



Published in final edited form as:

J Sex Med. 2008 April ; 5(4): 898–908. doi:10.1111/j.1743-6109.2007.00706.x.

Snoring as a Risk Factor for Sexual Dysfunction in Community Men

Viktor Hanak, MD^a, Debra J. Jacobson, MS^b, Michaela E. McGree, BS^b, Jennifer L. St Sauver, PhD^c, Michael M. Lieber, MD^d, Eric J. Olson, MD^a, Virend K. Somers, MD, PhD^e, Naomi M. Gades, DVM^c, and Steven J. Jacobsen, MD, PhD^f

^aDepartment of Pulmonary and Critical Care Medicine, Mayo Clinic, Rochester, MN

^bDivision of Biostatistics, Mayo Clinic, Rochester, MN

^cDivision of Epidemiology, Mayo Clinic, Rochester, MN

^dDepartment of Urology, Mayo Clinic, Rochester, MN

^eDepartment of Cardiovascular Diseases, Mayo Clinic, Rochester, MN

^fDepartment of Research and Evaluation, Southern California Permanente Medical Group, Pasadena, CA

Abstract

Introduction—Severe obstructive sleep apnea has been associated with sexual dysfunction; however, it is unclear whether milder forms of sleep disturbances might also be associated with sexual problems.

Aim—To evaluate the association between snoring and five measures of sexual dysfunction in a population-based sample of men.

Methods—A stratified random sample of men residing in Olmsted County, Minnesota completed a questionnaire containing questions from the Brief Male Sexual Function Inventory (BMSFI) and a sleep questionnaire.

Main Outcome Measures—Levels of sexual drive (libido), erectile function, ejaculatory function, sexual problem assessment, and sexual satisfaction, as assessed by the BMSFI.

Results—Of 827 men with a regular sexual partner, subjects were divided into categories of heavy ($n = 95$), moderate ($n = 573$) and none/mild ($n = 159$) snoring. Their median age was 64 years (range 51–90). The sexual satisfaction domain score was significantly lower in the heavy snoring group (p -value = 0.01). The odds of low sexual satisfaction was 2.3 (95% CI 1.2, 4.1) among the heavy snorers compared to the none/mild snoring group. This association remained statistically significant after adjustment for smoking, medical comorbidities, and mental health status. However, there was no significant difference in ejaculatory function, erectile function, sexual drive and sexual problem assessment across snoring categories.

Conclusions—These data provide evidence of an association between snoring severity and reduced sexual satisfaction in a population of elderly community males. Snoring was not associated with biologic measures of sexual dysfunction.

Keywords

Snoring; obstructive sleep apnea; sexual dysfunction; sexual satisfaction

Introduction

Sexual dysfunction is a common health problem in middle-aged and elderly males. The prevalence of dysfunction increases steadily with age, and this condition may affect up to 10% of men in their 40's and up to 80% of men ages 70 and over.¹ Sexual dysfunction can have a strong negative impact on the quality of life.²⁻⁵ Thus, it represents a significant health problem, and identification of potentially modifiable risk factors may be important for disease prevention and treatment.

Obstructive sleep apnea (OSA) is also a very common disease, affecting 5% to 20% of the adult population⁶, and could potentially represent a risk factor for sexual dysfunction in aging men. Hormonal changes, hypoxia-induced nerve impairment, vascular changes and reduced nitric oxide production associated with OSA have been proposed as potential biologic mechanisms that may lead to sexual dysfunction.^{7,8} Sleep disordered breathing therefore represents a potentially modifiable risk factor for sexual dysfunction and elimination of OSA could contribute to treatment of this common health problem.

The association between sleep-disordered breathing and sexual dysfunction was initially described by Guilleminault et al., who reported a high prevalence (48%) of erectile dysfunction among patients with severe OSA.⁹ Although the evidence is not completely consistent,^{10,11} OSA has also been associated with erectile dysfunction in several subsequent studies in patients evaluated in urology and sleep disorders clinics.^{7,12-17} These studies, however, have often been limited to small samples of patients recruited from specialty clinic referral populations. Additionally, the epidemiologic studies have tended to focus on only one aspect (erectile dysfunction) of sexual function. The accumulation of more severely affected patients in specialty disorder clinics may represent a referral bias that could limit the generalizability of such findings. Additionally, it is not clear whether more mild forms of disordered sleep (such as mild or moderate snoring) might also be associated with sexual dysfunction. The question of whether there is an association between snoring severity and multiple sexual dysfunction domains has not been addressed previously in a larger population-based study. To this end, we examined the question of whether snoring was associated with sexual dysfunction in a randomly selected, community-based population of middle-aged and elderly males.

Methods

Study Population

The Olmsted County Study of Urinary Symptoms and Health Status among Men is an ongoing cohort study of urologic conditions in community-dwelling men. Details related to the study population have been previously published.¹⁸ Briefly, a cohort of Caucasian men aged 40 to 79 years was randomly selected from the 1990 Olmsted County, Minnesota population. Men who had a history of prostate or bladder surgery, urethral surgery or stricture, or medical or other neurological conditions that could affect normal urinary function were excluded. After excluding men with these conditions, 3874 men were asked to join the study, and 2115 (55%) agreed to participate. A comparison of medical records of participants and non-participants indicated no differences except for a history of urologic diagnosis, with responders having a slightly greater prevalence of diagnosis of kidney stones, urinary tract infections or BPH.¹⁹ A 25% random sub-sample of the study cohort, 475 out of 537 men (88%), was chosen to complete a detailed clinical urologic examination, including anthropometric measurements.

The cohort was actively followed on a biennial basis for fourteen years. All study procedures were approved by the Mayo Foundation Institutional Review Board (IRB).

Sexual Function Questionnaire

The Brief Male Sexual Function Inventory (BMSFI) was incorporated into the follow-up questionnaire in the 6th year of follow-up and biennially thereafter (Appendix 1).²⁰ This previously validated questionnaire consists of 11 items related to five sexual function domains: sexual drive (2 questions), erectile function (3 questions), ejaculatory function (2 questions), sexual problem assessment (3 questions), and overall sexual satisfaction (1 question). All questions were scored on a scale from 0 to 4 with domain scores equaling the sum of the individual questions comprising the domain. The domain scores range from 0–12 for erectile function and sexual problem assessment, 0–8 for sexual drive and ejaculatory function and 0–4 for sexual satisfaction. For categorical analysis, the following cut-points were used: low libido if the sexual drive domain ≤ 2 , erectile dysfunction if the erectile function domain ≤ 3 , ejaculatory dysfunction if the ejaculatory domain ≤ 2 , sexual problems if the problem assessment domain ≤ 3 and low sexual satisfaction if the sexual satisfaction domain ≤ 1 .^{21,22}

Sleep Questionnaire

A sleep questionnaire was added to the biennial questionnaire during the 14th year of follow-up. The questionnaire consists of 4 questions about snoring (presence, severity, frequency and whether snoring bothered others) and 2 questions on breathing pauses (presence and frequency). Additionally, 2 questions on fatigue and sleepiness (lack of energy and falling asleep after dinner) were included from the Androgen Deficiency in Aging Males (ADAM) questionnaire. The subjects were divided into three groups of snoring severity: heavy snoring (high-probability of OSA), moderate snoring (indeterminate-probability of OSA) and none/mild snoring (low-probability of OSA). The subjects in the heavy snoring group must have experienced breathing pauses ≥ 1 –2 times per week in order to be considered. In addition, at least two of the following needed to be present for the subject to be assigned to the heavy snoring group: snoring bothersome to others, snoring louder than talking, snoring ≥ 3 –4 times per week and either lack of energy or falling asleep after dinner. Subjects assigned to the none/mild snoring group had no breathing pauses. In addition they either didn't snore at all, or if they snored, it must have been mild snoring that didn't bother others, was quieter than talking, the frequency was ≤ 1 –2 times per month, and the subject did not experience lack of energy or report falling asleep after dinner. Subjects were labeled as moderate snorers if they did not fulfill the criteria for the heavy snoring group or for the none/mild snoring group.

Potential Confounders

Potential confounders of associations between snoring and sexual dysfunction were also assessed, including mental health status, anthropometric characteristics, and comorbidities. Mental health status was assessed using the SF-36 questionnaire, which was administered in the 14th year of follow-up. The five questions directly assessing mental health status were evaluated in the current study. A mental health score was calculated, ranging from 0 to 100.²³ Anthropometric measures included height, weight, and neck and waist circumference measured on all study men at the 4th year of follow-up and on the clinical subset at the 14th year of follow-up. All anthropometric measures were performed using a standardized protocol by a trained study nurse. Medical comorbidities included myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease and diabetes. These were obtained through electronic ascertainment from the Mayo Clinic Medical Index. Current smoking status was assessed in the 14th year follow-up questionnaire.

Statistical Methods

Responses to the BMSFI and snoring questions at the 14th year of follow-up were used in these analyses. Previous work has shown that self-reported sexual function can be heavily influenced by the availability of a regular sexual partner.¹ Therefore only those men with a regular sexual partner were included in the analyses. The distributions of sexual function domain scores were compared across snoring categories using the Kruskal-Wallis test of significance and are presented as medians and first and third quartiles. Logistic regression models were used to evaluate associations between sexual function domains and snoring categories and to evaluate linear trends across snoring categories. Odds ratios and 95% confidence intervals were estimated to quantify the association between snoring status and sexual function. Multivariable logistic regression models were used to evaluate the potential confounding effects of age, anthropometric measures, co-morbidities and mental health status. For all analyses, a P value of less than 0.05 was considered statistically significant. Statistical analyses were completed using SAS statistical software, version 8.2 (SAS Institute, North Carolina).

Results

Data were available for 1326 subjects; the analysis was limited to the 827 men who reported a regular sexual partner. The median age in our population was 64 years (range 51–90). Of the 827 participants, 95 (11 %) subjects were classified the heavy snoring group, 573 (69%) subjects as the moderate snoring group, and 159 (19 %) subjects as the none/mild snoring group (Table 1).

The BMSFI scores for each snoring group are shown in Table 2. Sexual satisfaction scores were significantly lower in the heavy snoring group (p-value = 0.01); however, scores in the other sexual function domains did not differ among the three snoring groups.

When the sexual function domains were examined as dichotomous variables, men in the heavy snoring group were over two times more likely to have low sexual satisfaction compared to the none/mild snoring group (unadjusted OR=2.3, 95% CI=1.2, 4.1; Table 3). The association for men in the heavy snoring group also remained marginally significant after additional adjustment for age, anthropometrics, mental health (SF-36 scores), comorbidities (including diagnosis of myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, and diabetes), and smoking (OR=1.9; 95% CI = 1.0, 3.7). Since the use of phosphodiesterase type 5 (PDE5) inhibitors could modify the associations between snoring and sexual dysfunction, we repeated our analyses excluding the 43 men who reported use of these agents (sildenafil, tadalafil, and vardenafil). Exclusion of these men did not change our results or study conclusions (data not shown.)

Discussion

Snoring severity was associated with low sexual satisfaction in our study population and there was a dose-response decline in sexual satisfaction when compared across snoring categories. Men in the heavy snoring group were approximately two times more likely to have low sexual satisfaction compared to the none/mild snoring group. This association remained marginally significant after adjustment for age, anthropometrics, smoking, mental health status, and medical comorbidities. Snoring was not significantly associated with other measures of sexual function; therefore, the sexual satisfaction domain appeared to be disproportionately reduced in comparison to the other sexual function domains in snoring males.

A possible explanation for the association between heavy snoring and low sexual satisfaction may be related to mutual spousal interaction. Heavy snoring may adversely affect a partner's quality of life, and has been shown to increase partner symptoms such as insomnia, headache,

sleepiness, and fatigue.²⁴ Therefore, it is possible that heavy snoring may also affect a couple's sexual relationship, leading to decreased sexual satisfaction. Alternatively, snoring or disturbed breathing at night may have affected the snorer himself, leading to increased sleepiness, and less interest in sexual activity. However, we did not observe an association between sexual drive and snoring, suggesting that the first explanation may be more plausible.

A somewhat unexpected finding of this study was the lack of a significant association between snoring severity and most measures of sexual function. OSA has been previously associated with erectile dysfunction (ED), and treatment of sleep apnea may lead to resolution of ED in up to 25% of affected patients.^{7,8,12-14,16,17,25-28} OSA has also been associated with decreased sexual function in women as well as men.²⁹ One possible explanation for our failure to find an association may be that the association between ED and OSA has typically been observed only in the most severe cases of apnea. In a study by Margel et al, the relationship between sleep disordered breathing and erectile dysfunction was present in men with very severe sleep apnea (respiratory disturbance index > 40 / hour), but not in patients with mild sleep apnea.¹⁵ Goncalves et al. reported that the majority of subjects with ED and OSA had severe forms of sleep disordered breathing with night-time oxygen saturation below 80%.³⁰ It is difficult to quantify the severity of sleep apnea with a questionnaire; therefore, our study may have lacked the sensitivity to detect an association between severe apnea and sexual function problems. Additionally, we have relatively small numbers of men who might be expected to have more severe sleep apnea (only 11% of the study population was in the heavy snoring category), and we may not have had the power to detect more modest associations between heavy snoring and measures of sexual function. Our results do, however, suggest that different levels of snoring are not associated with physiologic measures of sexual dysfunction. Therefore, physiologic sexual dysfunction may be limited only to men with very severe cases of sleep apnea.

Our results are consistent with other studies that have not supported an association between ED and obstructive sleep apnea.^{10,11} For example, in a study of 285 urologic practice patients with ED, Seftel et al. reported that neither persistent snoring nor suspected obstructive sleep apnea were correlated uniquely to ED after adjustment for other factors.¹¹ Our results are also consistent with Mykeltun et al, who have suggested that sexual functional domains are not necessarily correlated with sexual satisfaction.³¹

When interpreting the results of our study, several potential limitations should be remembered. First, diagnosis of sleep-disordered breathing is most reliably established by a formal polysomnography study in a sleep laboratory.³² Thus, the use of a sleep questionnaire as a surrogate measure is a potential weakness of this study. Nonetheless, the use of a sleep questionnaire in a primary care population is considered accurate for identification of sleep-disordered breathing.³³ In a study of nearly 6,000 community subjects, a history of frequent snoring obtained via a self-completion questionnaire was strongly correlated with the respiratory disturbance index.³⁴ It has also been shown that self-reported snoring correlates well with the objective presence of snoring, particularly in subjects with a regular bed partner.³⁵ In a study by Netzer et al., a sleep questionnaire in the primary care population predicted the presence of sleep apnea with sensitivity of 86%, specificity of 77% and a positive predictive value of 89%.³³ In a medical subspecialty practice, a sleep questionnaire performed with 86% sensitivity and 89% specificity and had a positive predictive value of 97% for OSA.³⁶ However, in our community population, where we would expect the prevalence of OSA to be lower⁶, this tool would have a correspondingly lower positive predictive value.

Second, we examined the cross-sectional association between snoring and five domains of sexual dysfunction; therefore, it was not possible to establish whether snoring preceded sexual satisfaction problems or vice versa. Additionally, some participants may have been unwilling

to report accurate information about sexual function. However, it is unlikely that the responses to the various sexual domains would vary by snoring status; therefore, we feel comfortable that the observed association between heavy snoring and low sexual satisfaction probably did not arise due to differential reporting on the questionnaire. It is possible that the other sexual domains are indeed associated with snoring severity, but our questionnaire-based study was not sensitive enough to detect these more subtle associations. Finally, although we attempted to adjust for the potential confounding effects of age, anthropometrics, and medical comorbidities, some unmeasured confounders may have been responsible for the observed associations.

Conclusions

These data provide evidence of an association between increasing snoring severity and reduced sexual satisfaction in a population of elderly community males. Clinicians assessing patients for sexual dysfunction may therefore wish to explore snoring history, as well as whether some of the treatment options that exist for snoring (such as simple lifestyle changes, use of oral devices, continuous positive airway pressure machines, or surgery) might improve sexual satisfaction.^{28,37–40} However, snoring was not significantly associated with impaired sexual drive, erectile function, or ejaculatory function, suggesting that snoring itself may not be biologically associated with sexual dysfunction.

References

1. O'Leary MP, Rhodes T, Girman CJ, Jacobson DJ, Roberts RO, Lieber MM, Jacobsen SJ. Distribution of the Brief Male Sexual Inventory in community men. *Int J Impot Res* 2003;15:185–91. [PubMed: 12904804]
2. Latini DM, Penson DF, Colwell HH, Lubeck DP, Mehta SS, Henning JM, Lue TF. Psychological impact of erectile dysfunction: validation of a new health related quality of life measure for patients with erectile dysfunction. *J Urol* 2002;168:2086–91. [PubMed: 12394715]
3. Latini DM, Penson DF, Wallace KL, Lubeck DP, Lue TF. Clinical and psychosocial characteristics of men with erectile dysfunction: baseline data from ExCEED. *J Sex Med* 2006;3:1059–67. [PubMed: 17100939]
4. Mallis D, Moisisdis K, Kirana PS, Papaharitou S, Simos G, Hatzichristou D. Moderate and severe erectile dysfunction equally affects life satisfaction. *J Sex Med* 2006;3:442–9. [PubMed: 16681469]
5. Rosen RC, Fisher WA, Eardley I, Niederberger C, Nadel A, Sand M. The multinational Men's Attitudes to Life Events and Sexuality (MALES) study: I. Prevalence of erectile dysfunction and related health concerns in the general population. *Curr Med Res Opin* 2004;20:607–17. [PubMed: 15171225]
6. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea: a population health perspective. *Am J Respir Crit Care Med* 2002;165:1217–39. [PubMed: 11991871]
7. Fanfulla F, Malaguti S, Montagna T, Salvini S, Bruschi C, Crotti P, Casale R, Rampulla C. Erectile dysfunction in men with obstructive sleep apnea: an early sign of nerve involvement. *Sleep* 2000;23:775–81. [PubMed: 11007444]
8. Perimenis P, Karkoulas K, Markou S, Gyftopoulos K, Athanasopoulos A, Barbalias G, Kiriazopoulou V, Spiropoulos K. Erectile dysfunction in men with obstructive sleep apnea syndrome: a randomized study of the efficacy of sildenafil and continuous positive airway pressure. *Int J Impot Res* 2004;16:256–60. [PubMed: 15057257]
9. Guilleminault C, Simmons FB, Motta J, Cumiskey J, Rosekind M, Schroeder JS, Dement WC. Obstructive sleep apnea syndrome and tracheostomy. Long-term follow-up experience. *Arch Intern Med* 1981;141:985–8. [PubMed: 7247605]
10. Schiavi RC, Mandeli J, Schreiner-Engel P, Chambers A. Aging, sleep disorders, and male sexual function. *Biol Psychiatry* 1991;30:15–24. [PubMed: 1892958]
11. Seftel AD, Strohl KP, Loye TL, Bayard D, Kress J, Netzer NC. Erectile dysfunction and symptoms of sleep disorders. *Sleep* 2002;25:643–7. [PubMed: 12227360]

12. Teloken PE, Smith EB, Lodowsky C, Freedom T, Mulhall JP. Defining association between sleep apnea syndrome and erectile dysfunction. *Urology* 2006;67:1033–7. [PubMed: 16698364]
13. Schmidt HS, Wise HA 2nd. Significance of impaired penile tumescence and associated polysomnographic abnormalities in the impotent patient. *J Urol* 1981;126:348–52. [PubMed: 7277596]
14. Pressman MR, DiPhillipo MA, Kendrick JI, Conroy K, Fry JM. Problems in the interpretation of nocturnal penile tumescence studies: disruption of sleep by occult sleep disorders. *J Urol* 1986;136:595–8. [PubMed: 3735535]
15. Margel D, Cohen M, Livne PM, Pillar G. Severe, but not mild, obstructive sleep apnea syndrome is associated with erectile dysfunction. *Urology* 2004;63:545–9. [PubMed: 15028455]
16. Hirshkowitz M, Karacan I, Arcasoy MO, Acik G, Narter EM, Williams RL. Prevalence of sleep apnea in men with erectile dysfunction. *Urology* 1990;36:232–4. [PubMed: 2392814]
17. Heruti R, Shochat T, Tekes-Manova D, Ashkenazi I, Justo D. Association between erectile dysfunction and sleep disorders measured by self-assessment questionnaires in adult men. *J Sex Med* 2005;2:543–50. [PubMed: 16422852]
18. Panser LA, Rhodes T, Girman CJ, Guess HA, Chute CG, Oesterling JE, Lieber MM, Jacobsen SJ. Sexual function of men ages 40 to 79 years: the Olmsted County Study of Urinary Symptoms and Health Status Among Men. *J Am Geriatr Soc* 1995;43:1107–11. [PubMed: 7560700]
19. Panser LA, Chute CG, Guess HA, Larsonkeller JJ, Girman CJ, Oesterling JE, Lieber MM, Jacobsen SJ. The natural history of prostatism: the effects of non-response bias. *Int J Epidemiol* 1994;23:1198–205. [PubMed: 7536718]
20. O’Leary MP, Fowler FJ, Lenderking WR, Barber B, Sagnier PP, Guess HA, Barry MJ. A brief male sexual function inventory for urology. *Urology* 1995;46:697–706. [PubMed: 7495124]
21. Lutz MC, Roberts RO, Jacobson DJ, McGree ME, Lieber MM, Jacobsen SJ. Cross-sectional associations of urogenital pain and sexual function in a community based cohort of older men: olmsted county, Minnesota. *J Urol* 2005;174:624–8. [PubMed: 16006925]discussion 628
22. Burke JPJD, McGree ME, Nehra AX, Roberts RO, Girman CJ, Lieber MM, Jacobsen SJ. Diabetes and sexual dysfunction: Results from the Olmsted County Study of Urinary Symptoms and Health Status among Men. *Journal of Urology*. (In Press)
23. Ware, JE. SF-36 Physical and Mental Health Summary Scales: A User’s Manual. Boston, Massachusetts: The Health Institute, New England Medical Center; 1994.
24. Beninati W, Harris CD, Herold DL, Shepard JW Jr. The effect of snoring and obstructive sleep apnea on the sleep quality of bed partners. *Mayo Clin Proc* 1999;74:955–8. [PubMed: 10918859]
25. Margel D, Tal R, Livne PM, Pillar G. Predictors of erectile function improvement in obstructive sleep apnea patients with long-term CPAP treatment. *Int J Impot Res* 2005;17:186–90. [PubMed: 15510189]
26. Karacan I, Karatas M. Erectile dysfunction in sleep apnea and response to CPAP. *J Sex Marital Ther* 1995;21:239–47. [PubMed: 8789505]
27. Grunstein RR, Handelsman DJ, Lawrence SJ, Blackwell C, Caterson ID, Sullivan CE. Neuroendocrine dysfunction in sleep apnea: reversal by continuous positive airways pressure therapy. *J Clin Endocrinol Metab* 1989;68:352–8. [PubMed: 2493027]
28. Hoekema A, Stel AL, Stegenga B, van der Hoeven JH, Wijkstra PJ, van Driel MF, de Bont LG. Sexual function and obstructive sleep apnea-hypopnea: a randomized clinical trial evaluating the effects of oral-appliance and continuous positive airway pressure therapy. *J Sex Med* 2007;4:1153–62. [PubMed: 17081222]
29. Koseoglu N, Koseoglu H, Itil O, Oztura I, Baklan B, Ikiz AO, Esen AA. Sexual Function Status in Women with Obstructive Sleep Apnea Syndrome. *J Sex Med* 2007;4:1352–1357. [PubMed: 16907954]
30. Goncalves MA, Guilleminault C, Ramos E, Palha A, Paiva T. Erectile dysfunction, obstructive sleep apnea syndrome and nasal CPAP treatment. *Sleep Med* 2005;6:333–9. [PubMed: 15946896]
31. Mykletun A, Dahl AA, O’Leary MP, Fossa SD. Assessment of male sexual function by the Brief Sexual Function Inventory. *BJU Int* 2006;97:316–23. [PubMed: 16430637]
32. Kushida CA, Littner MR, Morgenthaler T, Alessi CA, Bailey D, Coleman J Jr, Friedman L, Hirshkowitz M, Kapen S, Kramer M, Lee-Chiong T, Loubé DL, Owens J, Pancer JP, Wise M. Practice

- parameters for the indications for polysomnography and related procedures: an update for 2005. *Sleep* 2005;28:499–521. [PubMed: 16171294]
33. Netzer NC, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med* 1999;131:485–91. [PubMed: 10507956]
 34. Gottlieb DJ, Yao Q, Redline S, Ali T, Mahowald MW. Does snoring predict sleepiness independently of apnea and hypopnea frequency? *Am J Respir Crit Care Med* 2000;162:1512–7. [PubMed: 11029370]
 35. Harding SM. Prediction formulae for sleep-disordered breathing. *Curr Opin Pulm Med* 2001;7:381–5. [PubMed: 11706312]
 36. Gami AS, Pressman G, Caples SM, Kanagala R, Gard JJ, Davison DE, Malouf JF, Ammash NM, Friedman PA, Somers VK. Association of atrial fibrillation and obstructive sleep apnea. *Circulation* 2004;110:364–7. [PubMed: 15249509]
 37. Barnes M, McEvoy RD, Banks S, Tarquinio N, Murray CG, Vowles N, Pierce RJ. Efficacy of positive airway pressure and oral appliance in mild to moderate obstructive sleep apnea. *Am J Respir Crit Care Med* 2004;170:656–64. [PubMed: 15201136]
 38. Cistulli PA, Gotsopoulos H, Marklund M, Lowe AA. Treatment of snoring and obstructive sleep apnea with mandibular repositioning appliances. *Sleep Med Rev* 2004;8:443–57. [PubMed: 15556377]
 39. Cistulli PA, Grunstein RR. Medical devices for the diagnosis and treatment of obstructive sleep apnea. *Expert Rev Med Devices* 2005;2:749–63. [PubMed: 16293102]
 40. Ferguson KA, Cartwright R, Rogers R, Schmidt-Nowara W. Oral appliances for snoring and obstructive sleep apnea: a review. *Sleep* 2006;29:244–62. [PubMed: 16494093]

Appendix 1

The Brief Male Sexual Function Inventory (BMSFI) Questionnaire²⁰

Table 1
Distribution of snoring questionnaire responses in the total cohort and by snoring group

	All subjects N=827 N (%)	None/mild N=159 N (%)	Moderate snoring N=573 N (%)	Heavy snoring N=95 N (%)
Snoring				
No	139 (17)	130 (82)	9 (2)	0 (0)
Yes	688 (83)	29 (18)	564 (98)	95 (100)
Snoring bothersome				
No	172 (25)	29 (100)	140 (25)	3 (3)
Yes	423 (61)	-	342 (61)	81 (85)
Did not answer	93 (14)	-	82 (15)	11 (12)
Snoring loudness				
Louder than breathing	246 (36)	29 (100)	212 (38)	5 (5)
Loud as talking	246 (36)	-	220 (39)	26 (27)
Louder than talking	97 (14)	-	73 (13)	24 (25)
Very loud	88 (13)	-	48 (9)	40 (42)
Did not answer	11 (2)	-	11 (2)	-
Snoring frequency				
Nearly every day	269 (39)	-	191 (34)	78 (82)
3-4 times / week	130 (19)	-	117 (21)	13 (14)
1-2 times / week	157 (23)	-	155 (27)	2 (2)
1-2 times / month	90 (13)	23 (79)	67 (12)	0 (0)
Nearly never	21 (3)	6 (21)	13 (2)	2 (2)
Did not answer	21 (3)	-	21 (4)	-
Stop breathing				
No	614 (74)	159 (100)	455 (79)	0 (0)
Yes	206 (25)	-	111 (19)	95 (100)
Did not answer	7 (1)	-	7 (1)	-
Stopping frequency				
Nearly every day	57 (28)	-	4 (4)	53 (56)
3-4 times / week	24 (12)	-	5 (5)	19 (20)
1-2 times / week	28 (14)	-	5 (5)	23 (24)
1-2 times / month	67 (33)	-	67 (60)	0 (0)
Nearly never	24 (12)	-	24 (22)	0 (0)
Did not answer	6 (3)	-	6 (5)	-
Fall asleep or lack energy				
No	475 (57)	115 (72)	315 (55)	45 (47)
Yes	352 (43)	44 (28)	258 (45)	50 (53)

Table 2

Distribution of sexual function scores by snoring group

Sexual function domains	None/mild snoring median (Q1,Q3)	Moderate snoring median (Q1,Q3)	Heavy snoring median (Q1,Q3)	P*
Sexual drive	4 (2, 5)	4 (3, 5)	4 (3, 5)	0.39
Erectile function	7 (3, 9)	7 (4, 10)	7 (4, 9)	0.29
Ejaculatory function	7 (5, 8)	7 (5, 8)	7 (5, 8)	0.55
Problem assessment	10 (6, 12)	10 (6, 12)	9 (6, 11)	0.41
Sexual satisfaction	3 (2, 3)	2 (2, 3)	2 (1, 3)	0.01

* Kruskal-Wallis p-value for comparison of symptoms across categories

Table 3

Association between snoring groups and sexual function

Outcome variable	Snoring group	Unadjusted		Anthropometric* and age-adjusted		Adjusted for all potential confounders†	
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)		
Sexual drive score ≤ 2	None/mild snoring	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)		
	Moderate	0.8 (0.6, 1.2)	0.9 (0.6, 1.4)	0.9 (0.6, 1.4)	0.8 (0.5, 1.3)		
	Heavy	0.9 (0.5, 1.6)	1.1 (0.5, 2.1)	1.1 (0.5, 2.1)	1.1 (0.5, 2.1)		
Erectile function ≤ 3	None/mild snoring	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)		
	Moderate	0.8 (0.5, 1.2)	1.0 (0.6, 1.6)	1.0 (0.6, 1.6)	0.9 (0.6, 1.6)		
	Heavy	0.8 (0.5, 1.5)	1.1 (0.5, 2.3)	1.1 (0.5, 2.4)	1.1 (0.5, 2.4)		
Ejaculatory function ≤ 2	None/mild snoring	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)		
	Moderate	0.7 (0.5, 1.2)	0.9 (0.5, 1.7)	0.9 (0.5, 1.7)	0.8 (0.4, 1.5)		
	Heavy	1.1 (0.6, 2.2)	1.8 (0.8, 4.1)	1.8 (0.8, 4.1)	1.7 (0.7, 4.0)		
Problem assessment ≤ 3	None/mild snoring	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)		
	Moderate	0.6 (0.4, 1.1)	0.6 (0.3, 1.1)	0.6 (0.3, 1.1)	0.5 (0.3, 0.9)		
	Heavy	1.1 (0.5, 2.2)	1.2 (0.5, 2.6)	1.2 (0.5, 2.6)	1.1 (0.5, 2.4)		
Sexual satisfaction score ≤ 1	None/mild snoring	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)		
	Moderate	1.1 (0.7, 1.7)	1.1 (0.6, 1.7)	1.1 (0.6, 1.7)	0.9 (0.6, 1.5)		
	Heavy	2.3 (1.2, 4.1)	2.2 (1.1, 4.1)	2.2 (1.1, 4.1)	1.9 (1.00, 3.7)		

* Anthropometrics: adjusted for anthropometrics (body mass index, neck and waist measurements taken at round 3 for the entire cohort)

† Adjusted for age, anthropometrics, smoking, comorbidities (diagnosis of myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease and diabetes), and mental health.