Cardiovascular Risk Factors in Snorers*
A Cross-Sectional Study of 3,323 Men Aged 54 to 74 Years: The Copenhagen Male Study

Poul Jennum, M.D.; Hans Ole Hein, M.D.; Poul Suadicani, O.D.; and Finn Gyntelberg, M.D., Ph.D.

Former studies on the association between snoring and cardiovascular disease (CVD) have only partly taken established CVD risk factors into consideration. In the Copenhagen Male Study, 3,323 men aged 54 to 74 years were classified according to self-reported snoring habits. Eleven CVD risk factors were examined. The prevalence of snoring decreased with age, with a 50 percent higher frequency of snorers among the youngest quintile than among the oldest (p<0.0001). Snoring, age adjusted, was positively associated with tobacco smoking (p<0.001), alcohol consumption (p<0.001), body mass index (BMI) (p<0.001), serum triglyceride level (p<0.01), systolic blood pressure (p<0.05) and nearly significantly associated with diastolic blood pressure (p=0.07). Snorers were less physically active in leisure time than others (p<0.01). The association between self-reported snoring and blood pressure disappeared when other factors, including BMI, were taken into consideration. No significant associations were found between snoring and social class, snoring and low- or high-density lipoprotein or between snoring and hypertension. We conclude that snoring is associated with major cardiovascular risk factors. Accordingly, it is evident that in studies on snoring and CVD, proper controlling for the influence of potential confounders is a sine qua non. (Chest 1992; 102:1371-76)

**CVD** = cardiovascular disease; **BMI** = body mass index; **SBP** = systolic blood pressure; **DBP** = diastolic blood pressure

During the last decade, a number of studies have demonstrated that associations exist between habitual snoring, blood pressure (BP), and cardiovascular disease (CVD). The associations have been questioned, since validation of questionnaire information and controlling for the influence of potential confounders, e.g., body mass index (BMI), BP, smoking, and alcohol consumption, has been inadequate.

To which extent snoring is associated with CVD, life-style factors, including alcohol consumption, smoking habits, and physical activity, remains unsettled.

To obtain a better understanding of the complex interrelationship between CVD risk factors, snoring, and CVD, we have analyzed data from a large ongoing cardiovascular cohort study.

**METHODS**

The data used are derived from the Copenhagen Male Study. The study was initiated in 1970 as a prospective cardiovascular cohort study, and included 5,249 male employees at 14 Copenhagen public or private companies. Their mean age was 48 years (range, 40 to 59 years). They were followed for approximately 15 years later, in 1985-1986, a new baseline was established. All survivors (except 34 emigrants) were traced by means of the Danish Central Person Register and invited to take part in a clinical follow-up study: 3,387 men corresponding to 75 percent agreed to participate and gave informed consent. Their mean age was 63 years (range, 54 to 74 years).

The 1985-1986 study took place at the Division of Prospective Medicine, Glostrup University Hospital. The examination comprised the following: (1) an interview by a physician (H.O.H.) based on a previously completed questionnaire; (2) a clinical examination by a physician (H.O.H.), including measurements of height, weight, and BP; and (3) a venous blood sample drawn for the determination of serum lipid and serum cotinine values, following a fasting period of minimum 12 h.

**RISK FACTOR ASSESSMENT**

**From the Questionnaire**

Snoring Habits: The question was phrased: "Do you know or have you been told that you snore during the night?" Answer options were "rarely or hardly ever" or "often or always."

Sleeping Partner: The question was phrased: "Do you share your bedroom with your spouse or other person with whom you cohabit?" Answer options were "yes" or "no."

Own Bedroom Due to Snoring: The question was phrased: "If you sleep alone, is it because you snore so much it would disturb others?" Answer options were "yes" or "no."

Tobacco Consumption: Smokers gave information on the number of cigarettes, cheroots, cigars, and number of grams of pipe tobacco smoked per day, and their daily use of tobacco was estimated: one cigarette equaled 1 g, one cheroot equaled 3 g and one cigar equaled 4 g of tobacco. Also, use of snuff and chewing tobacco was reported.

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Alcohol Consumption: Average daily alcohol consumption was calculated from the questionnaire. One beverage corresponded to approximately 10 g of alcohol.

Physical Activity in Leisure Time: According to questionnaire information, the men were divided into two groups: (1) those physically active less than 4 h/wk, and (2) those physically active 4 h or more/wk.

From the Clinical Examination

Blood Pressure: BP was measured on the right arm with the subject seated using a manometer developed by London School of Hygiene.\(^{(2)}\)

Body Mass Index: BMI was calculated as weight in kilograms per height in square meters.

From the Venous Blood Sample

Serum Lipids: Serum total cholesterol, serum triglycerides, and serum high-density lipoprotein values were analyzed using standardized methods.\(^{(2)}\) Serum low-density lipoprotein was estimated from the above.

Serum Cotinine: Radioimmunoassay determination of serum cotinine was performed (at Medi-Lab, Copenhagen) using the method developed by Knight et al.\(^{(2)}\)

Other Risk Factors

Hypertension: Based on questionnaire information and BP measurements, hypertension was defined as receiving antihypertensive treatment or having BP \(\geq150/100\) mm Hg.

Social Class: According to a system by Svalastoga,\(^{(2)}\) later adjusted by Hansen,\(^{(2)}\) the men were divided into five social classes, based on level of education and job profile. Men in social class 1 were academics or other well-educated administrators and executives. Men in social class 5 were unskilled and semiskilled workers. For use in the analyses, we made a binary variable by pooling social classes 1, 2, and 3, referred to as "higher social classes" and classes 4 and 5, referred to as "lower social classes."

Validation of Self-Reported Snoring

The validity of the questionnaire was tested by ambulatory night recordings. Fifty self-reported snorers randomly sampled from the population were asked to take part in a night recording. Ten self-reported nonsnorers served as control subjects. The abdominal and thoracic respiratory movements were determined using inductive plethysmography.\(^{(2)}\) Laryngeal sound was determined using a microphone (Sennheiser placed over the larynx. The amplifiers were calibrated (Briel and Kjaer, B&K 4230, Copenhagen, Denmark). The frequency band was 250 to 3,000 Hz. The laryngeal sound was filtered with a time constant of 0.3 s. The resulting data were sampled on a portable computer together with the respiratory measurements using a 12 bit analog-digital-converter (Analog Devices) with a sampling rate of 10 Hz. Data were visually analyzed on the computer ensuring that the data were correctly sampled and of sufficient quality. The average and peak laryngeal sound were calculated. The recordings were made during two nights. No differences were found between night 1 and night 2 (mean: 44.8 [range, 29 to 63] vs 45.4 [range, 30 to 66] db [A], not significant; peak: 84.6 [range, 35 to 93] vs 84.8 [range, 30 to 94] db [A], not significant). We used the following measurements to accept self-reported snoring: the average laryngeal sound should exceed 35 db (A) or peak laryngeal sound exceed 60 db (A).

Data Analysis

In the examination of possible differences in cardiovascular risk factors in self-reported snorers and nonsnorers, a Student's \(t\) test was applied for testing age means of the two groups. Other risk factors were included, one at a time, in a forward stepwise linear multiple regression analysis adjusting for age with snoring as the binary outcome variable. Probability-to-enter was for all analyses \(p<0.05\). A final analysis including all factors was performed using the same criteria.

The above analyses were carried out using specific software (SPSSPC+ basic statistical software, version 3.1).\(^{(2)}\)

The test for linear trend in the association between snoring and age (in quintiles)\(^{(2)}\) and the relative risk calculations as an expression of exposure rate ratios were calculated using specific software (Epi Info software version 5).\(^{(2)}\) The age-adjusted (with age dichotomized into youngest and oldest half of the population), weighted relative risks were calculated using the Mantel-Haenszel method\(^{(2)}\) with 95 percent confidence limits as calculated by the method proposed by Greenland and Robins.\(^{(2)}\)

A \(p\) value of \(<0.05\) was regarded as statistically significant for all analyses.

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Cardiovascular Risk Factors in Snorers (Jennum et al)
Figure 1. Snoring frequency by age (quintiles).

Figure 2. Snoring frequency by smoking habits.

p<0.00001

p<0.05
The study has been approved by the Copenhagen County Ethics Committee for Medical Research.

RESULTS

Some 1,670 (50.3 percent) subjects reported to be snorers, i.e., snoring always or often. Of those responding, 1,653 (49.7 percent) reported to be non-snorers, i.e., snoring never or occasionally. Sixty-four men did not answer the question on snoring habits. Responders to the question were included in the study (n = 3,323). Some 2,587 men (80 percent) reported that they slept with a partner, and 212 men reported that they had separate bedrooms due to snoring.

The prevalence of snoring decreased with age (Fig 1), with a 50 percent higher snoring frequency among the youngest quintile than among the oldest; χ² for linear trend was 57.934 (p<0.00001). This association was consistent and even slightly stronger when only those who reported that they slept with a partner were analyzed (not shown); χ² for linear trend was 60.910 (p<0.00001).

Snoring prevalence was significantly associated with smoking habits (Fig 2) (χ² = 14.807, df = 5, p<0.05). Never smokers had the smallest prevalence rate of snorers; cigarette and mixed smokers had the highest. The majority of mixed smokers were smokers of cigarettes and pipe.

Table 1 shows the distribution of cardiovascular risk factors in self-reported snorers and in self-reported non-snorers. Snorers were significantly younger than non-snorers (p<0.001), had a significantly higher BMI (p<0.001), they smoked more tobacco and drank more alcohol (p<0.01), were less physically active (p<0.01), had a higher serum triglyceride level (p<0.001), a higher systolic BP (p<0.05), and a nearly significant higher diastolic BP (p = 0.07). The prevalence of hypertension was slightly but not significantly higher in snorers than in non-snorers. Inclusion of all the potential risk factors in a forward stepwise multiple regression model indicated which factors were most likely to be genuinely associated with snoring. Due to the interrelationship between a number of factors, physical activity, serum triglyceride level, and systolic BP became nonsignificant. Age, BMI, smoking, and alcohol consumption were highly significant after multivariate adjustment.

Snorers who had their own bedroom were significantly older than other snorers, 63.5 years vs 62 years (p<0.001), with a significantly smaller proportion of men in lower social classes, 45 percent vs 53 percent (p<0.05). No other differences were found (not shown in table).

Table 2 shows the exposure rate ratio for snoring, denominated as relative risk, for various subdivisions of the population. Obesity, tobacco smoking, and alcohol consumption were associated with a 20 to 30 percent increased risk of being a snorer. Men who smoked ≥15 g/day, drank ≥28 alcoholic beverages per week, and had a BMI ≥28 had an approximately 60 percent higher risk of snoring than men who smoked <15 g/day, drank <28 alcoholic beverages per week, and had a BMI <28; RR was 1.62 (1.37 to 1.91); p<0.0001.

The above analyses were performed separately for those who reported that they slept with a partner (not shown). There were no discrepancies between the

Table 1—Prevalence of Cardiovascular Risk Factors in Relation to Occurrence of Snoring

<table>
<thead>
<tr>
<th></th>
<th>Self-Reported Snoring</th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>p*</td>
<td>p†</td>
</tr>
<tr>
<td>N (%)</td>
<td>1,670 (50.3%)</td>
<td>1,653 (49.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age,† yrs</td>
<td>62</td>
<td>64</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI‡ kg/sq m</td>
<td>25.8</td>
<td>25.2</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Smoking,¶ g/day</td>
<td>9.4</td>
<td>8.0</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Alcohol,¶ beverages per week</td>
<td>18.7</td>
<td>16.7</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Physical act§%</td>
<td>49.7%</td>
<td>54.8%</td>
<td>&lt;0.01</td>
<td>&lt;0.09</td>
</tr>
<tr>
<td>Social class† (percent with no professional education)</td>
<td>49.0%</td>
<td>50.2%</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LDL‡ mmol/L</td>
<td>4.50 (1.00)</td>
<td>4.45 (1.02)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Triglyceride‡ mmol/L</td>
<td>1.62 (0.93)</td>
<td>1.51 (0.84)</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
<tr>
<td>HDL‡ mmol/L</td>
<td>1.35 (0.35)</td>
<td>1.34 (0.35)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Systolic BP‡ mm Hg</td>
<td>121.7 (16.7)</td>
<td>120.9 (16.6)</td>
<td>&lt;0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Diastolic BP‡ mm Hg</td>
<td>73.1 (19.1)</td>
<td>72.2 (11.3)</td>
<td>0.07</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension‡%</td>
<td>13.4%</td>
<td>12.8%</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*p values of linear regression adjusted for age.
†p values of the forward stepwise multiple regression.
‡Mean (standard deviation).
¶Percent reporting physical leisure time activity >4 h/wk.
††Percent belonging to social classes 1, 2, or 3 according to designation of occupation.
§Percent receiving antihypertensive treatment and/or with blood pressure exceeding 150/100 mm Hg.
Table 2—Exposure Rate Ratio for Snoring as Calculated by a Mantel-Haenszel Age-Adjusted Relative Risk (RR) Equation (with 95% Confidence Limits) by Various Subdivisions of the Population*

<table>
<thead>
<tr>
<th></th>
<th>RR (95% Confidence Limits)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI ≥25 kg/sq m vs rest</td>
<td>1.39 (1.20-1.39)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Tobacco smoking ≥15 g/day vs rest</td>
<td>1.17 (1.09-1.26)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Alcohol consumption ≥29</td>
<td>1.19 (1.10-1.29)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>beverages per week vs Tobacco smoking ≥15 g/day and</td>
<td>1.32 (1.18-1.45)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>alcohol consumption ≥28</td>
<td>beverages per week</td>
<td>tobacco smoking &lt;15 g/day and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>alcohol consumption ≥28</td>
</tr>
</tbody>
</table>

*The p value represents the probability outcome of a Mantel-Haenszel 2 × 2 age-stratified analysis (with age dichotomized into youngest and oldest half).

Table 3—Association between Self-Reported and Objective Recorded Snoring by Microphone*

<table>
<thead>
<tr>
<th>Laryngeal Sound (Snoring)</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaire (snoring)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>45</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>

*p<0.0001; sensitivity, 94 percent; specificity, 58 percent.

In accordance with previous studies,1-5,7,10-12,17 snorers had a higher BP than nonsnorers. When adjustments were made for relevant confounders associated with BP, ie, BMI, alcohol consumption, physical activity, and smoking, the association between snoring and BMI, physical activity, and smoking has been found previously by others.7,9,11,17

When controlling for smoking, we found that the relationship between snoring and BMI was significant, with a p value of <0.0001. This finding is consistent with previous studies.1,7,9,10,11

The main conclusion to be drawn from this study is that snoring is strongly correlated with well-established CVD risk factors. Accordingly, it is evident that in studies on snoring and CVD, proper controlling for the influence of potential confounders is a sine qua non.

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