Sleep Complaints in Elderly Tinnitus Patients: A Controlled Study

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Objectives: **Sleep difficulties are among the most frequent complaints associated with tinnitus. Yet most studies reporting on this problem are rather succinct, and all of them lack proper age- and health-matched control subjects.**

Design: **The present study reports on 102 participants (51 with and 51 without tinnitus), assessed with the Pittsburgh Sleep Quality Index (PSQI), the Beck-II depression inventory, a hyperacusis questionnaire, and a tinnitus-reaction questionnaire (tinnitus group only). Participants were matched for health and relevant socioeconomic factors.**

Results: **Results show that tinnitus patients have greater self-reported sleep difficulties compared with control subjects, specifically sleep efficiency and sleep quality, and that high tinnitus-related distress is associated with greater sleep disturbance.**

Conclusions: **Rather than hearing loss, sleep complaints in this population are mainly explained by hyperacusis, a hallmark of tinnitus, and to a lesser extent by subclinical depressive symptoms.**

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Tinnitus is the perception of sound in the ears or head that does not match external auditory stimuli. Incidence of tinnitus is about 10.2% of the adult population, and rises after 50 yr of age (Davis, 1995). The most important predictive factor for the presence of tinnitus is hearing loss, especially sensorineural hearing loss, which increases with age. The diagnosis of tinnitus is based entirely on subjective self-reports of symptoms. Currently, there is no FDA-approved drug to alleviate tinnitus (Vio & Holme, 2005). Most individuals afflicted with tinnitus eventually learn to cope with the condition. However, a small proportion experience significant psychological distress, continually seek aid, and are at risk for depression (e.g., Attias, Shemesh, & Bleich, 1995; Halford & Andersson, 1991; Rizzardo, Savastano, Maron, et al., 1998; Scott & Lindberg, 2000).

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Several studies have found that sleep difficulties are one of the most frequent complaints associated with tinnitus in either selected (e.g., a self-help group, Tyler & Baker, 1983) or unselected (e.g., first-time referrals to a tinnitus clinic Sanchez & Stephens, 1997) tinnitus patient samples. A recent survey administered to a large random sample of 6,103 elderly people in Sweden confirmed a higher prevalence of sleep disturbance in individuals with than without tinnitus (Asplund, 2003). Some studies have found that sleep disturbances in tinnitus patients are partially independent from other complaints such as emotional distress, suggesting that mood alone is unlikely to account for the presence of insomnia (Hallam, 1996; Hallam, Jakes, & Hinchcliffe, 1988; Hiller & Goebel, 1992). However, other studies have found significant correlations between sleep disturbance and depression (Alster, Shemesh, & Ornan, 1993) and between sleep difficulties and tinnitus severity (Folmer & Griest 2000). Sleep difficulties have in turn been regarded as a risk factor (Holgers, Erlandsson, & Barrenas, 2000), correlates (Axelsson & Ringdahl, 1989), characteristics (Nondahl, Cruickshanks, Wiley, et al., 2002), and predictors (Langenbach, Olderog, Michel, et al., 2005) of tinnitus-related distress. The contribution of hearing loss to sleep difficulties nevertheless remains controversial. Although some studies have found better hearing thresholds in tinnitus patients without than with insomnia (Alster, Shemesh, & Ornan, 1993; Hallam, 1996), other studies have found no such association (Folmer & Griest 2000). Note, however, that participants in the study of Alster et al. (1993) were young (36 yr old, on average), whereas the participants in the Hallam (1996) study were not age-matched.

In summary, studies almost unanimously report sleep difficulties associated with tinnitus, and sleep difficulties increase in severity with tinnitus distress. However, although a few studies used specific, detailed sleep questionnaires (Alster, Shemesh, & Ornan, 1993; Asplund, 2003; Hallam, 1996), most studies are rather succinct, and include only one or a few questions on sleep (Axelsson & Ringdahl, 1989; Folmer & Griest, 2000; Hallam, Jakes, & Hinchcliffe, 1988; Hiller & Goebel, 1992; Holgers et al., 2000; Langenbach, Olderog, Michel, et al., 2005; Nondahl, Cruickshanks, Wiley, et al., 2002). More

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importantly, all these studies lack proper age- and health-matched control groups. Given that age, hearing loss, depressive symptoms, and general health may all affect sleep (e.g., Asplund, 2003; Benca et al., 2004; Buysse, 2004; Kamel & Gammack, 2006), it is important to disentangle the contribution of these factors to sleep difficulties in tinnitus patients.

In this study, we used a standardized sleep questionnaire, the Pittsburgh Sleep Quality Index (PSQI), to investigate sleep complaints in a group of well-screened elderly tinnitus patients and a control group without tinnitus. Groups were matched for age, education level, and general health. Data on depressive symptoms, hearing loss, and tinnitus-related distress (in the tinnitus group) were collected. To further qualify hearing difficulties experienced by the tinnitus sufferers, data on hyperacusis were also collected in the tinnitus group. Since tinnitus is a chronic condition that resembles chronic pain (Folmer, Griest, & Martin, 2001; Møller, 2000), we hypothesized that tinnitus patients would complain of similar sleep difficulties, namely, poorer sleep efficiency and quality compared with matched control subjects (see the review by Benca, Ancoli-Israel, & Moldofsky, 2004). Tinnitus severity was expected to correlate with severity of sleep complaints. Finally, since tinnitus severity is correlated with depressive symptomatology (e.g., Hébert, Paiement, & Lupien, 2004; Henry & Wilson, 1995; Kirsch, Blanchard, & Parnes, 1989), and given that the latter is often associated with insomnia (e.g., Mellinger, Balter, & Uhlenhuth, 1985), we also hypothesized that sleep complaints would be associated with depressive symptoms, irrespective of hearing loss.

METHODS

Participants

Fifty-one tinnitus patients (21 female, 30 male) and 51 control subjects without tinnitus (27 female, 24 male), who had previously participated in several research protocols at our laboratory, were included in this study. They were recruited through newspaper ads and tinnitus self-help groups and by word of mouth. They were matched for age and education ($p > 0.05$) and had similar socioeconomic backgrounds (see Table 1 for sociodemographic and audiologic data). Years of education were calculated continuously starting with Grade 1 (therefore on average, patients had 1 to 2 yr of post–high school education).

All participants were in good health, as established by an in-house questionnaire that assessed current medication, diseases and conditions, and history of operations and neurological and psychiatric diseases. They reported no uncontrolled medical condition that might interfere with metabolic functioning (e.g., diabetes, uncontrolled hyper- or hypotension, lupus, surrenal insufficiency, etc.), history of neurological disease, recent history of psychiatric disease, or dependence on alcohol or other drugs. Participants who took antidepressant drugs were excluded from the study. Additional psychoacoustic criteria included no hearing aid or tinnitus masker (tinnitus participants) and no ear pathology except for hearing loss. In addition, all participants in the tinnitus group had suffered from tinnitus for at least 6 mo (estimated duration = 14 yr, SD = 12.2).

All participants were nonsmokers, except for one male control who smoked two cigarettes a day. Participants who took daily sleep medication were excluded, with the exception of six tinnitus patients (three men, three women), who took such medications occasionally (between once a month and three times per week), as prescribed by their Ear Nose and Throat specialist for tinnitus. Of the 48 postmenopausal women, 9 were taking hormone replacement therapy at the time of testing (3 tinnitus and 6 control subjects).

TABLE 1. Sociodemographic and audiologic characteristics of the two groups

	Tinnitus (n = 51)	Control subjects (n = 51)	*p* value
Age (SD)	67.96 (6.43)	68.04 (6.80)	NS
Education (SD)	13.55 (3.60)	14.37 (3.19)	NS
PTA – Mean hearing loss at 500, 1K, and 2K (SD)	28.86 (15.32)	18.2 (9.51)	<0.01
PTA- Mean hearing loss at 4K and 8K (SD)	53.96 (16.73)	37.71 (16.40)	<0.01
Tinnitus-related distress (SD)	17.39 (18.04)	—	—

The TRQ score excludes the question on sleep disturbance.

Questionnaires

Pittsburgh Sleep Quality Index (hereafter PSQI, Buysse et al., 1989): This questionnaire evaluates subjective sleep quality in the last month. It includes 19 items assessing seven subscales: 1) subjective quality, 2) sleep duration, 3) sleep efficacy, 4) sleep perturbations, 5) time to fall asleep, 6) use of sleep medication, and 7) sleepiness during the day. The questionnaire has good psychometric properties ($r = 0.85$ and $r = 0.83$ for reliability and internal validity, respectively). A recent study (Coles, Motivala, Buysse, et al., 2006) validated a 3-factor structure that separates Sleep Efficiency (sum of scores on subscales 3 and 4), Perceived Sleep Quality (sum

of scores on subscales 1, 2, and 6), and Daily Disturbances (sum of scores on subscales 5 and 7), and was deemed preferable to the usual single-factor (total score) model for use in this study. The higher the score, the more disturbed the sleep.

Beck-II Depression Inventory (hereafter BDI-II, Beck 1997): This questionnaire assesses subjective depressive symptomatology in the past 2 wk through 21 items describing attitudes, behaviors, and symptoms related to depression. One item (number 16) specifically refers to sleep disturbance, and was excluded from the total score due to overlap with the sleep questionnaire. Total score is the sum of item scores rated from "neutral" (0 points) to "maximal severity" (3 points). The questionnaire has good psychometric properties ($r = 0.93$ and $r = 0.92$ for reliability and internal validity, respectively).

Hyperacusis questionnaire (Khalfa, Dubal, Veuillet, et al., 2002): This questionnaire assesses auditory sensitivity to external sounds. It was broken down into three subscales corresponding to various symptom types of intolerance to external sounds in everyday life: Attentional (questions 1 to 4), Social (questions 5 to 10), and Emotional (questions 11 to 14). Each item is rated on a 4-point scale, ranging from "no" (0 points) to "yes, a lot" (3 points). A score of 15 (SD = 6.7) was determined as normal. Internal consistency (Cronbach's coefficient α) is about 0.67.

Tinnitus reaction questionnaire (hereafter TRQ, Wilson, Henry, Bowen, et al., 1991) (Meric, Pham, & Chery-Croze, 2000, for the French adaptation): This questionnaire assesses tinnitus subjective distress (i.e., tinnitus severity) within the preceding week. It contains 26 items describing the impact of tinnitus on social and professional life, general well-being, and emotional state. Here again, one item (number 23) specifically refers to sleep disturbance, and was excluded from the total score due to overlap with the sleep questionnaire. Each item is rated on a 4-point scale, ranging from "not at all" (0 points) to "almost all the time" (4 points). The questionnaire has good psychometric properties ($r = 0.88$ and $r = 0.96$ for reliability and internal validity, respectively).

Auditory Testing

Hearing loss was assessed by an audiogram following the standard Hughson-Westlake procedure in a soundproof booth with a clinical audiometer and insert phones (Interacoustics AC40, ANSI S3.6 norms, 1989). Standard pure-tone averages (PTA) were calculated for standard frequencies 500–1000–2000 Hz (hereafter PTA). Thresholds at 2000 Hz, right ear, could not be obtained for one participant with tinnitus, so the missing value was replaced by the tinnitus group mean for this frequency. No differences were measured between right and left ears or between men and women (both ps >0.05 for paired and independent t-tests, respectively). PTAs were therefore averaged for gender and ear. As expected, the tinnitus group showed slightly higher detection thresholds than the control group for PTAs (mean = 28.2 versus 18.2, t (100) = 4.22, $p < 0.01$). Pure-tone averages for 4000 and 8000 Hz frequencies (hereafter PTA-High) were calculated separately to better quantify hearing loss, since tinnitus and aging are associated with high-frequency hearing loss. Thresholds at one of these frequencies (n = 4 participants with tinnitus and n = 1 control) or both (n = 3 participants with tinnitus) could not be obtained, so the missing values were replaced by their respective group mean frequencies. Overall, no difference was found between men and women ($p >$ 0.05), although a significant asymmetry was noted between ears, with the left ear at a disadvantage (mean = 43.47 and 46.20 for right and left ear, respectively, t (92) = –2.40, $p < 0.02$ for paired t-test). This finding has been reported before in the elderly (Divenyi, Stark, & Haupt, 2005). An additional ANOVA was therefore run with Group as the between-subject factor and Ear as a within-subject factor to determine whether the ear difference was group dependent. No interaction was observed between Group and Ear, $F < 1$. As expected, the tinnitus group had higher PTA-highs than control subjects (mean = 53.96 versus 46.20, F (1,100) = 30.93, $p < 0.001$). PTA highs were averaged across ears for subsequent analysis.

Procedure

Questionnaires were administered to all participants in one (n = 62) or two (n = 40) testing sessions separated by a few days (median = 15.5 d). There was no time constraint for filling out the questionnaires, and participants took 10 to 15 minutes on average to complete each questionnaire. Testing took place between May 2003 and September 2005. The study was approved by the Ethics Committee of the Institut universitaire de gériatrie de Montréal and was conducted with the understanding and written consent of all participants.

Data Analysis

Preliminary analyses were run on the questionnaire data (PSQI, BDI-II, and hyperacusis) with group (tinnitus versus control subjects) and gender (female versus male) as between-subject factors. The analyses yielded no main gender effect or interaction, with the exception of a main effect for sleep efficiency (Factor 1), F (1, 98) = 4.4, $p < 0.04$, with women reporting poorer sleep efficiency than men

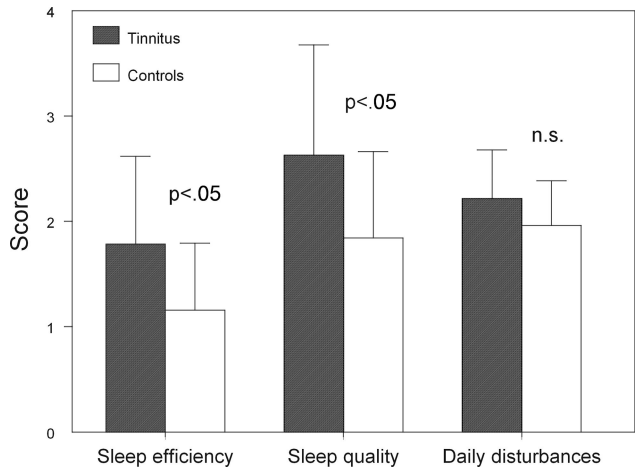

Fig. 1. Mean PSQI scores for the 3-factor structure for the tinnitus and control groups.

(mean = 1.80 versus 1.19). Data were collapsed across gender for subsequent analysis. An initial MANOVA was run, with Group (tinnitus versus control subjects) as the between-subject factor and Questionnaires (PSQI factors, BDI-II, and hyperacusis subscales) as the dependent factors. Univariate ANOVAs, ANCOVAs, and correlations were subsequently run using SPSS (version 11.0).

RESULTS

The MANOVA revealed a significant overall effect: F (7,94) = 3.66, $p < 0.01$, and the univariate analysis uncovered several significant differences between the groups. As illustrated in Figure 1, tinnitus patients showed poorer Sleep Efficiency compared with the control group on the PSQI: F (1,100) = 4.58, $p < 0.05$, and poorer Sleep Quality: F (1,100) = 4.42, $p < 0.05$. No difference in Daily Disturbances: F (1,100) = 2.11, $p = 0.15$ was found between groups. Mean global scores on the PSQI for the tinnitus and the control groups were 6.63 (SD = 3.69) and 4.96 (SD = 2.97), respectively.

Table 2 presents means and standard deviations for depressive symptoms and hyperacusis in tinnitus patients and control subjects. Tinnitus patients scored higher on depressive symptoms: F (1, 100) = 11.11, $p < 0.01$, although mean scores were within the normal range (<13), even when including question 16 on sleep (mean = 8.92 versus 4.76). They also scored higher on hyperacusis, as evidenced by the Emotional and Social subscales: F (1, 98) = 10.50, $p < 0.01$ and F (1, 100) = 15.73, $p < 0.001$, respectively. The difference in the Attentional subscale was not significant: F (1, 100) = 3.33, $p = 0.08$. Mean global scores for tinnitus and control groups were 20.02 (SD = 8.92) and 13.94 (SD = 8.21), respectively.

TABLE 2. Mean scores (standard deviation) for the tinnitus and control groups on the hyperacusis and BDI-II

	Tinnitus (n = 51)	Control subjects (n = 51)	p value
Hyperacusis total (SD)	20.02 (8.92)	13.94 (8.21)	$p = 0.08$
Attentional subscale (SD)	5.02 (3.01)	3.96 (2.85)	$p = 0.07$
Social subscale (SD)	8.04 (4.42)	4.88 (3.58)	$p < 0.001$
Emotional subscale (SD)	6.96 (2.96)	5.10 (2.84)	$p < 0.01$
BDI-II (SD)	8.08 (7.22)	4.16 (4.30)	$p < 0.01$

Note: The BDI-II score excludes item 16 on sleep disturbances.

Total PSQI scores were correlated with BDI-II scores: r (101) = 0.38, $p < 0.001$, hyperacusis total scores: r (101) = 0.53, $p < 0.001$, and PTA-Highs: r (101) = 0.25, $p < 0.05$, but not with PTAs ($p = 0.08$). BDI-II scores were also correlated with PTA-Highs: r (101) = 0.25, $p < 0.05$ but not with PTAs (p = 0.13).

Multiple Regression

To determine whether the BDI-II, hyperacusis, or PTA-high scores best explain the PSQI scores, they were entered as predictors in a stepwise multiple regression with PSQI total scores as the dependent variable. Hyperacusis ($R2$ = 0.277, $p < 0.001$) and BDI-II scores ($R2$ = 0.035, $p < 0.05$) together explained 31.2% of the variance. PTA-high scores did not add to the explained variance and were not considered in the model.

Tinnitus-Related Distress

In the tinnitus patients group, a significant correlation was found between TRQ and Sleep Quality: r (50) = 0.433, $p < 0.001$, but not between TRQ and Sleep Efficiency: r (50) = 0.08, $p = 0.60$, or Daily Disturbances: r (50) = 0.20, $p = 0.15$. TRQ and BDI-II were significantly correlated: r (50) = 0.63, $p < 0.001$, as were TRQ and hyperacusis: r (50) = 0.52, $p < 0.001$. TRQ and PTA-High scores were not: r (50) = 0.21, $p = 0.15$.

PTA-highs, hyperacusis, BDI-II, and TRQ scores were entered as predictors for sleep quality in a stepwise regression analysis. Once again, hyperacusis ($R2$ = 0.296, $p < 0.001$) and BDI-II scores ($R2$ = .129, $p < 0.01$) together explained most (42.5%) of the variance. PTA-high and TRQ scores did not add to the explained variance and were not considered in the model (no $R2$ values). This finding suggests that sleep complaints are mediated by the severity of annoyance caused by external noise and depression, rather than by tinnitus-related distress per se or hearing loss.

DISCUSSION

The main finding of this study is that elderly tinnitus patients report greater sleep difficulties compared with age-, education-, and overall health-matched control subjects. Several previous studies have demonstrated sleep disturbances in tinnitus patients, but all of them lacked proper control subjects for age, education, and overall health, and few used a validated questionnaire. Our study further qualifies sleep complaints by showing that, compared with control subjects, tinnitus patients were more disturbed in terms of sleep efficiency and quality. This is analogous to findings in chronic pain and fibromyalgia patients, whose main complaints are nonrestorative sleep (a qualitative aspect) and sleep maintenance difficulty (for a review, see Benca et al., 2004). Tinnitus patients also had similar complaints, more specifically sleep duration, habitual sleep efficiency, use of sleep medication, sleep latency, and subjective sleep quality. Sleep disturbances (getting up to go the washroom, being too cold or too hot, etc.) and daytime dysfunction were not affected. However, since epidemiological studies have found an association between insomnia and a decreased capacity for dealing with stress (e.g., Roth & Ancoli-Israel, 1999), it is likely that insomnia is linked to the anomalies in the physiological stress response previously found in tinnitus groups (Hébert et al., 2004; Hébert & Lupien, 2006). Thus, it is possible that their poor sleep contributes to these anomalies without their knowledge.

A second important finding is that hearing loss, even at the high frequencies that characterize tinnitus, can be ruled out as a significant contributor to sleep difficulties, while both hyperacusis and subclinical depressive symptoms are targeted as culprits. Although PSQI was correlated with hearing loss at high frequencies, the multiple regression model did not demonstrate the contribution of hearing loss as exceeding those of hyperacusis and depressive symptoms.

That tinnitus patients display more depressive symptoms than their nontinnitus counterparts is a pervasive finding in tinnitus research (Rizzardo, Savastano, Maron, et al., 1998). Additionally, our research group has reported more severe subclinical depressive symptoms and greater auditory sensitivity (or hyperacusis) in tinnitus groups (Hébert, Paiement, & Lupien, 2004; Hébert & Lupien, 2006). Although this finding may appear paradoxical, since tinnitus patients have greater hearing loss, hyperacusis is intimately associated with tinnitus. It is likely that this greater sensitivity to noise involves both psychological (attention bias toward noise) and physiological (a decrease in central inhibition) mechanisms. Previous studies have shown an association between noise sensitivity and psychiatric disease (e.g., Stansfeld, 1992). Future studies should examine whether sleep is more easily disturbed by auditory stimulation in tinnitus patients than in control subjects.

The present study is limited by the fact that, even though the sleep complaints appeared robust, they were not objectively measured. A study is ongoing to verify whether the sleep complaints of tinnitus patients can be objectified and whether the putative disturbances do in fact correspond to sleep efficiency and quality. An objective measurement would also provide stronger support for the argument that insomnia may interfere with the stress response of tinnitus patients.

It is surprising that although sleep complaints are among the most frequently seen in tinnitus patients, very few studies have examined appropriate treatments for this particular population. Only two studies have investigated the effects of melatonin on sleep in tinnitus patients, with inconclusive results (Megwalu, Finnell, & Piccirillo, 2006 Rosenberg, Silverstein, Rowan, et al., 1998). The results of the present study clearly show that, while the most distressed patients might benefit from antidepressants (Zöger, Svedlund, & Holgers, 2006), it is doubtful that the majority would be good candidates for such medication. Indeed, it is likely that only a few, if any, meet the criteria for clinical depression, since the mean BDI-II scores for *both* groups are in the "nondepressed" range determined by Beck (1997). Moreover, it remains to be determined whether subclinical depressive symptoms are a consequence of tinnitus onset, or, as some authors (Mülhau, Rauschecker, Oestreicher, et al., 2006) have recently suggested, a predisposing factor. Since sleep-inducing and anti-depressant medications may interfere with one another, clinicians should dispense either of these to tinnitus patients with caution until the underlying mechanisms of these conditions are better understood. On the other hand, these patients might benefit from cognitive behavioral therapy, which offers the promise of relief from tinnitus-related distress (Andersson et al., 2005).

In conclusion, our results are consistent with those of previous investigations of self-reported sleep difficulties in elderly tinnitus patients where age and overall health were controlled. Our study provides new information by further qualifying these complaints as mainly related to hyperacusis (a hallmark of tinnitus) and, to a lesser extent, subclinical depressive symptoms, rather than hearing loss. Given the elderly age of our patient sample, it remains to be confirmed whether younger tinnitus patients have similar profiles. Because clinical tin-

nitus treatments have not yet been developed, and because sleep complaints are mediated by hyperacusis and depression, we suggest that clinical goals for improving the sleep as well as the overall quality of life for tinnitus patients should focus on decreasing sensitivity to external noise and coping with depressive symptoms.

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