collection

Data was collected at the department of Otorhinolaryngology of the Unidade Local de Saúde de Lisboa Ocidental (ULSLO), from September 2024 to January 2025.

2.3.1. Sociodemographic data and medical history

Clinical data collected included age, sex, history of arterial hypertension, dyslipidemia, and smoking status.

2.3.2. Anthropometric measurements

Body mass index (BMI) using the standard formula:

$$\mathrm{BMI} = \frac{\mathrm{Weight\ \ kg}}{\mathrm{Height\ (m)}^2}$$

Neck circumference was assessed through direct measurement using a flexible tape measure placed around the widest part of the neck, just below the laryngeal prominence.

Physical oropharyngeal examination parameters included tonsil size grading (Brodsky scale),

Friedman tongue position, Mallampati classification, and the presence of a high-arched palate or ankyloglossia.

2.3.2. Tongue strength

Anterior maximum tongue strength was measured using the Iowa Oral Performance Instrument (IOPI), which records the highest value from three attempts, with 30-second intervals between each attempt. The measurement was recorded in kilopascals (KpA). Patients were instructed to press their tongue as hard as possible against the device's bulb until a peak pressure was reached, ensuring consistent and maximal effort during each trial.

2.3.3 Sleep study

The diagnosis of OSAS was established through level 1 polysomnography using the Natus Xltek Brain Monitor EEG & Sleep System, equipped with the Natus SleepWorks PSG software, and through level 3 polysomnography conducted with the Embletta MPR system with the Software RemLogic. Obstructive apneas were characterized as breathing pauses lasting ≥10 seconds, accompanied by simultaneous chest and abdominal movement, and hypopneas as a reduction in airflow of ≥50%, combined with a ≥4% drop in pulse oximetry. The apnea–hypopnea index (AHI) was calculated as the average number of apnea and hypopnea episodes per hour of sleep. The severity of OSAS was classified as mild for an AHI between 5 and 14.9, moderate for an AHI ranging from 15 to 29.9, and severe for an AHI of ≥30. The percentage of recording time with SpO_2 below 90% was designated as T90.

Daytime sleepiness was assessed using the Epworth Sleepiness Scale (ESS), a validated questionnaire comprising 8 items designed to assess the likelihood of falling asleep in various daily situations. The ESS score ranges from 0 to 24, with a score of 0 to 9 indicating minimal daytime sleepiness, while a score of 10 or higher suggests excessive daytime sleepiness

2.3.4. Swallowing assessment

Fiberoptic Endoscopic Evaluation of Swallowing (FEES) was performed by an otorhinolaryngologist and a speech language therapist using a flexible endoscope. The anatomical assessment by FEES included the observation of velopharyngeal closure, pharyngeal and laryngeal anatomy, vocal folds' mobility, the execution of the tight breath-holding and squeezing maneuvers. Presence of secretion was assessed using the portuguese version of the secretion severity rating scale which evaluates the residual accumulation of secretions from 0 (no visible or only transient secretions) to 3 (severe accumulation at the level of the laryngeal vestibule).[9]

During dynamic evaluation, the patient swallowed foods of four different consistencies in the following order: mildly thick (IDDSI 2), thin (IDDSI 0), extremely thick (IDDSI 4), and regular (IDDSI 7), all stained green with Wilton Leaf Green Gel Icing Colour® for visualization. Nutricia Nutilis Clear ® thickener was used to prepare consistencies corresponding to IDDSI Level 2 (half a spoon per 100mL) and IDDSI Level 4 (one and a half spoons per 100mL). For each liquid (mildly thick, thin and extremely thick) 5 mL and 10 mL boluses were administered, with the patient completing three swallows per consistency and volume, totaling 18 swallows. For the regular consistency, the patient was offered 2.5 x 2.5 cm pieces of cookie, also three trials. All FEES were videotaped for later analysis.

The evaluation assessed the presence and severity of penetration and aspiration, pharyngeal residue and premature posterior spillage. Premature posterior spillage was considered if it occurred in at least 2 of the 18 swallows, whereas the other parameters were classified as present after a single occurrence.[10] Penetration and aspiration were graded using the Penetration-aspiration scale (PAS), and pharyngeal residue using the Yale Pharyngeal Residue Severity Rating Scale (YPRSRS).[11,12]

2.3.5. Self-perceived impact of swallowing in daily life

The Deglutition Handicap Index (DHI) is a patient-reported outcome used to assess the impact of swallowing in three domains: emotional, functional and physical. The total DHI score ranges from zero (indicating no impact) to 120 (indicating maximum impact).[13]

2.4. Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics version 26.0 (SPSS Inc., Chicago, IL, USA). For exploratory data analysis, continuous variables were summarized using means, medians, and standard deviations, while categorical variables were presented as absolute and relative frequencies. Data normality was assessed using the Kolmogorov-Smirnov test. Comparisons between two independent groups (participants with and without swallowing disorders) were performed using Student's t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed or ordinal variables. Categorical variables were analyzed using Pearson's Chi-square test or Fisher's exact test, depending on expected cell frequencies. An ordinal logistic regression was performed with the assessment of the assumptions of multicollinearity and proportional odds. A p-value ≤ .05 was considered statistically significant.

Results

This study included 50 participants, 25 PwOSAS cases and 25 controls, accurately matched by sex and age. The sample was predominantly male (68%, n = 34), with a mean age of 50 years (± 1.55). In the OSAS group, 64% (n=16) had severe disease and 36% (n= 9) had moderate disease, with a mean AHI of 39.8 ± 4.9 events/hour and a mean duration of oxygen saturation below 90% (T90) of 14.96 ± 3.97 %. When compared to the control group, the OSAS group showed statistically significant higher BMI, Friedman tongue position, and Mallampati scores. Table 1 describes the characteristics of the included participants.

In the FEES study, 15 cases (60%) and 7 controls (28%) exhibited swallowing abnormalities (p = 0.023). The most frequent finding was residue accumulation in the valleculae or pyriform sinus, observed in 13 participants (52%) in the OSAS group and 6 participants (24%) in the control group (p = 0.041). The second most common finding was premature posterior spillage, occurring in 12% (n=3) in the OSAS group and 4% (n=1) in the control

Figure 1
Graph comparing difference between cases and controls in terms of average values for residue accumulation and PAS scores

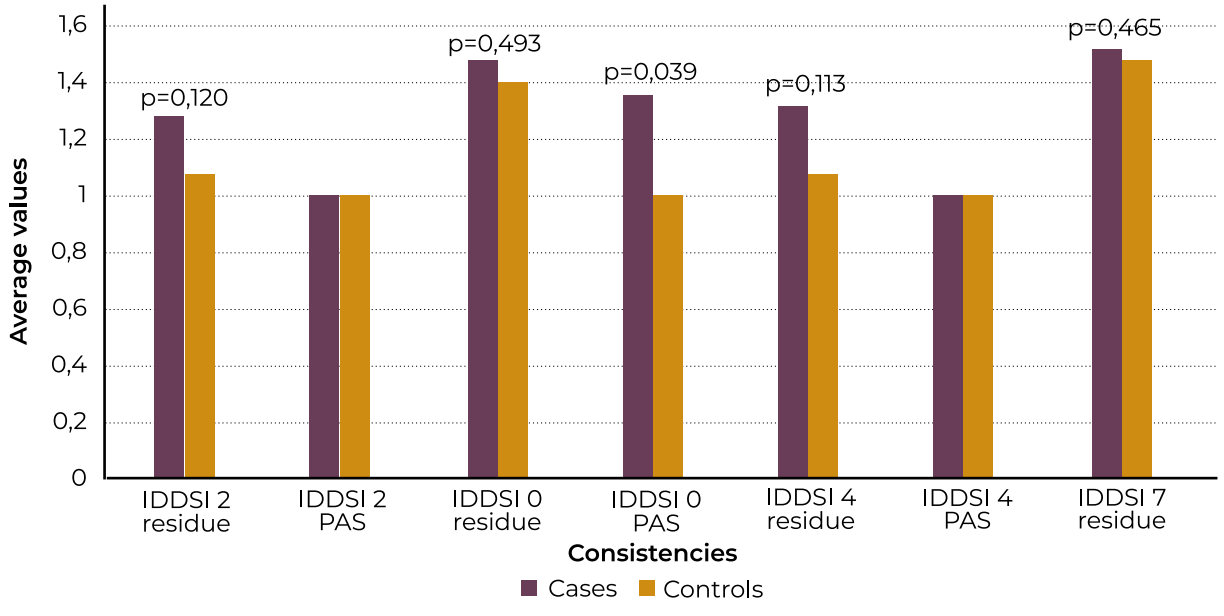

Table 1
Comparative analysis of demographic, anthropometric and clinical characteristics of cases and controls

	OSAS group (n=25)	Control group (n=25)	P value
Age (years)	50.24 ± 10.98	49.76 ± 11.15	0.808
ESS	7.48 ± 5.18	2.40 ± 2.92	0.000
DHI	7.20 ± 13.59	1.36 ± 2.58	0.024
DOSS	6.48 ± 0,71	6.76 ± 0.43	0,170
PPS, n (%)	4 (16%)	1 (4%)	0,349
BMI (Kg/m2)	31.64 ± 6.73	26.04 ± 3.39	0.003
Neck circumference (cm)	42.33 ± 5.89	38.96 ± 4.09	0.112
Maximum anterior tongue pressure (kPa)	57.43 ± 14.24	53.35 ± 10.86	0.531
Tonsil grade size	1.16 ± 0.62	1.54 ± 0.77	0.284
Friedmann Tongue Position	2.44 ± 1.19	1.56 ± 0.77	0.024
Mallampati	2.44 ± 1.04	1.64 ± 0.86	0.045
Ogival palate, n (%)	4 (16%)	6 (24%)	0.725
Short frenulum, n (%)	4 (16%)	2 (8%)	0.667

Abbreviations: ESS: Epworth Sleepiness Scale; DHI: Dysphagia Handicap Index; DOSS: Dysphagia Outcome and Severity Scale; PPS: Premature Posterior Spillage; BMI: Body Mass Index

Table 2
Comparative Analysis of Anthropometric and Polysomnographic Characteristics Based on Swallowing disorders presence

	Without swallowing disorders (n= 10)	With swallowing disorders (n=15)	P value
Age (years)	52.50 ± 10,05	48.73 ± 11.65	0.495
Male, n (%)	6 (60%)	11 (73.3%)	0.667
Smoking, n (%)	1 (10%)	3 (20%)	0.626
AHI	35.00 ± 13,72	43.01 ± 29.41	0.849
SpO2 <90%	7.06 ± 8.47	19.46 ± 21.49	0.212
ESS	9.40 ± 5.30	6.20 ± 4.86	0.091
DHI	4.90 ± 9.81	8.73 ± 15.76	0.531
DOSS	6.90 ± 0.32	6.20 ± 0.76	0.031
BMI (Kg/m2)	30.52 ± 6.96	32.39 ± 6.71	0.461
Neck circumference (cm)	41.14 ± 4.98	42.96 ± 6.42	0.643
Maximum anterior tongue pressure (KPa)	57.50 ± 15.87	57.40 ± 13.89	0.925

Abbreviations: AHI: apnea/hypopnea index; ESS: Epworth Sleepiness Scale; DHI: Dysphagia Handicap Index; DOSS: Dysphagia Outcome and Severity Scale; BMI: Body Mass Index

group (p = 0.297). Finally, only 1 participant (4%) in the OSAS group showed signs of aspiration, with a grade 3 on the Penetration Aspiration Scale for all consistencies tested. A subanalysis was performed to assess differences for each consistency tested (graph 1). Only one statistically significant difference was found for thin liquid, on the average value of the Penetration Aspiration Scale, between cases and controls (p=0,039).

Table 3
Characterization of swallowing impairments in participants with OSAS and swallowing disorders

Sex	Age (years)	AHI	PPS	Residue	Penetration/ aspiration
Male	46	69	No	Yes, Yale 2 all consistencies	No
Male	39	17,2	No	Yes, Yale 2 (IDDSI 7)	No
Male	58	16,4	No	Yes, Yale 3 (IDDSI 0), Yale 2 (IDDSI 7)	No
Male	65	49,9	Yes	Yes, Yale 3 all consistencies	Yes, PAS 4 (IDDSI 0; 5mL and 10mL)
Male	55	24,5	No	Yes, Yale 2 all consistencies	No
Male	38	90	No	Yes, Yale 2 (IDDSI 0)	No
Female	34	32,8	No	Yes, Yale 2 (IDDSI 7)	No
Male	40	119	Yes	No	No
Male	52	41,6	No	Yes, Yale 2 (IDDSI 2 and 0), Yale 3 (IDSSI 4 and 7)	No
Male	38	35,0	No	Yes, Yale 2 all consistencies	No
Male	52	18,9	No	Yes, Yale 2 (IDDSI 7)	No
Male	53	40,8	No	Yes, grade 3 (IDDSI 0)	No
Male	65	45,1	No	Yes, grade 2 (IDDSI 0)	No
Male	65	28,0	No	Yes, grade 3 (IDSSI 0)	No
Male	31	16,0	Yes	No	No

Abbreviations: AHI: apnea-hypopnea index; PPS: Premature Posterior Spillage; PAS: Penetration-Aspiration Scale

Table 4
Ordinal Regression Results for the Dependent Variable DOSS

PREDITOR	COEF	WCS	P-VALUE	ODDS RATIO	LOWER	UPPER
T90	-0,254	4,352	0,037	0,776	-0,493	-0,015
IAH	0,242	4,908	0,270	1,274	0,028	0,456
ESS	0,312	3,070	0,080	1,366	-0,037	0,661
DHI	-0,407	5,511	0,019	0,666	-0,746	-0,067
IMC	-0,238	1,523	0,217	0,789	-0,617	0,140
IDADE	0,038	0,203	0,652	1,039	-0,128	0,205

The OSAS group was further subdivided into two groups based on the presence of swallowing impairments observed by FEES. Fifteen participants (60%) were assigned to the swallowing disorders group based on the presence of swallowing impairments. There was a statistically significant difference in the DOSS score between the groups (p = 0.031). No other differences were identified between groups (table 2).

The results from the ordinal regression analysis (table 4) revealed that AHI was a significant positive predictor of DOSS (β=0,079, p=0,045), with an 8,2% increase in the odds of being in a higher DOSS category for each unit increase in IAH. In contrast, T90 was a significant negative predictor of DOSS (β=-0,086, p=0,037), with an 8.3% decrease in the odds of being in a higher DOSS category for each unit increase in T90.
Table 3 presents the detailed findings for the

OSAS participants with swallowing disorders.
The analyses of quality of life showed that OSAS participants had statistically significant worse values on the Dysphagia Handicap Index (p = 0,024).

Discussion

In our cohort, 60% of OSAS participants exhibited swallowing impairments, a markedly higher prevalence compared to controls (28%). These findings reinforce previous studies suggesting that OSAS is associated with an elevated risk of swallowing disorders, likely due to sensory deficits in the upper airway mucosa, particularly in the palate, larynx and oropharynx.[14,15] This impairment is thought to result from pharyngeal collapse events and the vibratory trauma induced by snoring, which may impair neural regulation of microcirculation in these structures [16,17]. Given the critical role of sensory receptors in coordinating bolus preparation, muscle contraction and swallowing timing, such damage could contribute to the observed swallowing abnormalities in OSAS participants.[6]

The most prevalent swallowing abnormality in PwOSAS with swallowing disorders was the accumulation of residue in the valleculae or pyriform sinus, observed in 52% of cases. This aligns with Schindler et al.'s findings, who reported that 44% of OSAS patients exhibited bolus residue when swallowing solid textures (half cook trial).[6] In our cohort, residue accumulation in PwOSAS was more frequent in IDDSI 0 and IDDSI 7, although the difference compared to controls was not statistically significant (see graph 1). Furthermore, the highest score recorded on the YPRSRS was 3, occurring in 5 participants (20%), while all remaining cases displayed only pharyngeal coating (see table 3).

Although residue accumulation in our study was generally mild, its presence may still suggest pharyngeal desensitization, which could potentially explain the significantly higher penetration/aspiration scores for thin liquid (IDDSI 0) in PwOSAS. This interesting finding raises the question of whether, in a normal meal setting with unregulated consistencies and volumes, the risk of penetration or aspiration might be higher for other consistencies as well.

Premature posterior spillage was observed more frequently in PwOSAS than controls, though the finding did not reach statistical significance. While this may suggest that premature spillage may be less prominent than other swallowing impairments in OSAS-related swallowing disorders, prior studies have reported it as the most common swallowing impairment in this population. [18,19] Premature posterior spillage is influenced by multiple factors, including tongue pressure, which plays a crucial role in bolus control and containment. In our study, tongue pressure was assessed using the IOPI, and no significant differences were found between OSAS participants and controls. This finding may explain the low prevalence of premature spillage observed in our cohort, as preserved tongue strength likely contributed to adequate bolus management.

Ordinal regression analysis revealed that T90 is a positive predictor of the severity of swallowing disorders. This finding contrasts with previous literature, which has reported no significant correlation between polysomnographic parameters and the severity of dysphagia (6,18). We hypothesize that these findings suggest that sustained hypoxia, better captured by T90, have a more profound effect on swallowing function than the frequency of apneas and hypopneas. These results further highlight that swallowing disorders are multifactorial conditions, influenced by factors such as neurological impairments and comorbidities, which may exert a greater impact on its severity than polysomnographic measures alone.

Participants with OSAS also exhibited significantly higher scores on the DHI compared to controls, reflecting a greater self-perceived impact of swallowing disorders in daily life. However, no statistically significant differences were observed between OSAS participants with and without swallowing

disorders observed by FEES. This suggests that OSAS participants may experience a more pronounced swallowing disorders-related impact, even though the swallowing impairments may be subclinical and not always detectable through FEES.

This study has several limitations. First, although type I polysomnography remains the gold standard for OSAS diagnosis, we employed both type I and type III polysomnography, potentially introducing variability in sleep parameter assessments. Second, FEES evaluations were not blind and were performed by three otolaryngologists specialized in swallowing disorders, which, while ensuring expertise, may have introduced observer bias, limiting the generalizability of results. Third, the controls did not undergo polysomnography to exclude OSAS, which may have led to misclassification of control subjects. Lastly, the relatively small sample size may have reduced statistical power, potentially affecting the ability to detect subtle clinical differences. Future research with larger cohorts, standardized polysomnographic methodologies and different volumes and consistencies is warranted to further elucidate the relationship between OSAS severity and swallowing disorders.

Conclusão

Swallowing impairments, particularly the accumulation of pharyngeal residue, are significantly more common in OSAS participants, suggesting pharyngeal sensory impairment and a potentially increased risk of aspiration. The results of this study reinforce the importance of swallowing assessment in patients with moderate to severe OSA, especially in the presence of higher T90 values. This is the first study to suggest that T90 is a predictor of dysphagia severity in PwOSAS. Therefore, integrating swallowing dysfunction into the OSAS assessment could enable a more holistic management strategy, ultimately improving participant quality of life and mitigating the risk of associated complications.

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data confidentiality

The authors declare having followed the protocols used at their working center regarding patient data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and the 2013 Helsinki Declaration of The World Medical Association.

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Availability of scientific data

There are no datasets available, or publicity related to this work.

Declaration on the Use of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors declare that they did not use any generative AI tools or AI-assisted technologies in the writing process.

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