The prevalence of obstructive sleep apnea syndrome in patients up to the age of 60 is known to be two times higher in men than in women. Hormonal changes during menopause might underlie changes in this relationship in the elderly. This study was designed to detect differences in the type and frequency of sleep-disordered breathing between women and men over the age of 65 years, having the same body mass index. The study was conducted using a matched-pair approach consisting of a sample population of 40 pairs of patients over the age of 65. All patients met the following exclusion criteria: age below 65, heart failure, chronic obstructive lung disease. Polygraphy was conducted by means of a portable recorder. All measured indices were higher in men than in women. The apnea index was 2.8 ±4.1 in men and 0.6 ±1.4 in women. The apnea/hypopnea index was 10.2 ±11.4 and 4.8 ±3.9, respectively. These differences were significant (P<0.05). Significant differences also were observed when central (men 8.1 ±13.1, women 3.1 ±8.2), mixed (men 5.1 ±11.4, women 0.4 ±1.3), and obstructive (women men 8.6 ±20.1, 1.0 ±4.3) apnea indices were compared. In conclusion, the study demonstrates that elderly patients showed gender-dependent differences in the type and frequency of sleep-related breathing disorders. Men suffered from all kinds of apnea more frequently than women.

Key words: elderly, gender, obstructive sleep apnea, sleep-disordered breathing

INTRODUCTION

Obstructive sleep apnea (OSA) is a disorder characterized by repetitive sleep-induced collapse of the pharyngeal airway, resulting in arousals and daytime
sleepiness. About 25 years ago, it was believed that OSA was primarily a disease of men. In 1979 Block et al demonstrated that apneas and hypopneas and also oxygen desaturations are more common in men than in women (1). The Wisconsin sleep cohort study observed a three times higher prevalence of sleep-disordered breathing (SDB) in men (24%) then in women (9%) (2). This gender difference in the prevalence of SDB has not been adequately explained but suggests that the risk factors and mechanisms for OSA may differ between men and women.

It is commonly thought that hormonal factors may be one of the reasons accounting for these differences. Other possible reasons under consideration are: structural and functional differences in the upper airway (3, 4, 5), differences in body fat distribution (6), and differences in the control of breathing.

Nevertheless, several studies have failed to demonstrate differences in the upper airway size between normal men and women and between obese women with or without OSA (7, 8). Another explanation for the gender difference is underdiagnosing OSA in women. This is due to the somewhat different symptom manifestations than in men. Usually, frank apnea is not as evident in women (9). Thus, women are underrepresented in sleep laboratory referrals, even though women who snore experience more subjective daytime sleepiness than men (10).

Several studies subsequently reported that sleep, sleep disorders and SDB differ in important ways between men and women. In clinical populations, women are more likely to present with insomnia than are men, although their sleep may be better preserved (11). The presentation of OSA in women is distinct from that of men and is less likely to include a 'classic' history of witnessed apnea or heavy snoring. It presents with non-specific symptoms, such as fatigue or mood disturbance (12). Post-pubescent adolescents show gender differences in clinical and polygraphic parameters, which are not observed at earlier pubertal stages (13). These findings support the influence of sex hormones on gender differences in SDB. Netzer et al (14) have demonstrated that reductions in female sex hormones are associated with increased probability of SDB in women with daytime sleepiness.

Because of pregnancy and menopause, women may experience changes in sleep that may present as clinical problems. Especially, elderly women may suffer from OSA symptoms because of changes in the hormonal status (15). Few papers have addressed the gender difference concerning OSA in elderly patients.

In the present study we investigated the sleep architecture and the nocturnal respiratory pattern in the groups of elderly women and men matched by age and weight. The objective of this study was to compare the frequency of obstructive, central, and mixed sleep apnea between men and women in a sample of 80 patients referred to hospital. A standardized sleep and sleepiness-questionnaires were administered and anthropometric data were measured. The patients underwent a cardiorespiratory polygraphy during one night.
MATERIAL AND METHODS

Study subjects

The study received human subjects approval from the institutional Ethics Committee was conducted using a matched-pair approach. The patient population consisted of 80 aged participants: 40 women and 40 men admitted to the Department of Internal Medicine in a city hospital in Germany. The group was quite heterogeneous in terms of the presenting complaints. None of the patients were admitted because of snoring, day time sleepiness, observed periods of cessation of breathing, insomnia or suspected parasomnia. Most patients were admitted for treating diabetes.

All patients met the following exclusion criteria: age below 65, heart failure, chronic obstructive lung disease. All 80 subjects completed the study.

Table 1. Demographic baseline characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total n=80</th>
<th>Women n=40</th>
<th>Men n=40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>74.1 ±6.3</td>
<td>73.3 ±4.8</td>
<td>74.9 ±7.5</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.8 ±4.6</td>
<td>26.8 ±4.7</td>
<td>26.8 ±4.5</td>
</tr>
<tr>
<td>HbA1c</td>
<td>6.9 ±2.4</td>
<td>6.5 ±2.1</td>
<td>7.3 ±2.8</td>
</tr>
</tbody>
</table>

Measurements

The patients were studied with overnight polygraphy. Breathing was assessed by monitoring chest and abdominal wall movements using strain gauge pneumographs. Nasal and oral flows were measured using thermistors. Arterial oxygen saturation was measured with a pulse oximeter. All variables were recorded simultaneously. Sleep recording was scored referring to standard criteria. SDB was quantified using the apnea-hypopnea index (AHI). Indices of overnight desaturation were additionally taken. The exact definition of OSA is not easy; hence making robust estimates of OSA prevalence is difficult. A simple approach using sleep study indices, as the only definition criteria, overestimates the clinically relevant events. Therefore, the AHI in conjunction with an index of sleepiness was used. The Epworth Sleepiness Scale (ESS) was utilized to assess excessive daytime sleepiness (2). A sleep questionnaire (16) was distributed to all participants.

Data are presented as means ±SE. Differences in the anthropometric data, ESS, and respiratory events during sleep between genders were assessed with the Mann-Whitney U and Wilcoxon signed rank tests. P value <0.05 was considered significant.

RESULTS

A total of 34 patients (43%) (male/female ratio 1:0.7) fulfilled the OSA criterion with respect to the AHI ≥ 5. The mean apnea index turned out to be 0.6 ±1.4 in women and 2.8 ±4.1 in men. The mean AHI was 4.8 ±3.9 and 10.2 ±11.4, respectively. These differences were significant (P<0.05). The gender differences were independent of the cut-off points used to define apnea; the AHI of 5/h, 10/h, or 15/h (Table 2).

The frequency and intensity of daytime hypersomnolence was similar in both genders; ESS was 6.8 ±3.5 in men and 6.7 ±2.7 in women. Morning headaches,
insomnia, depression, and the use of sedatives were more frequent in women than in men. Men complained more of being unable to concentrate.

Using the most restrictive definition of OSA (AHI ≥10 and ESS >9), 6 men (15%) and 2 women (5%) fulfilled the criteria of OSA (male/female ratio 3:1), which points to the possibility of different causes of daytime sleepiness in elderly women and men (Fig. 1). BMI in patients with OSA did not differ significantly from that in patients without it.

Significant differences also were observed when central (women 3.1 ±8.2, men 8.1 ±13.1) (P=0.022) mixed (women 0.4 ±1.3, men 5.1 ±11.4) (P<0.001) and obstructive (women 1.0 ±4.3, men 8.6 ±20.1) (P=0.049) apnea indices were compared. All indices were significantly higher in men than in women (Fig. 2).

### Table 2. Apnea index and apnea/hypopnea index (AHI) in elderly men and women.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total n=80</th>
<th>Women n=40</th>
<th>Men n=40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea index</td>
<td>1.7 ±2.5</td>
<td>0.6 ±1.4</td>
<td>2.8 ±4.1</td>
</tr>
<tr>
<td>Apnea/hypopnea index</td>
<td>7.5 ±7.1</td>
<td>4.8 ±3.9</td>
<td>10.2 ±11.4</td>
</tr>
<tr>
<td>Subjects with AHI ≥5/h</td>
<td>34 (43%)</td>
<td>14 (35%)</td>
<td>20 (50%)</td>
</tr>
<tr>
<td>Subjects with AHI ≥10/h</td>
<td>15 (18%)</td>
<td>3 (8%)</td>
<td>12 (30%)</td>
</tr>
</tbody>
</table>

![Fig. 1. Elderly men have an elevated AHI and suffer more from OSA than women, although both genders have similar daytime sleepiness score (ESS) in relation to daytime hypersomnolence. This leads to a hypothesis that women may suffer more often from other sleep disturbances.](image1.png)

![Fig. 2. Distribution of different apnea indices in women and men showing that central obstructive and mixed apneas are more common-place in elderly men.](image2.png)
DISCUSSION

Here we report that there were significant differences in the type and frequency of sleep-related breathing disorders between elderly men and women, despite the same age and body mass index. Men suffered more frequently from central, mixed, and obstructive apneas. The main finding of the study was that elderly men had a prevalence of clinically relevant SDB of 15% and women of 5% (ratio 3:1). In contrast to other studies, obesity had no considerable effect in either gender.

In 1993 Young et al (2) have estimated that 2% of middle-aged women and 4% of middle-aged men meet the minimum diagnostic criteria for the sleep apnea syndrome (AHI ≥5/h plus daytime hypersomnolence). In the present study, using similar diagnostic criteria, we found the prevalence of OSA in the elderly population to be 2.5-fold higher. The greatest differences in the prevalence of OSA between middle and older age patients was found in a large Spanish study using AHI as the only diagnostic criterion (17), which may lead to an overestimation of clinical relevant OSA. In that study, for the age group 71-100 years the prevalence of AHI >5/h was 80% for women and 81% for men. This prevalence was three times higher than in the middle-aged participants of the cohort. The Cleveland family study (18) has found a higher prevalence in patients over 60 years of age, which also is in line with our findings that the prevalence of OSA in elderly patients is 2 to 3 times higher than in middle-aged patients.

Several reports that described adult women with OSA have emphasised its frequent association with massive obesity (19). Sex hormones have been thought to influence the development of OSA. An interesting finding by Bixler et al (20) was that all premenopausal women and those on hormone replacement therapy (HRT) who had AHI >15 had BMI over 32. In contrast, in postmenopausal women without HRT who had AHI >15 the occurrence of BMI over 32 was less than 50% (similar to that in men). In our study, BMI of women with AHI >15 was only 23. This generates the hypothesis that BMI in elderly women no longer plays the predicted dominant role.

Postmenopausal women have generally been reported to have a higher prevalence of apnea than the premenopausal ones do (15, 20, 21). HRT has been shown to decrease sleep-disordered breathing indices (apnea/hypopnea). This suggests that estrogen deficiency or testosterone excess may play an important role. Studies from Dancey et al (22) and Pickett et al (23) have shown more severe OSA in postmenopausal women and reductions in indices of sleep-disordered breathing from HRT (estrogen and progesterone) in healthy postmenopausal women. Likewise, Shahar et al (24) have observed an inverse association between hormone use and sleep-disordered breathing. These authors have postulated that HRT could have a role in preventing or alleviating sleep-disordered breathing. Conversely, testosterone may provoke OSA, perhaps by effects on the upper airway (25). On the other hand, our data could neither show that hormone deficiency in elderly women leads to a higher prevalence of OSA nor that testosterone deficiency in elderly men
can protect against OSA. The effect of menopause on the upper airway resistance syndrome and on the severity of OSA remains an unresolved issue.

Redline et al (26) have found that men, but not women, show evidence of poorer sleep with aging, suggesting important sex differences in sleep physiology. The results of a sleep questionnaire in our study support this hypothesis. Referring to functional differences in upper airways, a couple of studies have investigated the gender differences related to upper airway muscle tone. There appears to be no significant difference in muscle tone in the upper airway dilators (genioglossus and tensor veli palatini) between men and women during sleep, although men have a higher upper airway resistance (3). To determine whether structural differences could underlie the sex differences in OSA, MRIs of the upper airway have been performed. Non-obese men have more fat in some regions of their necks that impinge on the pharynx, compared with women (27). Popovic and White (28) have found an effect of female hormones on the pharyngeal dilator muscle activity. The authors have concluded that female hormones (possibly progesterone) have a substantial influence on upper airway dilator muscle activity. Putting all together, it appears that differences in tissue characteristics alone, be it functional or structural, can not explain the epidemiological facts.

In conclusion, our study demonstrates that the male dominance in regard to the prevalence and severity of OSA does not disappear over the age of 65 years. The risk of SDB increases 2-3-fold with age, although women at any age are less susceptible than men. Hormonal changes in menopause do not seem to play a pivotal role in modulating both the presence and the degree of sleep disorders. Perhaps the sexes are more different than we think, and perhaps our understanding will benefit from a closer examination of differences between the sexes.

REFERENCES


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