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CLINICAL & BASIC RESEARCH

Gender Difference in Relationship of Apnoea/Hypopnoea Index with Body Mass Index and Age in the Omani Population

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الاختلاف بين الجنسين وعلاقته مع منسب انسداد التنفس النومي ومنسب كتلة الجسم والعمر في العُمانيين

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الملخص: **الهدف**: متلازمة انسداد التنفس النومي اضطراب يتميز بتقلص المسالك التنفسية العليا المتكرر أثناء النوم مصحوبا بالنعاس أثناء النهار، ويعتبر من الإمراض الشائعة التي تصيب 2% من النساء و 4% من الرجال أثناء الكهولة. الهدف من هذه الدراسة هو معرفة العلاقة بين متلازمة انسداد التنفس النومي ومنسب كتلة الجسم و العمر والاختلاف بين الجنسين عند العمانيين. **الطريقة**: تمت مراجعة واستخلاص البيانات من سجلات مستشفى جامعة السلطان قابوس وتقارير فحص النوم في مختبر النوم بقسم الفسيولوجيا السريرية لجميع مرضى متلازمة انسداد التنفس النومي بين يناير 1995 وديسمبر 2006 بصورة استعادية. **النتيجة**: تمت مراجعة 1042 تقريرا كان 608 منها صالحا للدراسة. أوضحت الدراسة أن معدل الانسداد لأكثر من 15 مرة يحصل عند الذكور أكثر من الإناث (47.9% مقابل 33.5% على التوالي) والفرق معتدّ من الناحية الإحصائية ($P < 0.001$). كذلك توجد علاقة طردية معتدة إحصائيا بين منسب كتلة الجسم ومعدل الانسداد عند الرجال ($P = 0.01$) مقارنة بالنساء ($P = 0.0001$) إلا أن علاقة معدل الانسداد بالعمر كانت أكثر لدى النساء ($P < 0.0001$) مقارنة بالرجال($P = 0.1$) . **الخلاصة**: هناك فرق بين الجنسين في العلاقة بين معدل انسداد التنفس النومي ومنسب كتلة الجسم والعمر عند العمانيين. السمنة نؤدي إلى الانسداد أكثر عند الرجال بغض النظر عن العمر فيما يكون العمر هو العامل الأساسي للانسداد عند النساء.

مفتاح الكلمات: متلازمة انسداد التنفس النومي، العمر، السمنة، عُمان.

ABSTRACT: ***Objectives:*** Obstructive sleep apnoea/hypopnoea syndrome (OSAHS) is a disorder characterised by repetitive upper airway collapse during sleep in association with daytime sleepiness. It has an estimated prevalence of 2% and 4% among middle-aged women and men respectively. The aim of the study was to look at the association of body mass index (BMI), age and gender and prevalence of OSAHS in the Omani population. ***Methods:*** Polysomnography reports and hospital medical records of all patients who took part in the Sleep Study at the Sleep Laboratory of the Clinical Physiology Department, Sultan Qaboos University Hospital, between January 1995 and December 2006, were retrospectively reviewed. Data from both sources was gathered and analysed. ***Results:*** A total of 1,042 sleep studies were conducted with 608 valid studies for analysis. The study showed that the apnoea/hypopnoea index (AHI) >15 was more prevalent in men compared to women (47.9% versus 33.5%, $P = 0.001$). There was significant correlation of AHI with BMI ($P < 0.0001$) among men compared to women ($P = 0.1$); however, age was significantly correlated with AHI among women ($P < 0.0001$), but not with men ($P = 0.1$). ***Conclusion:*** The results indicate that there is a gender difference in the prevalence of OSAHS and obesity is a major risk factor for OSAHS among Omani men whereas age is found to be a risk factor for OSAHS among women.

Keywords: Sleep; Apnoea; Age; Obesity; Oman

Advances in knowledge

1. *This is the first study to be conducted in Omani population assessing the risk factors of obstructive sleep apnoea/hypopnoea syndrome (OSAHS) and describing the difference in the prevalence of apnoea/hypopnoea syndrome.*
2. *The study revealed that there is a major gender difference in the prevalence of OSAHS between men and women in Oman.*
3. *Age is the major determinant among women compared with men. Men are more susceptible to OSAHS at younger age compared to women.*

Application to patient care

1. *This article provides evidence-based information for sleep physicians to aid in the diagnosis of OSAHS.*
2. *It will also help them to prioritise the need for a sleep study as hospital waiting lists are long.*

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Obstructive sleep apnoea/hypopnoea syndrome (OSAHS) is a disorder characterised by repetitive upper airway collapse during sleep associated with arterial oxygen desaturation. This leads to repetitive night awakenings and excessive daytime sleepiness.[1] OSAHS has also been associated with adverse cardiovascular consequences such as hypertension,[2] and ischaemic heart disease.[3] Major aetiological factors, such as obesity, and craniofacial anatomic predisposition, are both genetically and environmentally influenced, and it is therefore pertinent to determine the prevalence of sleep apnoea in different populations.[4] It was shown previously by Young *et al.* that the prevalence of OSAHS was 2% in women and 4% in men in subjects who had an apnoea/hypopnoea index (AHI) of more than 5 and had symptoms.[5] AHI is determined by number of apnoeas and hypopnoeas per hour of sleep. Duran *et al.* showed that the prevalence was higher with AHI of more than 5 and no symptoms, but with marginal gender difference between males and females. However, the gender difference became more obvious with higher levels of AHI with higher prevalence among men in all age groups.[6] Nevertheless, gender differences in OSAHS prevalence could not be well established due to controversial results.[7]

Obesity is the main risk factor for OSAHS and more than 80% of OSAHS patients have a body mass index (BMI) of more than 30 Kg/m.[2,8] Recently, obesity has been found to be a major health problem in the Omani population with increasing prevalence in relatively young subjects.[9] Nevertheless, age also has a major role in increasing the prevalence of OSAHS.[10] To date, there has been scanty documentation of the gender difference in the prevalence of OSAHS in the Omani population. The aim of the study is to evaluate the association of BMI, age, and gender difference with prevalence of OSAHS in the Omani population.

Methods

A retrospective analysis study was conducted among all patients (N = 1,042) listed in the registry of the Sleep Laboratory of the Clinical Physiology Department, of Sultan Qaboos University Hospital (SQUH), Oman, between January 1995 and December 2006. Polysomnography data were retrospectively collected from polysomnography reports. Information on demography and related medical disorders, e.g. hypertension, chronic obstructive pulmonary disease (COPD), ischaemic heart disease (IHD), hypothyroidism, behavioural disorders and diabetes were collected from hospital medical electronic records and paper files. Details of data collection were previously published.[11] The study was approved by the Ethical Committee of the College of Medicine & Health Sciences at Sultan Qaboos University.

Weight and height were measured with bare feet and light clothing, using a standard scale (Seca, Germany) for all patients attending for a sleep study. All the anthropometric measurements were done at the time of the sleep study. Weight was recorded to nearest 0.5 Kg and height to the nearest centimetre. The BMI was calculated as weight divided by square of height in meters (BMI = weight [Kg] / height [m^2]). Age was verified based on hospital medical records.

A sleep study was conducted for all patients. The study consisted of two channels of electroencephalogram (EEG), two electro-oculograms (EOG), a chin and legs electromyography (EMG) and an electro-cardiogram (ECG). Respiratory events were monitored by means of an airflow sensor and chest and abdominal movement sensors. Snoring was recorded using a microphone. Leg movements and sleep position were also monitored using special sensors. Oxygen saturation was assessed by pulse oxymetry and the patient was observed with an infra-red camera. The test is supervised by a trained polysmnographer who was also responsible for the manual scoring of the study. Polysomnography records were scored manually based on the guidelines of the American Academy of Sleep Medicine.[12] An abnormal breathing event during objectively measured sleep was defined according to the commonly used clinical criteria of either a complete cessation of airflow lasting 10 seconds (apnoea) or a discernible reduction in airflow accompanied by a decrease of 4% in oxyhaemoglobin saturation (hypopnoea). The apnoea/hypopnoea index (AHI) was calculated as number of apnoeas and hypopnoeas per hour of sleep.

Descriptive and comparative analyses were performed using the Statistical Package for the Social Sciences (SPSS®) software (IBM, USA,

Table 1: Prevalence of co-morbidities in males and females with apnoea/hypopnoea index (AHI) <15 or AHI >15/ hour

Comorbidity	Males		Females	
	AHI <15 %	AHI >15 %	AHI <15 %	AHI >15 %
Chronic obstructive pulmonary disease/ Asthma	8.9*	6.0§	22.4	24.3
Hypertension	9.1*	12.9	22.2	22.1
Ischaemic heart disease	4.8	5.2	8.1	8.8
Diabetes mellitus	5.2*	4.3§	12.6	14.7
Hypothyroidism	0.8*	1.7§	6.7	8.8
Behavioural diseases	10.3*	0.9§	8.1	2.9

*Notes: * = P <0.05 for gender difference in co-morbidity in group AHI <15; § = P <0.05 for gender difference in co-morbidity in group AHI >15.*

Version 13.0). Parametric data were expressed as means ± standard deviation (SD). A *P* value of <0.05 was considered significant.

The relationship of AHI with age and BMI was tested using Pearson's bivariate correlations. Correlations were estimated separately for men and women. AHI was grouped as ≤15 and >15.1 per hour. Age and BMI were categorised as follows: Age: <40 years, 41–60 and >60 years; BMI: <24.9, 25–29.9, 30–34.9 and >35 Kg/m^2. An age of 40 years was chosen based on the distribution of the sample population.

The χ^2 analysis was used to test the association of AHI with gender and association of co-morbidities with gender in both AHI groups. The first model of binary logistic regression was used to estimate odds of having AHI >15 included gender, age, BMI and other associated co-morbidities like hypertension, COPD, asthma, IHD, hypothyroidism, behavioural disorders and diabetes. Co-morbidities were removed from the final model as there were no significant associations of AHI with co-morbidities adjusted for age, BMI and gender. Finally, age adjusted odds for having AHI >15 with BMI and BMI adjusted odds for having AHI >15 with age were calculated in males and females. The BMI <24.9 Kg/m^2 and age up to 40 years were taken as a reference control.

Results

The total number of patients reviewed between January 1995 and December 2006 were 1,042. The analysis was conducted on 608 valid sleep study reports for patients of more than 18 years old of age. A total of 374 reports were excluded because of incomplete data and 60 sleep study reports for patients under 18 years of age. The men (n = 405) to women (n = 203) ratio of studied patients was approximately 3:1. Women were significantly older than men (women: 45.3 ± 12.1 versus men: 39.8 ± 13.2 years *P* = 0.0001) and had higher BMI (36.0 ± 8.7 versus 31.8 ± 5.5 Kg/m^2, *P* = 0.0001). The total number of patients who had AHI >15 was 300 (232 men and 68 women). The prevalence of comorbidities in men and women with AHI <15 and AHI >15 are given in Table 1. In men, the prevalence of hypertension, IHD and hypothyroidism was higher in the group with AHI >15 compared with AHI <15. In women, the prevalence of COPD/ asthma, IHD, diabetes and hypothyroidism was higher with AHI >15 [Table 1]. The AHI <15 group showed a significant gender difference for all comorbidities except IHD, but the group AHI >15 showed a significant gender difference only in COPD (*P* = 0.005), diabetes mellitus (DM) (*P* = 0.007), and hypothyroidism (*P* = 0.018) [Table 1].

Gender was strongly associated with AHI ($\chi^2$12.1, *P* = 0.0001, df1). The AHI showed a weak but significant correlation with age (r^2: 0.092; *P* = 0.02) and BMI (r^2: 0.121; *P* = 0.004). However, the gender difference surfaced when AHI was correlated with age and BMI separately in males and females. Interestingly, in males, AHI was correlated significantly with BMI (r^2: 0.224; *P* = 0.0001), but not with age (r^2: 0.066; *P* = 0.14). By contrast, AHI in women showed significant correlation with age

Table 2: Age adjusted odds for apnoea/hypopnoea index (AHI) >15 for different categories of body mass index (BMI) in males and females

	Total		Males		Females	
BMI kg/m²	**OR**	***P***	**OR**	***P***	**OR**	***P***
< 24.9		--	--	--	--	
25–29.9	1.79	0.10	2.51	0.18	2.58	0.41
30–34.9	2.50	0.011	3.39	0.02	3.10	0.32
> 35	5.03	0.0001	6.97	0.0001	5.51	0.11
Age in years	1.05	1.00	0.49	1.00	1.04	0.01
Gender	0.32	0.0001	--	--	--	-

Legend: OR = Odds ratio.

(r^2: 0.295; P = 0.0001) but not with BMI (r^2: 0.117; P = 0.13).

The age adjusted odds of having AHI >15 for pooled data were significant in all BMI categories, the highest value being for the BMI >35 category, and were significantly dependent on age and gender [Table 2]. When estimated separately for gender, men showed significant odds of having AHI >15 for all BMI categories. However, the odds were maximum for category BMI >35 Kg/m² (Odds: 6.97, P = 0.0001). On the contrary, in women, having AHI >15 was independent of BMI [Table 2].

In pooled data, the BMI adjusted odds of having AHI >15 were significant for BMI (P = 0.0001) and gender (P = 0.006). The gender difference became prominent when BMI adjusted odds were estimated separately for males and females. Compared with women aged <40 years, women aged 41–60 had odds of 2.64 (P = 0.025) and women aged >61 had odds of 4.08 (P = 0.01) of having AHI >15. In men, the odds of having AHI >15 were independent of age [Table 3].

Discussion

This study was conducted for the first time in the Omani population to understand the relationship between OSAHS and the two main risk factors, age and obesity. The study was conducted on a clinic-based population sample at Sultan Qaboos University Hospital, Oman, and was done as part of the sleep medicine audit in Oman.[11] The main outcome of analysis was that having AHI >15 is differently related to gender; in men, it is related to BMI and not age, on the contrary, in women, it is related to age and not BMI.

The prevalence of OSAHS of 4% in men and 2% in women estimated by Young *et al.* was based on an AHI score of 5 or higher and moderate to severe daytime hypersomnolence.[5] In this study, AHI >15 was implicated as a cut-off point for OSAHS and the results showed that 49% of the study sample had obstructive sleep apnoea, with higher prevalence among men (57%) compared with women (33%). A limitation of this study is that the study sample was hospital-based and may therefore have selection bias. In addition, daytime sleepiness was not assessed by a validated scale or questionnaire, e.g. the Epworth Sleepiness Scale, which could be a further limitation of this study. However, this study confirmed that there is a gender difference in the association of OSAHS with age and BMI. AHI correlated significantly with BMI, but not with age, in men. On the contrary, AHI in women showed a significant correlation only with age with a four-fold increase in risk for women older than 60 years of age compared to women under 40 [Tables 2 and 3]. These findings could be attributed to the lower levels of sex hormones, especially progesterone, which occurs in post-menopausal women. The association of reduced female sex hormones with an increased probability of obstructive sleep apnoea

Table 3: Body mass index (BMI) adjusted odds ration (OR) for apnoea/hypopnoea index (AHI) >15 for different age groups in males and females

	Total		Males		Females	
Age years	**OR**	***P***	**OR**	***P***	**OR**	***P***
≤40			--	--	--	--
41–60	1.31	0.16	1.05	0.83	2.64	0.025
≥61	1.89	0.059	1.28	0.58	4.09	0.01
BMI kg/m²	1.07	0.0001	1.07	0.0001	1.04	0.06
Gender	0.30	0.006				

in women is well documented.[13] Previous studies found that those women with an AHI >10 had significantly lower levels of 17-OH progesterone, progesterone, and estradiol than those with an AHI less than 10.[12] Similar results were found by Redline *et al*. who found in a community study that females with OSAHS were significantly older (P <0.01) than apnoeic male subjects and the majority of those females were postmenopausal.[8] However, they found no significant difference in BMI between the two genders.[8] Furthermore, Young *et al*. found that postmenopausal women had a higher odds ratio of having AHI >15 compared to perimenopausal women (perimenopause: 1.1 [0.5, 2.2] versus postmenopause: 3.5 [1.4, 8.8]).[14]

Our results were in accord with the increasing prevalence of obesity and metabolic syndrome in the Omani population. Al-Lawati *et al.* found that the prevalence of metabolic syndrome increased with age in both sexes, but the increase was steeper in women.[9] Furthermore, in the age group 20–29 years, 4.7% of men and 2.8% of women had metabolic syndrome. In the age group 60 years and over, the prevalence was 29.8% and 48.7%, respectively. In Durán's study, a strong association between AHI and age was found in the logistic regression model adjusted to sex and BMI, suggesting that factors other than obesity play a role in the presence of OSAHS.[6] When AHI for men and women were pooled together, there was significant correlation with age and BMI. The results indicated that obesity is the main risk factor for OSAHS in Omani men with increasing risk with higher BMI. Similar results were found by Young *et al*. who found that male sex, age and BMI were strongly associated with AHI >15.[15] A study by BaHammam *et al*. found that the prevalence of obstructive sleep apnoea among middle-aged Saudi women (35–60 years) was 40%.[16] However, the population sample was screened using the Berlin questionnaire only and found no correlation with age. It was shown in an urban Indian population that, when BMI was normal, metabolic syndrome may be the first event, followed by OSAHS as age increases and eventually it may culminate in syndrome Z (OSAHS and metabolic syndrome together).[17] More recently, it was found that metabolic syndrome prevalence, including obesity is associated with increased severity of OSAHS.[18]

Conclusion

Our study revealed gender difference in associations of sleep disordered breathing in an Omani population. Male gender and obesity led to higher risk compared to women in the same age group. However, age is the major predictor for obstructive sleep apnoea among women, with a higher risk of OSAHS in postmenopausal woman

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CONFLICT OF INTERESTS

The authors reported no conflict of interest.

References

1. Guilleminault C, Tilkian A, Dement W. The sleep apnoea syndrome. Ann Rev Med 1976; 27:465–84.
2. Peppard P, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med 2000; 342:1378–84.
3. Kuniyoshi FH, Pusalavidyasagar S, Singh P, Somers VK. Cardiovascular consequences of obstructive sleep apnoea. Indian J Med Res 2010; 131:196–205.
4. Ip MS, Lam B, Lauder IJ, Tsang KW, Chung KF, Mok YW, et al .A community study of sleep-disordered breathing in middle-aged Chinese men in Hong Kong. Chest 2001; 119:62–9.
5. Young T, Finn L. Epidemiological insights into the public health burden of sleep disordered breathing: Sex differences in survival among sleep clinic patients. Thorax 1998; 53:16–19.
6. Durán J, Esnaola S, Rubio R, Iztueta A. Obstructive sleep apnea-hypopnea and related clinical features in a population-based sample of subjects aged 30 to 70 yrs. Am J Respir Crit Care Med 2001; 163:685–9.
7. Redline S, Kump K, Tishler PV, Browner I, Ferrette V. Gender differences in sleep disordered breathing in a community-based sample. Am J Respir Crit Care Med 1994; 149:722–6.
8. Redline S, Tishler PV. The genetics of sleep apnoea. Sleep Med Rev 2000; 4:583–602.
9. Al-Lawati JA, Mohammed AJ, Al-Hinai HQ, Jousilahti P. Prevalence of the metabolic syndrome among Omani adults. Diabetes Care 2003; 26:1781–5.
10. Bixler EO, Vgontaz AN, Ten Have T. Effect of age on sleep apnea in men: I. Prevalence and severity Am J Respir Crit Care Med 1998; 157:144–8.
11. Al-Abri MA, Al-Hashmi KM, Jaju D, Al-Rawas OA, Al-Riyami BM, Hassan MO. An audit of the sleep medicine service in Oman. Saudi Med J 2008; 29:1621–4.
12. Iber C, Ancoli-Israel S, Chesson A, Quan S. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications. Westchester: American Academy of Sleep Medicine, 2007. IL 45–7.
13. Netzer NC, Eliasson AH, Strohl KP. Women with sleep apnoea have lower levels of sex hormones. Sleep Breath 2003; 7:25–9.
14. Young T, Finn L, Austin D, Peterson A. Menopausal status and sleep-disordered breathing in the Wisconsin Sleep Cohort Study. Am J Respir Crit Care Med 2003; 167:1181–5.
15. Young T, Shahar E, Nieto FJ, Redline S, Newman AB, Gottlieb DJ, et al. Predictors of sleep-disordered breathing in community-dwelling adults: The Sleep Heart Health Study. Arch Intern Med 2002; 16:893–900.
16. Bahammam AS, Al-Rajeh MS, Al-Ibrahim FS, Arafah MA, Sharif MM. Prevalence of symptoms and risk of sleep apnoea in middle-aged Saudi women in primary care. Saudi Med J 2009; 30:1572–6.
17. Sharma SK, Sreenivas V. Are metabolic syndrome, obstructive sleep apnoea and syndrome Z sequential? A hypothesis. Indian J Med Res 2010; 131:455–8.
18. Ozol D, Turkay C, Kasapoglu B, Karamanlı H, Yıldırım Z. Relationship between components of metabolic syndrome and polysomnographic findings in obstructive sleep apnoea. Metab Syndr Relat Disord 2010. In press.