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## Rhinitis and snoring as risk factors for hypertension in post-menopausal women

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Received 28 June 2005; accepted 25 November 2005

### KEYWORDS

Snoring;  
Rhinitis;  
Hypertension;  
Menopause

### Summary

**Objective:** Several studies have suggested an association between snoring and hypertension. An association between rhinitis and hypertension has been recently indicated in men but not in women. Since menopausal status is an important determinant of blood pressure, we evaluated the relationship between rhinitis, snoring and blood pressure taking into account the modifying effect of menopausal status.

**Design:** Cross-sectional survey.

**Settings:** Four areas of Italy: the Po river Delta, Pisa (Tuscany), Viterbo (Lazio) and Rome.

**Main outcome measures:** Data were collected by a questionnaire and a medical visit.

**Participants:** One thousand five hundred and fifty-four female non-smokers.

**Results:** Systolic blood pressure (SBP) was significantly related to both occasional and habitual snoring in the overall sample. No associations were found between SBP, snoring, and rhinitis in pre-menopausal women. Both occasional and habitual snoring, but not rhinitis, were significant risk factors for increased SBP in women who stopped menstruating fewer than 11 years previously ( $\beta = 10.27$  mmHg, 95% confidence interval (CI) = 3.5, 17.01 and  $\beta = 9.91$  mmHg, 95% CI = 2.3, 17.5, respectively). However, women who had been menopausal for more than 11 years

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were found to have an increased SBP if they were occasional snorers ( $\beta = 8.94$  mmHg, 95% CI = 1.2, 16.6) or habitual snorers ( $\beta = 8.01$  mmHg, 95% CI = 0.10, 15.9). The increase in SBP was even greater in these women when habitual snoring was associated with rhinitis ( $\beta = 11.96$  mmHg, 95% CI = 1.01, 22.9).

*Conclusion:* We suggest that the association of snoring with rhinitis may facilitate the development of apnea during sleep, which in post-menopausal women may increase the risk of developing hypertension.

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## Introduction

In recent years sleep-related disorders, ranging from habitual snoring to sleep apnea, have been recognized as important causes of morbidity and mortality due to cardiovascular disease.<sup>1</sup> Habitual snoring is very common in adults and may represent the first step towards developing sleep-apnea syndrome. The association between snoring and hypertension, however, is still debated since some studies have indicated that snoring is an independent risk factor for hypertension<sup>2,3</sup> while others have found that this relationship may be explained by confounding effects such as age, sex or obesity.<sup>4</sup>

Kony et al.<sup>5</sup> recently reported that rhinitis, which is considered a risk factor for snoring both in adults and in children,<sup>6,7</sup> is associated with increased systolic blood pressure (SBP) in men but not in women. Similar results have been reported by Peppard and Young.<sup>8</sup> However, this finding was not confirmed by studies conducted in Germany<sup>9</sup> and in Japan<sup>10</sup>: in Germany authors studied a large population sample (896 subjects aged 28–56 years) and SBP was not higher in subjects with rhinitis. In a Japanese adolescent sample there was no difference in SBP between subjects with and without allergic rhinitis.<sup>10</sup>

We suggest that age (a key determinant of blood pressure) and the definition of rhinitis used may explain the differences in the studies' results. The lack of association between SBD and rhinitis in women in the study of Kony et al. may be due to the age of the sample (mean 44.6 years  $\pm$  7.4): SBP is lower in women than in men before menopause, as a result of hormonal regulation,<sup>11</sup> but as women age it approaches the levels found in men.<sup>12</sup> Therefore, we wanted to determine what effect rhinitis may have on SBP in women after menopause.

We analysed the data set from a population sample of women with a large age range in order to study the role of rhinitis and snoring as determinants of SBP and diastolic blood pressure (DBP).

## Methods

The data set was derived from an epidemiological study of female non-smokers. A detailed description of the study design is reported elsewhere.<sup>13</sup> Briefly, the study was conducted in four areas of Italy and was based on population-based samples: the Po river Delta (a rural area in northern Italy), Pisa (a historic middle-sized town in Tuscany, central Italy), Viterbo (a small town and the nearby rural area in Lazio, central Italy) and the metropolitan area of Rome. Out of a total of 3330 women eligible for the study, 2552 subjects (76.7%) returned the questionnaire. A total of 217 women were excluded for being active smokers. A total of 1633 of the 2335 confirmed never-smokers participated in the medical examination, and 1554 answered questions on snoring.

Data were collected by a questionnaire and a physical examination. The questionnaire included several questions regarding respiratory and cardiovascular health, sleeping habits, and drug use. Rhinitis was defined by a positive response to the following question: "Have you ever had hay fever or any other atopic condition that causes a runny or stuffy nose apart from common colds?". Snoring was investigated by the question "Do you ever snore during sleep?" with the following possible answers: never or only with colds, occasionally without a cold, nearly always (i.e. habitual).

Hypertension was defined by a doctor's diagnosis or use of anti-hypertension drugs. High cholesterol was defined by doctor diagnosis. Number of pregnancies and menopausal age, if applicable, were also recorded. Use of sleep-inducing drugs was also investigated. Informed consent was obtained for the medical examination, which was performed by a physician. The following measurements taken of each subject: standing height, weight, circumference of waist and hips. Two measures of SBP and DBP, at 30-min intervals, were performed using a mercury sphygmomanometer with the subject in a supine position. We considered the second of the two measures.

Women were divided into pre-menopausal and post-menopausal groups. The latter was divided in

two subgroups according to the number of years they had been menopausal (11 years cut-off, the median of the distribution).

We employed linear regression analysis to evaluate the variables related to SBP and DBP. The results are reported as regression coefficients ( $\beta$ , change in blood pressure) with 95% confidence intervals (CI). We considered age, body mass index (BMI), waist-to-hip ratio, number of pregnancies, high cholesterol, use of sleep-inducing drugs, and both rhinitis and snoring. We formally tested the interaction between snoring and rhinitis in the overall sample and by menopausal status using the likelihood test.

## Results

The main characteristics of the sample by snoring category are shown in Table 1. Of the 1554 women for whom we had clinical examinations, 265 (17.%)

were habitual snorers whereas 536 (34.5%) were never-snorers. Habitual snorers were older, with a larger BMI and a larger waist-to-hip ratio than non-snorers. Women who snored occasionally were also older, with an increased BMI and waist-to-hip ratio than non-snorers although to a lesser extent than habitual snorers.

There were 548 (35.3%) post-menopausal women in the studied sample. Rhinitis occurred in 407 women (26.2%) whereas high cholesterol and blood hypertension occurred, respectively, in 253 (16.4%) and 259 (16.7%) women. Both high cholesterol and hypertension were more frequent in women who snored occasionally or habitually. SBP was significantly related to occasional snoring ( $\beta = 2.33$  mmHg; CI = 0.2, 4.4) and habitual snoring ( $\beta = 2.98$  mmHg; CI = 0.3, 5.6) adjusting for age, BMI, number of pregnancies, menopause, high cholesterol, waist-to-hip ratio and use of sleep-inducing drugs. No association was found between

**Table 1** Characteristics of the study sample.

	Never Mean (sd) n(%)	Only with colds Mean (sd) n(%)	Occasionally without a cold Mean (sd) n(%)	Habitual Snorers Mean (sd) n(%)
Overall sample	536 (34.5%)	276 (17.8%)	477 (30.7%)	265 (17.0%)
Age (years)				
< 40	263 (49.1%)	144 (52.2%)	113 (23.7%)	31 (11.7%)
40–49	157 (29.3%)	86 (31.2%)	159 (33.3%)	63 (23.8%)
50–59	64 (11.9%)	32 (11.6%)	98 (20.5%)	68 (25.6%)
+60	52 (9.7%)	14 (5.1%)	107 (22.4%)	103 (38.9%)
BMI (kg/m <sup>2</sup> )				
< 25	321 (60.2%)	158 (57.9%)	208 (43.7%)	49 (18.6%)
25–30	150 (28.1%)	78 (28.6%)	172 (36.1%)	112 (42.4%)
> 30	62 (11.6%)	37 (13.5%)	96 (20.2%)	103 (39.0%)
Pregnancy				
0	96 (18.0%)	50 (18.3%)	40 (8.4%)	15 (5.6%)
1–2	279 (52.3%)	145 (53.1%)	266 (56.1%)	136 (51.3%)
3–4	141 (26.4%)	72 (26.4%)	141 (29.7%)	91 (34.3%)
+5	17 (3.2%)	6 (2.2%)	27 (5.7%)	23 (8.7%)
Menopause	109 (20.4%)	41 (14.9%)	213 (44.6%)	173 (65.3%)
Rhinitis	111 (20.7%)	88 (32.0%)	134 (28.1%)	74 (27.9%)
Hypercholesterolemia	57 (10.6%)	29 (10.5%)	96 (20.4%)	71 (27.1%)
Hypertension	43 (8.0%)	28 (10.2%)	96 (20.3%)	92 (35%)
Use of drugs with progesterone	24 (4.5%)	17 (6.2%)	16 (3.3%)	12 (4.5%)
Use of sleep-inducing drugs				
Sometimes	54 (10.2%)	22 (8%)	62 (13.2%)	28 (10.6%)
Always	8 (1.8%)	3 (2%)	22 (4.7%)	20 (7.6%)
Waist-to-hip ratio				
Mean	0.78 (0.30)	0.80 (0.43)	0.89 (0.78)	0.90 (0.73)
PA Max (mmHg)	121.2 (16.2)	120.8 (15.9)	129.3 (20.4)	136.3 (22.6)
PA Min (mmHg)	74.8 (9.9)	75.2 (10.2)	78.1 (10.5)	81.7 (12.8)

Totals may vary because of missing values.

SBP and rhinitis or between SBP and snoring with colds. When the interaction terms were included in the model (snoring × menopause, rhinitis × menopause, rhinitis × snoring), the interactions of menopause with both habitual ( $P = 0.025$ ) and occasional snoring ( $P = 0.01$ ) were statistically significant. No significance was found for the other two interactions. DBP was significantly related to habitual snoring ( $\beta = 1.76$  mmHg; CI = 0.1, 3.4) but not with occasional snoring, snoring with colds, or with rhinitis.

Table 2 shows the results of the association of rhinitis and snoring with blood pressure stratified by menopausal status. Women who snored only with colds were excluded from this analysis. The subjects were divided in six mutually exclusive categories: no rhinitis no snoring (reference), rhinitis only, occasional snoring only, rhinitis and occasional snoring, habitual snoring only, rhinitis and habitual snoring. In the overall sample, both “occasional snoring only” and “habitual snoring only” were significantly related to an increased SBP. In pre-menopausal women no relation was found between rhinitis, snoring, SBP or DBP. In the more recent post-menopausal women (< 11 years), both “occasional snoring only” and “habitual snoring only” were related to an increased SBP whereas no association was found with regard to rhinitis alone or associated with snoring. DBP was higher in women with “habitual snoring only” than in any other group. Lastly, women who were post-menopausal longer (> 11 years) and who snored occasionally or habitually had a significant increase of SBP, and the highest was observed in women with habitual snoring associated with rhinitis. SBP was also higher but not significantly so in women with rhinitis alone.

### Discussion

Our study indicates that snoring is a risk factor for an increase in SBP in post-menopausal women. Moreover, SBP is higher in women who have been menopausal for more than 11 years if they both snore and have rhinitis.

Our sample included only non-smoking women. Smoking is a risk factor for snoring,<sup>14</sup> for cardiovascular disease,<sup>15</sup> and for rhinitis,<sup>16</sup> and it has been found to be a confounding factor in the relationship between snoring and hypertension.<sup>4</sup> Thus, although the prevalence of snoring, rhinitis and hypertension could be lower among never-smokers than in the general population, the study of this selected group assures that smoking is not a

**Table 2** Regression analysis of blood pressure, rhinitis, snoring or both after stratification by menopausal age.

	No rhinitis and no snoring						Occasional snoring						Habitual snoring					
	No rhinitis only			Rhinitis and snoring			Snoring only			Rhinitis and snoring			Snoring only			Rhinitis and snoring		
	N	$\beta$	95% CI	N	$\beta$	95% CI	N	$\beta$	95% CI	N	$\beta$	95% CI	N	$\beta$	95% CI	N	$\beta$	95% CI
Overall sample	425	Ref	-1.97	111	-1.48	-3.6, 3.2	343	3.01	0.6, 5.4	134	-0.16	-3.4, 3.0	191	3.12	0.05, 6.2	74	1.90	-2.2, 5.9
	PA Max	Ref	-1.48	Ref	-1.48	-3.6, 0.6	Ref	0.78	-0.7, 2.3	Ref	-0.29	-2.3, 1.7	Ref	1.86	-0.04, 3.8	Ref	0.13	-2.4, 2.7
Pre-menopausal age	335	Ref	-0.68	89	-0.68	-3.9, 2.5	167	0.56	-2.0, 3.2	92	-0.35	-3.6, 2.9	53	0.15	-3.9, 4.3	35	-0.65	-5.4, 4.1
	PA Max	Ref	-1.77	Ref	-1.77	-4, 0.45	Ref	0.43	-1.4, 2.2	Ref	0.27	-2.0, 2.5	Ref	0.85	-2.0, 3.7	Ref	1.48	-1.8, 4.8
Post-menopausal age < 11 years	44	Ref	0.48	14	0.48	-10.5, 11.5	92	10.27	3.5, 17.01	27	4.06	-4.6, 12.8	54	9.91	2.3, 17.5	17	2.39	-7.7, 12.6
	PA Max	Ref	-1.66	Ref	-1.66	-7.6, 4.2	Ref	3.19	-0.4, 6.8	Ref	-0.39	-5.1, 4.3	Ref	4.81	0.71, 8.9	Ref	1.50	-4.0, 7.0
Post-menopausal age ≥ 11 years	46	Ref	9.59	8	9.59	-6.2, 25.4	84	8.94	1.2, 16.6	15	-2.74	-15.4, 9.9	84	8.01	0.10, 15.9	22	11.96	1.01, 22.9
	PA Max	Ref	5.48	Ref	5.48	-3.8, 14.8	Ref	-0.11	-4.6, 4.4	Ref	-2.17	-9.6, 5.3	Ref	1.21	-3.4, 5.9	Ref	-3.39	-9.8, 3.06

Age, BMI, N, of pregnancies, hypercholesterolemia, use of sleep inducing-drug, waist-to-hip ratio in the model.

confounder. Our sample covered a large age range, and we had accurate reproductive histories, important since hormonal changes, especially after menopause, play a role both in the incidence of snoring<sup>17</sup> and in the regulation of blood pressure.<sup>18</sup> It has been recently indicated<sup>17</sup> that the menopausal transition is significantly associated with increased likelihood of having sleep-disordered breathing independent of known confounding factors. Although post-menopausal women are more likely than men to suffer from hypertension, the precise mechanism, through which menopause favours the development of hypertension, is still a matter of debate.<sup>19</sup>

Our results suggest that snoring is a risk factor for increased SBP. This finding is still debated as it has been suggested that confounding factors such as age, BMI, alcohol consumption, and smoking weaken this association.<sup>4</sup> On the other hand, a recent prospective study on women<sup>14</sup> has demonstrated that both occasional snoring and regular snoring were risk factors for the incidence of hypertension. It has been suggested<sup>20</sup> that these discrepancies could be due to the sample selection because the definition of "snoring" as "snorers" could include subjects with obstructive sleep-apnea syndrome rather than simple snorers. Hoffstein<sup>21</sup> reviewed the link between snoring with hypertension and cardiovascular disease and concluded that snoring was not an independent risk factor for hypertension or for cardiovascular disease. Young, however, performed a study on 805 subjects using a polysomnography<sup>22</sup> and he demonstrated that subjects with simple snoring (less than five apneas and hypopneas per hour of sleep) had higher SBP and concluded that snoring should be considered as part of a dose-response relationship between sleep-disordered breathing and blood pressure.

We were unable to perform a polysomnography in our sample, and therefore may have misclassified some subjects with sleep-apnea syndrome as regular snorers.

The association between snoring and SBP is stronger in post-menopausal than in premenopausal women. This may be due to hormonal factors that both increase the risk of hypertension<sup>11</sup> and the risk of snoring as the prevalence of snoring is significantly higher in the post-menopausal age.<sup>23</sup>

We found that rhinitis alone was associated with high SBP in women who were post-menopausal for 11 years or more, although not significantly. This might be due to the fact that very few women with rhinitis-only were in this subgroup, but since the activation of nasal afferent nerves can have effects on heart rate and blood pressure, it is an avenue worth further exploration.<sup>24</sup>

Women in menopause for 11 years or more with habitual snoring and rhinitis had the significantly highest SBP. Nasal resistances represent about half of the total respiratory resistances in humans and changes of vascular tone (vasoconstriction or vasodilatation) could modify the nasal mucosa so as to increase or to reduce the nasal patency. It has been demonstrated that nasal obstruction leads to disturbed sleep, apneic episodes and loud snoring.<sup>25</sup> A recent population-based study in adults showed that subjects with nasal congestion due to allergy or nasal obstruction were more likely to be habitual snorers with frequent episodes of apnea and hypopnea during sleep.<sup>6</sup> It is likely that early in life the presence of snoring and rhinitis facilitates the development of sleep apnea that later in life may lead to an increased risk of developing hypertension.

In conclusion, our results add further data on the relationships between snoring, hypertension and rhinitis. Post-menopausal women who snore and suffer from rhinitis should be checked for hypertension and the presence of sleep-disordered breathing should be investigated.

## Acknowledgements

This work was funded in part by the Center for Indoor Air Research (C.I.A.R.), Linthicum (MD), USA (contracts 96-18 and 96-18A).

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