Obstructive Sleep Apnea, Depression, and Oral Status in Elderly Occupants of Residential Homes

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Purpose: Obstructive sleep apnea syndrome (OSAS) is a sleep disorder characterized by repetitive episodes of upper airway obstruction. Recently, it has been suggested that edentulism worsens sleep apnea; sleeping without dentures is associated with a significant increase in the apnea-hypopnea index. OSAS is also related to depression. The aim of this study was to assess, in a group of elderly occupants in residential homes in the Turin district of Italy, *(1)* the prevalence of key symptoms and indicators of OSAS and the prevalence of depressive feelings; *(2)* how the reduction of vertical dimension of occlusion (VDO) influenced the onset of OSAS; and *(3)* whether a relationship between OSAS and depression was present. ***Materials and Methods:*** The sample population consisted of 403 people (77% men, 23% women; age range, 65 to 90 years). The subjects underwent the Italian version of the Mini Mental State Examination (MMSE) to assess their mental condition. The remaining collaborating subjects completed 2 questionnaires to assess the risk of OSAS (Berlin Questionnaire) and depressive feelings (Beck Depression Inventory). ***Results:*** Of the 403 elderly residents initially evaluated with the MMSE, 97 were excluded from the study, reducing the sample size to 306 subjects (75% women, 25% men; mean age ± standard deviation, 83.12 ± 11.10 years).The analysis of these data revealed a statistically significant association between the risk for sleep apnea and the VDO ($P < .0001$), and between sleep apnea and depressive feelings ($P < .05$). ***Conclusion:*** This study revealed that inadequate VDO is closely associated with the risk of OSAS, and that depressive feelings are more present if there is a high risk for OSAS. *Int J Prosthodont 2005;18:316–322.*

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Obstructive sleep apnea (OSA) is a sleep disorder characterized by repetitive episodes of upper airway obstruction (apnea) or reduced airflow (hypopnea)[1,2] despite persistent respiratory effort.[1,3] Apnea is defined as the cessation of breathing for at least 10 seconds during sleep, while hypopnea is defined as at least 30% reduction in airflow for 10 seconds with a 4% decrease in oxygen saturation.[1] OSA is often associated with anatomic features that favor the obstruction of the upper airway, such as a large tongue, a redundant amount of soft palate tissue, and nasal obstruction by nasal polyps.[4] The clinical characteristics of obesity (body mass index [BMI] $>$ 29 kg/m^2), large neck circumference ($>$ 42.5 cm), male sex, and in-

creased age (> 45 years) are considered significant risk factors for OSA.[4,5] Other risk factors for sleep apnea include craniofacial abnormalities, hypothyroidism, and acromegaly.[6] The OSA syndrome (OSAS) is defined as an apnea-hypopnea index (AHI; total number of episodes of apnea and hypopnea per hour of sleep) of 5 or higher in association with excessive somnolence.[1,6] Associated symptoms often include loud snoring, daytime somnolence, morning headaches, memory problems, and related feelings of depression.[1–6] Daytime symptoms are usually the result of sleep disruption caused by apnea- or hypopnea-associated arousals and awakenings.[7] OSAS is often associated with hypertension, myocardial infarction, and other cardiovascular complications; a reduction in neurocognitive function; and an increased risk of car accidents caused by driving while drowsy.[6,7] Recent studies suggest that OSAS occurs in 4% of men and 2% of women between 30 and 60 years of age.[8] The prevalence of OSAS in persons over 60 is estimated to be between 20%[9] and 24%,[10] but in some studies it reaches 62%.[11]

The recommended method for assessment of patients with suspected sleep disorders, including sleep apnea, is polysomnography.[6,12] The use of polysomnography for the evaluation of sleep-related breathing disorders requires a minimum of the following channels: electroencephalography, electro-oculography, chin electromyography, nasal and oral airflow, arterial oxygen saturation, thoracic and abdominal respiratory effort, and electrocardiography. Nevertheless, specific questionnaires permit a good approximation of the presence or absence of this sleep disorder.[4,13,14]

Recently, it has been suggested that edentulism worsens sleep apnea; sleeping without dentures is associated with a significant increase in the AHI.[15,16] The worsening of the degree of upper airway collapse in these patients seems to be associated with the lack of an obstacle to jaw elevation.[15] In addition, the reduction of the vertical dimension of occlusion (VDO) in the rehabilitated edentulous patient worsens continuously because of bone resorption.[17] Thus, appropriate follow-up is critical, as some overadapted patients are satisfied with their dentures in spite of an insufficient VDO.[18]

It has been suggested that obstructive sleep apnea can be related to depression. Using the Beck Depression Inventory (BDI), Vandeputte and de Weerd found a significant correlation between the severity of depression and the AHI in patients with OSAS: 41% of the patients had some form of depression and 1.6% were moderately or severely depressed.[19] In addition, the authors found that depression in these patients improved after a few months of continuous positive airway pressure (CPAP) therapy.[19] Akashiba et al also described a strong correlation between the quality of life and depression in a population of patients with severe OSAS.[20] Chamberlain and Chamberlain examined a group of 120 patients with complete dentures, aged 33 to over 75 years, and found potential depression in 10.7% of the sample using the BDI.[21]

The aim of this study, therefore, was to assess, in a group of elderly occupants in residential homes:

1. The prevalence of key symptoms and indicators of OSAS and the prevalence of depressive feelings,
2. How the reduction of VDO influenced the onset of OSAS, and
3. Whether a relation between OSAS and depression was present.

Materials and Methods

Study Subjects

The sample population consisted of 403 people (77% men, 23% women; age range, 65 to 90 years) who resided in 8 institutional residences for the elderly in the Turin district of Italy. The socioeconomic status of the population was uniform. The study was conducted with authorization from these institutions. The protocol was approved by the Ethical Committee of the San Giovanni Battista Hospital, and all the patients were informed of the modalities and the purpose of the study before consenting to participate. All the subjects were visited and interviewed. The interviews and the visits were made collegially by a team of 4 expert clinicians.

Among the participating subjects, 64% were completely edentulous, 12% were completely edentulous only in one arch, and 24% were partially edentulous in both arches. Clinically, the techniques for assessing the vertical dimension of occlusion are: the presence of a interocclusal rest space in the postural position of the mandible[22]; the absence of tooth contacts during speaking (phonetic method)[23]; and, most important, a pleasant profile (esthetic method).[24,25] The esthetic method alone was, in most cases, a sufficient criterion for assessing the correctness of VDO. However, if the correctness of VDO was unclear when the esthetic method alone was used, the phonetic method was used, and the interocclusal rest space was evaluated. The VDO was considered inadequate when the criteria for these parameters were not met.[22–24]

Subjects were asked to answer a series of questions related to continuous dry mouth sensation. The subjects also underwent the Italian version of Mini Mental State Examination (MMSE) to assess their mental condition. Since the specificity of MMSE for cognitive disorders is 84% when the cut-off point is 24 or less,[26] the subjects who did not attain age- and education-adjusted scores of 24 were excluded from the study.[27] The remaining collaborating subjects completed 2 ques-

tionnaires to assess the risk of OSAS (Berlin Questionnaire)14 and depressive feelings (BDI).[19]

Assessment of OSA Risk

The Berlin Questionnaire was developed in 1996 and was shown to have a positive predictive value of 89% for sleep apnea.[14] It is a self-report instrument that focuses on a set of known symptoms and clinical features associated with sleep apnea. One introductory question and 4 follow-up questions concern snoring, witnessed apneas, and the frequency of such events. Three questions address daytime sleepiness, and a subquestion concerns drowsiness while driving. One question queries whether the subject has a history of high blood pressure. The subjects provided information on age, weight, height and sex; BMI was calculated from the self-reported information on weight and height.

The responses to the Berlin Questionnaire were grouped into 3 risk-factor categories to determine the overall risk for OSA. In category 1, positive risk was defined as a self-report of frequent symptoms (ie, responses of "more than 3 to 4 hours per week" or "almost every day" to the questions regarding snoring and witnessed apneas). In category 2, positive risk was defined as self-report of frequent symptoms for 2 or more questions concerning awaking sleepy, daytime sleepiness, and drowsiness while driving. In category 3, positive risk was defined as a self-report of high blood pressure and/or BMI of > 30 kg/m^2. Individuals with positive risk scores in 2 or more of the categories were considered at high risk for OSA. Patients who did not have frequent symptoms, who did not report sufficient symptoms to permit risk assessment, or who had a positive risk score in only 1 category were considered to be at low risk for OSA.[14]

Assessment of Depressive Feelings

The BDI was developed by Beck in 1961 and comprises 21 questions, each with 4 possible answers corresponding to scores of 0 to 3 points; higher scores indicate greater severity of symptoms. The total scores are classified into 6 grades of depression, with higher total scores indicating more severe depression:

0–9: No or minimal depression
10–14: Borderline depression
15–20: Mild depression
21–30: Mild to moderate depression
31–40: Moderate to severe depression
41–63: Severe depression

Clearly, the BDI scale investigates the presence of depressive feelings, not the presence of the clinical syndrome of depression.

Statistical Analysis

The data were analyzed using the Chi-square test and the Student *t* test ($P < .05$ was used as the level of significance).

Results

Of the 403 elderly residents initially evaluated with the MMSE, 97 did not reach a weighted score of 24 and were excluded from the study, reducing the sample size to 306 subjects (75% women, 25% men; mean age ± standard deviation, 83.12 ± 11.10 years). Of the completely edentulous subjects, 34% lacked prosthetic rehabilitation. Among the subjects with dentures, 47% used them both day and night; 42% used them only during the day, 8% wore them only at meals, and 3% never wore them.

The VDO was estimated to be inadequate in 193 patients (63%). The evaluation of the subjects' responses to the Berlin Questionnaire indicated that 187 (61.1%) of the 306 subjects were classified as being at high risk for sleep apnea.

Among the 193 subjects with inadequate VDO, 78.6% were classified as high risk for OSAS, compared to 35% of the 113 subjects with adequate VDO ($P<.0001$; Chi-square = 49.84; Table 1, Fig 1). The analysis of these data revealed a statistically significant association between a high risk for sleep apnea and VDO.

Among the subjects with dental prostheses, 53% did not wear their dentures during the night; thus, the VDO in these subjects, even if adequate with the denture in place, was reduced during sleep. A high risk of OSA was identified in 71% of the subjects who did not wear their dentures at night, whereas among the subjects who wore their dentures during the night, high and low risk for OSA was equally distributed (Table 2, Fig 2). Chi-square and Student *t* tests showed a statistically significant association between these variables ($P = .0002$, Chi-square = 14.13 and $P = .003$, t = 2.947, respectively).

Findings showed that 11.1% of the subjects had noticed subjective symptoms of continuous oral dryness, but they were equally distributed among the entire population.

The responses to the BDI questionnaire indicated that 28.1% of the subjects had depressive feelings (BDI $\geq$ 15) and 66.3% were not affected or had borderline depression (BDI $\leq$ 14) (Table 3). The responses of 17 subjects (5.6%) who did not answer all the questions, or who gave more than one answer to a question, were excluded from the analysis.

Table 1 Risk of OSAS and VDO

	Risk for OSAS		
	High	Low	Total
Correct VDO	40	73	113
Inadequate VDO	147	46	193
Total	187	119	306

Table 2 Risk of OSAS and Nighttime Prosthesis Wear

	Risk for OSAS		
	High	Low	Total
Night wear	72	72	144
No night wear	115	47	162
Total	187	119	306

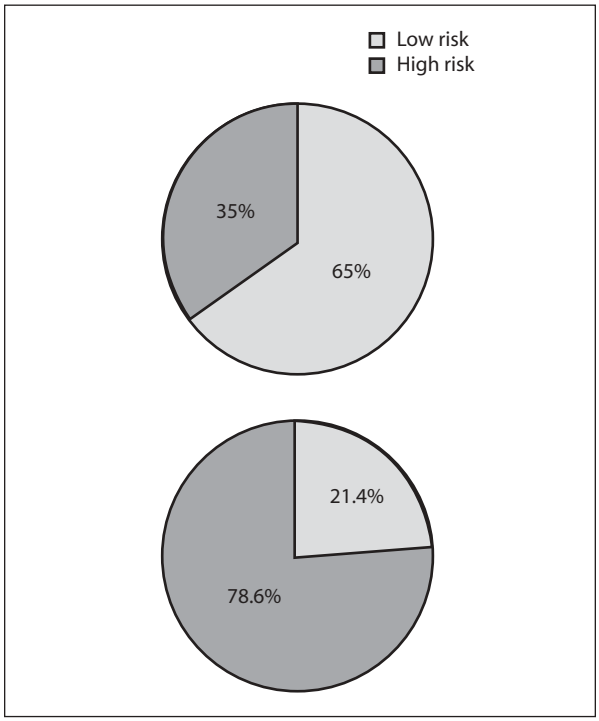

Fig 1 Distribution of risk for OSAS in patients with correct VDO (*top*) and with a reduced VDO (*bottom*).

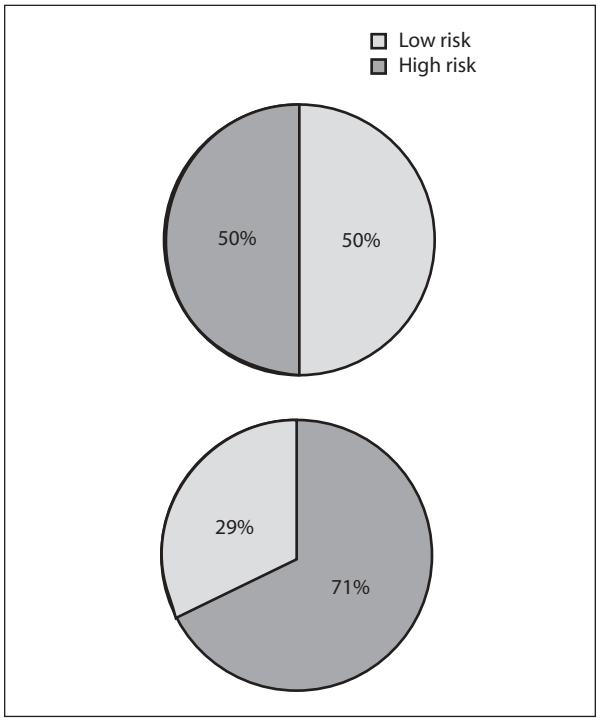

Fig 2 Distribution of risk for OSAS in daytime wearers (*top*) and day and nighttime wearers (*bottom*) of dentures.

Among the 203 subjects without depressive symptoms, 56% were at high risk for sleep apnea, while 71% of the 86 subjects with signs of depression were at high risk (Figs 3a and 3b; $P = .018$; Chi-square = 5.519, relative risk = 1.263). A high risk for OSAS appeared to be associated with the degree of depression. In addition, a comparison between the BDI scores of subjects with adequate and inadequate VDO revealed a difference that approached statistical significance ($t = 1.950$; $P = .052$).

Discussion

In the present study, 61.1% of the subjects examined were at high risk for OSAS, as identified by the Berlin questionnaire.

Associations were also found between VDO and risk for OSAS ($P < .0001$; Chi-square = 49.84; relative risk = 0.4648) and between OSAS and depressive feelings, since 71% of the subjects with signs of depression were at high risk for OSAS ($P = .018$; Chi-square = 5.519, relative risk = 1.263), while among the subjects without depressive feelings the risk of OSAS was equally distributed.

The prevalence of OSAS, as defined by AHI scores of 5 or higher, is 4% in men and 2% in women aged 30 to 60 years[8] and up to 20% in subjects over age 60.[9] Ancoli-Israel et al[10] found that 24% of a sample of community-dwelling elderly subjects (age $\geq$ 65 years) met the criterion of AHI scores $\geq$ 5, and the majority of these had AHI scores $\geq$ 10,[10] but in a previous study the same authors found an AHI $>$ 5 in 53% of people aged between 80 and 89 years.[11]

Table 3 Occurence of Depression Among Elderly Residential Patients (Beck Depression Inventory Scale)

Depressive class	Frequency	Percent
No or minimal depression	162	52.9
Borderline depression	41	13.4
Mild depression	67	21.9
Mild to moderate depression	19	6.2

Table 4 Risk of OSAS and Depression

	Risk for OSAS		
	High	Low	Total
Depression	61	25	86
Low or minimal depression	114	89	203
Total	175	114	289

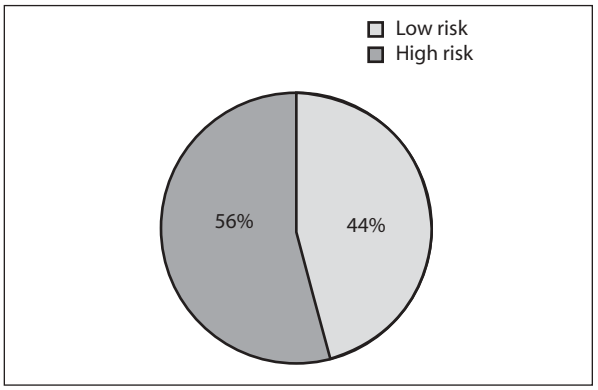

Fig 3a Distribution of risk for OSAS in subjects who do not suffer from depression.

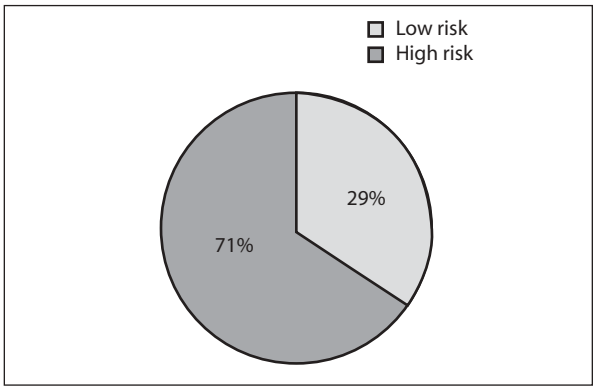

Fig 3b Distribution of risk for OSAS in subjects who suffer from depression.

The questionnaire approach seems acceptable to patients and may be more convenient and less costly than an instrumental examination. The sensitivity of 86% for an AHI > 5 is higher than that of strategies currently used in clinical practice.[14]

There is a dearth of studies examining the possible correlation between VDO and sleep disorders; however, there are several reports of oral appliances proposed to prevent mild to moderate levels of sleep apnea by increasing the VDO[28–30] or by increasing the protrusion of the mandible. The reduction of the VDO implies a forward and upward mandibular drift[31] associated with a backward shift when in the supine position, which could favor a shift of the tongue and soft palate against the posterior pharyngeal wall. In addition, Malhotra et al[32] found that in older adults the soft palate is longer, the pharyngeal fat pads are larger, the shape of the bony structures around the pharyngeal airway is altered, and the response of the genioglossus muscle to negative pressure stimulation is diminished as compared to younger adults. Inadequate VDO, which worsens as a result of bone resorption,[17] when combined with the age-related changes described above, could lead to a reduction of the patency of the pharyngeal airway through an anterior rotation and backward shifting of the mandible.

With the restoration of an adequate VDO, the jaw returns to a physiologic position through a downward rotation. Ono et al[33] speculated that, in response to the downward rotation of the mandible, the genioglossus activity increases, which may enlarge the retroglossal space by protruding the tongue forward. It can be hypothesized that the insertion of a prosthesis may also favor an increase in the neuromuscular activation of the pharyngeal muscles by the central nervous system, which is typically reduced during sleep,[7] and could induce modifications in the position of the jaw, the soft palate, and the tongue that promote improved patency of the pharynx. It can also be supposed that in the supine position, the intercuspation provided by the dentures could serve as a brake to the backward shifting of the mandible. The results obtained in the present study support the hypothesis that the reduction of the VDO is a contributing factor in OSA.

The prevalence of continuous dry mouth sensation in the present study population (11.1%) was similar to the rate reported by Narhi (12%),[34] but lower than the 29% reported by Sreebny et al.[35] The most frequent cause of dry mouth is medication.[34] Neural control of salivation is extremely complex, and pharmacologic agents can mimic or antagonize numerous regulatory aspects of salivation. More than 95% of the examined subjects took habitually one or more medications (cardiovascular and gastrointestinal medications, diuretics, sedatives, and neuroleptics), but it was not an aim of this research to investigate the specific interactions of these medications with the dry mouth sensation. Dry mouth can also be caused by several diseases, health conditions, and treatments. The use of removable dentures may be difficult for patients with dry mouth and can contribute to the high prevalence of malnutrition in older patients.[34]

Previous reports have shown that subjects with OSAS often complain of mood disturbances. In a study by Guilleminault and Dement, 24% of the subjects with OSAS had seen a psychiatrist for depression and anxiety, and 28% had elevated depression scale scores.[36] Kales et al found that 56% of subjects with severe OSAS also had high scores on the Minnesota Multiphasic Personality Inventory scale for depression.[37] Ohayon[38] found a high positive association between major depressive disorder and OSAS, with depressive subjects being 5 times more likely to have breathing-related sleep disorders than non-depressed subjects.

Some clinical studies have attempted to determine whether breathing-related sleep disorders play a role in the etiology or course of depressive disorders. To date, the results of these clinical studies have been mixed. Some have found that OSAS is associated with higher rates and/or severity of clinical depression. Other studies have found that OSAS patients do not have higher rates of depression than do individuals with chronic diseases or control subjects. Some studies have also measured whether depressive symptomatology is lessened when a breathing-related sleep disorder is treated with CPAP. However, the mood amelioration could be a result of the placebo effect of the CPAP.[38] Millman et al[39] also showed that 45% of subjects with OSAS had depressive symptoms, and that nasal CPAP therapy returned their depression scores to a normal range.

In our study, mood disorders appeared to be more frequent in subjects with reduced VDO and those at high risk for OSAS, which was consistent with the results of other studies.[19,20] This finding suggests that reduced VDO is involved in the pathogenesis of nocturnal breathing disorders, as well as depressive feelings.

It has also been reported that other neuropsychologic deficits are often found in subjects with OSAS, such as decreased concentration, memory loss, decreased libido, irritability, moodiness, psychosis, and depression. All of these neuropsychologic deficits, together with depressive disorders and excessive diurnal somnolence, could have a profound impact on the normal activities of daily living and could cause significant impairment in quality of life.[20]

A limit of this study is the lack of a polysomnographic evaluation of the patients; therefore, further studies are needed to confirm through an instrumental examination the diagnosis of OSAS to assess how VDO influences pharyngeal patency occurring or worsening of sleep apnea. Finally, the reversibility of OSAS symptoms and depressive feelings with the restoration of a correct VDO should be assessed.

The high prevalence (63%) of the need for prosthodontic treatment described in this study demonstrates that the level of dental care for the elderly occupants of residential homes remains inadequate. Catovic et al found that more than 82% of the subjects in a group of residential homes were in need of prosthodontic treatment,[40] while Simons et al found that only 4% of the edentulous residents and 20% of the dentate residents of homes for the elderly had seen a dentist in the previous 2 years.[41]

Conclusions

The prevalence of high risk for sleep apnea in the elderly population examined (age > 65 years) was 61.1%. This study revealed that several parameters of oral health closely correlate with the risk of obstructive sleep apnea:

- A statistically significant association was found between a reduction in the VDO and an increased risk of sleep apnea. Among subjects with adequate VDO, 35% and 65% were at high and low risk for sleep apnea, respectively. In contrast, among subjects with reduced VDO, 76% and 24% were at high and low risk of sleep apnea, respectively.
- A statistically significant association was found between the wearing of dentures at night and the risk of sleep apnea among the subjects with dental prostheses. In subjects who wore their dentures at night, 50% were at high risk and 50% were at low risk for sleep apnea, whereas of the subjects who did not leave their prosthesis in place at night, and therefore had a greater likelihood of reduced VDO, 71% were at high risk for sleep apnea.
- The results confirmed the association between OSAS and depression, as described in the literature.[19,20]

The high prevalence of the need for prosthodontic treatment described in this study demonstrates that the level of dental care for the elderly in residential

homes remains inadequate. Regular dental follow-up of edentulous elderly patients is not only important for the restoration of appropriate VDO, correct masticatory function, and a pleasing esthetic, but can be the basis for minimizing the aggravation of diseases which, if untreated, could lead to worsened hypertension, cardiovascular complications, and neurocognitive dysfunction.

Acknowledgments

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