Hormonal related variability in auditory dysfunctions

Dr. Jacinthe Baribeau, Full Professor, Laval University

Contact: Dr. J. Baribeau, Ph.D., and Director. of LANNH
Laval University, Pavillon Félix-Antoine-Savard, FAS 1020,
Québec, Qc, Canada, G1K 7P4
tel: 418-681-7932
jbaribeau2@videotron.ca

Acknowledgements: Research grants from PNRT-Québec and IRSC-Canada to Dr. J. Baribeau. Thanks to M. Johnson, Tinnitus Clinic, for references and discussion of this project and to the Québec section of RQPA for their support. Thanks to Salon de la Musique de Montréal

Request reprints to jbaribeau2@videotron.ca
ABSTRACT

Despite tinnitus and hyperacusis being considered hearing dysfunctions typical of old age or of occupational hazards in noisy work environments, a rapidly growing number of women suffer from idiopathic tinnitus/hyperacusis from unknown aetiology. Female hormone cyclic shifts affect the ear, and therefore, possibly the perception of loudness. The goal of this study was to use self-assessment methods to explore auditory dysfunction fluctuations in women in relation to hormonal variability. Human physiological research demonstrates hormonal related variability in sensory processing in females. Its hypothesized effect on auditory dysfunctions is explored in a questionnaire addressed via Internet or standard mail. As expected, the main factor discriminating participants involved by Internet was age, followed by education level. Preliminary results show changes in perception of auditory dysfunctions in relation to hormonal cycles. In a future report, this data must be validated with double blind procedures, which must be adapted for Internet methodology.

INTRODUCTION

Until recently, tinnitus was considered a hearing dysfunction typical of old age or a occupational hazard in noisy work environments, but a rapidly growing number of women suffer from idiopathic tinnitus/hyperacusis unrelated to either causes. Female hormone cyclic shifts affect the ear, and therefore, possibly tinnitus and hyperacusis. The goal of this study is exploratory in order to assess the most efficient way to obtain self-assessment of perceptual fluctuations in women in relation to hormonal variability.

Gender and demographic prevalence – Tinnitus is generally considered a hearing dysfunction more common during aging and/or in individuals working in noisy environments, more frequently in males. Recent studies (Baribeau, 2005, 2006) showed a rapidly growing number of women suffering from idiopathic tinnitus. Andersson (1999) had shown in the population over 40, that 20% of normal individuals experience tinnitus for some period in their life. Ten to 15% of them report it as distressful to the point of adversely affecting daily functioning. Tinnitus is the 10th most commonly reported symptom among the elderly in primary care and is rapidly growing in affecting middle-age women (Andersson, 2002). Preceding studies showed fewer responses to polls about tinnitus in the female population when using the Internet as opposed to newspapers and community group networks (Baribeau, 2004; Baribeau, Gordon & Roy, 2005).

In middle-age women, idiopathic tinnitus and hyperacusis go often unreported in Quebec health statistics, remain considered a non-medical condition and as untreatable (RQPA, 2004). Idiopathic tinnitus and hyperacusis are not presently medically treated with predictable results despite the fact that on average, they last from several months to several years, with no scientifically demonstrable curative method.

Hormonal variability. Most of the review of physiological literature below demonstrates hormonal related variability in sensory processing in human females (Johnson, 2000). Objective measures of thresholds and brainstem auditory evoked potentials vary with the menstrual cycle in women (Campbell et al, 1981; Laurent et al, 1986a; 1986b). On the other hand, variance is also reported in terms of auditory dysfunctions in schizotypal personality, which is known to be prone to auditory perceptual illusions (Baribeau & al, 1994, 2006; Roth et al, 1994; Roth et al, 1996).

The inner ear has receptors dedicated to estrogenic hormones. Estrogens may have an effect on the functioning of the cochlea and on hearing (Stenberg et al, 1999). The impact of hormone cycles in the auditory system include changes in blood pressure which are different in men and women (Chen 1996), changes in hearing sensitivity in women during menstruation cycles (Swanson et al 1988), changes in the acoustic reflex during hormone shift.
(Laws et al, 1986), and in the immune system which may also directly influence the health of the cochlear structures (Angstwurm et al, 1997), and finally, modulations of brainstem and middle-latency auditory evoked potentials in auditory pathways in women (Campbell et al, 1981; Picton et al, 1978; 1984). These studies involve younger females, prior to middle age.

Animal research demonstrates significant changes in auditory responses in relation to biocycles (Baribeau et al, 2006) and when ovaries are removed (Cooper et al, 1999). There is also evidence that hearing changes take place which prolong processing in older female subjects, and that are directly linked to blood estrogenic levels. Johnson (2000) is in the process of duplicating the present study with a larger number of subjects and with a more detailed daily assessment of tinnitus ratings. Removing the ovaries produces changes in cardiovascular function that effect changes in the blood flow to the cochlea and therefore could potentially have an impact on auditory function (Laugeir et al, 1987). Embryological studies show that the ear is an encapsulated epidermal tissue including hormonally influenced cells. Its blood rich *stria vascularis* lines the wall of the cochlea. Cyclical hormone fluctuations are thought to be responsible for some of the changes in the metabolic function and neurotransmission in the *stria vascularis* of the inner ear. On the other hand, several demographic studies demonstrate shifts in blood pressure between men and women until women enter menopause, at which point gender differences become non-significant. After menopause, this risk tends to equalize between the sexes. In conclusion, in addition to clinical observations by audiologists (e.g. Johnson, 2000), many empirical findings support the hypothesis that auditory dysfunctions such as tinnitus are influenced by hormonal variations.

**Idiopathic tinnitus and hyperacusis** - Although tinnitus is often related to hearing loss, long-term noise exposure, and medications, idiopathic tinnitus and hyperacusis demonstrate no known aetiology. Often, the cumulative factors required for specifying aetiology are not consistently reported in medical files or clinical studies (Andersson & Lyttkens; 1999). However, careful analysis with comprehensive questionnaires demonstrates higher frequencies of aetiological categories and distressing symptoms than the statistics derived from medical records (Baribeau, 2005).

In Québec, subjective idiopathic tinnitus and hyperacusis are more frequently correctly diagnosed in patients who care to make the extra requests for follow-up with one or another of the few available audiologists who specialize in tinnitus assessment (Baribeau, 2005). A minority will undergo an exhaustive diagnostic investigation including repeated ORL examinations and extensive audiometric testing. Because patients with cumulative and chronic distressing idiopathic symptoms do not receive treatment, they are often excluded from clinical statistics. In addition, because women’s tinnitus may more often be linked to other non-audiological disorders, many cases might have gone unnoticed in health statistics.

**Degree of distress and perceived loudness.** - Preceding studies by Baribeau et al (2004; 2005) showed that out of 500 individuals identified as having tinnitus and/or hyperacusis, approximately 350 indicated significant tinnitus and, according to the method of questioning, 16% to 37% expressed severe distress with impact on daily activities and quality of life.

Even higher incidence was derived from comparisons of different quantifiable and verifiable methods of data collection, which provided standardized questionnaires administered in semi-structured interviews in order to improve validity and reliability (Baribeau et al, 2004). The lowest rate of 16% derived from objective behavioural estimates based on the frequency of behaviours demonstrating seeking help. This largest rate of 37% for distressing tinnitus is significantly higher than the 15% reported in less exhaustive surveys (Andersson, 1999) and frequently includes hyperacusis. This highest incidence number was based on a method of interviews detailing impact of distress on specified lists of daily activities. This indicates that, with proper reaching out and questioning, affected women might account for a larger percentage of distressful tinnitus than in general statistics.
According to Budd (1996), individuals with distressing joint tinnitus/hyperacusis experience significant stress and major dwindling in their quality of life, because of stress, of the annoyance factor associated with tinnitus, and related symptoms such as hearing deficits and sensitivity to noise (hyperacusis). According to Meric et al (2000), rates of report of distress are higher with a more elaborate questionnaire. According to Baribeau et al (2004; 2005) activities of daily living are affected in proportion to the distressing characteristics of the tinnitus, its qualitative aspects as much as its intensity (Baribeau et al, 2004, 2005) largely unrelated to voluntary control. Because of their monthly experience with stress tolerance in relation to menses, it is hypothesized that women make a conscious connection between their experience of tinnitus, their stress tolerance and menstrual variability. The potential relation between intensity of the auditory dysfunction, its perception and monthly fluctuations deserves to be explored in women, until more systematic and complex direct measures of hormonal fluctuations are ascertained.

Goal. The present study attempted to attend to untreated female tinnitus/hyperacusis sufferers in order to more fully assess the phenomenology of such symptoms in relation to their experience of monthly hormonal variability.

The review of literature reports studies on how female hormones affect hearing in young healthy subjects, but few studies report perception of tinnitus in middle age women in Québec. A link between variations of female hormone cycles, hyperacusis and tinnitus perception was suggested in a previous study using open-ended questions (Baribeau et al, 2004) and was observed by practitioners in clinical practice (Johnson, 2000)

This issue demands consideration of demographic parameters and polling approach. The goal of the present study is to examine the incidence of idiopathic tinnitus in women in relation to hormonal variability. Women were recruited via standard mail procedures or via internet-mediated support network for individuals affected by tinnitus. The question asked to women in this study is whether they noticed changes related to their menstrual cycles in their auditory dysfunctions in relation to loudness perception.

METHODS

The present study investigates self-assessment methods in order to analyze responses obtained in standard mailed questionnaires and in an internet/email-based method, from middle-aged female participants. Given the nature of this goal, obviously, double-blind procedures were not applied. Double-blind procedures require a laboratory environment in order to be properly applied in self-assessment approaches.

Procedure. Due to the formal definition of tinnitus and its link to aging and auditory dysfunctions, many middle-aged women with stressful tinnitus are not recruited in tinnitus studies. In order to circumvent this communication issue and in order to reach out to the middle aged female population, potential subjects were recruited through internet, using advertisement for widely publicized public events related to music, such as concerts and music shows (Meetings of l’Association des musiciens de Montréal’05, Salon de la musique 2005, Music Fest Show’05, Place Bonaventure-Journées de la musique’05etc). The Internet address was thus distributed to hundreds of potential subjects via such media, along with a basic definition of key words such as "acouphène" and tinnitus. In itself, this resulted in hundreds of email responses and Internet communications. When email addresses were missing subjects were contacted by phone.

Participants. In response to first contact, participants were offered support and answers to their questions while obtaining responses to items derived from a standardized questionnaire (Baribeau, 2004; 2005). Out of approximately 350 individuals expressing a need for support groups, 230 signed in, out of which 98 followed up with semi-structured open-ended questions, of which approximately half were women. Approximately 50% of the
sample were 40 years of age or older. These volunteers originated from 4 regional locations: Québec, Montréal, Victoriaville, Trois-Rivières. About half were from a major city (Montreal) and half from the regional smaller town locations. All volunteers were offered alternative support via regional support group meetings and peer counselling (non professional) via the RQPA telephone help line.

**Subjects.** Selected women participants were screened for minimal tinnitus/hyperacusis duration of 6 months and for presence of auditory distress. Since there were no major differences between urban and smaller regional towns, the data from subjects of regions and cities were pooled. Inclusion criteria: 40 to 65 years of age, cycle regularity between 27 and 31 days. Exclusion criteria: any other medical condition, hormone therapy. For 35 subjects, tinnitus variance was reported in a structured interview with a grid covering a 2 month period, and questions targeting the degree of related discomfort. In the rest of the sample, similar questions were asked on an open-ended questionnaire covering the same period, complemented by a list of objective questions on the ways tinnitus affected daily activities (Baribeau et al, 2005). In the first group, 90 individuals in the target age range received the invitation to participate in a mailed distribution of a bulletin. A sub sample of 20 women was analyzed in order to verify potential differences from the rest of the sample. Due to absence of significant differences, the 2 sub samples were merged. Overall, out of a pool of approximately 350 contacted individuals 98 provided contact by email/internet. In total, forty women met the age criteria between 45 and 65, met the cycle regularity requirement and did not take hormone therapy and 35 of them also filled a calendar-type grid.

**Data collection.** Table 1 gives a summary of dependent and independent variables. These cases were examined with reference to rating scales, varying from 1 to 10, going from absent, difficult to rate, light, moderate to severe: A) monthly variability. B) Intensity of tinnitus and/or hyperacusis C) Impact on daily activities D) Distressing quality of tinnitus and/or hyperacusis. Subjects were asked to rate their perception in reference to the same daily point in time and following the standard procedure in the audio logical literature: the loudness rating required that subjects rate the hyperacusis experience and listened to the tinnitus in a quiet place for a few seconds until confident about rating its loudness on a 0-10 scale, where 0 would be completely silent and 10 would be as loud as a jet engine of an airplane. Responses were organized using a calendar type grid with cycles varying from 27 to 31 days. In order to compare results between participants with varying cycle length and since there was little variability in the 1rst and 3rd quartile, 1 to 4 days were removed in order to obtain comparable cycle length of 28 days for all participants. Due to the importance of collecting data during menses, ratings were taken at 2-day intervals during menses and at 3-4 day intervals between menses.

Based on preceding validation studies of the questionnaire (Baribeau et al, 2004, 2005, 2006), 24 items of a 70-question survey (QDDT v.1) were used to serve as reference points to categorize and compare mailed and internet/phone reports. Responses and follow-up questions were presented in a standard format using most of the formulations of the QDDT, and responses from participants were rated using the same procedure. The internal consistency of these questions was assessed with 79 subjects (with no missing values) in order to measure Cronbach alpha index of internal consistency. Similar methods to Zachariae et al (2000) were used. This internal validity index calculated for the 24 items used in the Internet version of the present questionnaire in French is excellent, with a value of .92. It is significant and comparable to other questionnaires formatted in English (Meric et al, 2000), and Danish studies (Zachariae et al, 2000).

**Statistical analyses -** For the structured questionnaire items, group differences were assessed with t-tests for ratio variables and Chi square tests for frequency counts. For content analysis of text, frequency and category data were analyzed with non-parametric Chi
square statistics. Other demographic data were analyzed with t-tests with significance p value set at .05. Monthly variations were not tested for significance given the large number of data. Tests will be done with larger samples in future analyses.

RESULTS:

Table 1 – Top: Dependent and independent variables—Bottom: Monthly variability of loudness ratings and distress ratings*

<table>
<thead>
<tr>
<th>Demographic information</th>
<th>Age</th>
<th>Education</th>
<th>Occupation</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory dysfunctions</td>
<td>Hearing deficit Left/Right</td>
<td>tinnitus/hyperacusis characteristics</td>
<td>Onset and triggers</td>
<td>Impact on daily activities: total score (QDDT)</td>
</tr>
<tr>
<td>Hormonal cycles</td>
<td>Abnormalities endocrine conditions</td>
<td>Ovary related conditions</td>
<td>Pre-menopausal circumstances</td>
<td>Peri-Menopausal</td>
</tr>
<tr>
<td>Tinnitus loudness rating 1-10</td>
<td>Mean week 1/5 Day 1/3/6 etc</td>
<td>Mean week 2/6 Day 10/13/16 etc</td>
<td>Mean week 3/7 Day 20/23/26 etc</td>
<td>Mean week 4/8 Day 26/28/30</td>
</tr>
<tr>
<td>Mean distress Rating 1-10</td>
<td>Mean week 1/5</td>
<td>Mean week 2/6</td>
<td>Mean week 3/7</td>
<td>Mean week 4/8 Menses</td>
</tr>
<tr>
<td>Monthly variability</td>
<td>Loudness Rating</td>
<td>Distress Rating</td>
<td>Variance/Variance Loudness</td>
<td>Distress</td>
</tr>
<tr>
<td>Day 1</td>
<td>7,1</td>
<td>7,9</td>
<td>37,15</td>
<td>36,02</td>
</tr>
<tr>
<td>Day 3</td>
<td>6,1</td>
<td>6,5</td>
<td>36,05</td>
<td>36,14</td>
</tr>
<tr>
<td>Day 6</td>
<td>5,1</td>
<td>5,9</td>
<td>37,05</td>
<td>39,48</td>
</tr>
<tr>
<td>Day 10</td>
<td>5,5</td>
<td>5,6</td>
<td>36,55</td>
<td>36,41</td>
</tr>
<tr>
<td>Day 13</td>
<td>5,5</td>
<td>5,9</td>
<td>36,06</td>
<td>38,08</td>
</tr>
<tr>
<td>Day 16</td>
<td>5,4</td>
<td>5,2</td>
<td>35,57</td>
<td>34,90</td>
</tr>
<tr>
<td>Day 20</td>
<td>5,3</td>
<td>5,2</td>
<td>35,90</td>
<td>35,70</td>
</tr>
<tr>
<td>Day 23</td>
<td>5,6</td>
<td>4,9</td>
<td>35,17</td>
<td>34,01</td>
</tr>
<tr>
<td>Day 26</td>
<td>5,3</td>
<td>5,9</td>
<td>35,29……37,09</td>
<td>.81</td>
</tr>
<tr>
<td>Day 28</td>
<td>6,3</td>
<td>6,3</td>
<td>34,90</td>
<td>33,90</td>
</tr>
<tr>
<td>Day 30</td>
<td>7,5</td>
<td>7,1</td>
<td>36,25</td>
<td>36,39</td>
</tr>
<tr>
<td>Day 33</td>
<td>6,7</td>
<td>6,8</td>
<td>35,04</td>
<td>35,71</td>
</tr>
<tr>
<td>Day 36</td>
<td>5,5</td>
<td>5,4</td>
<td>35,42</td>
<td>35,38</td>
</tr>
<tr>
<td>Day 40</td>
<td>5,2</td>
<td>6,0</td>
<td>36,04</td>
<td>39,39</td>
</tr>
<tr>
<td>Day 43</td>
<td>5,6</td>
<td>5,5</td>
<td>36,52</td>
<td>37,01</td>
</tr>
<tr>
<td>Day 46</td>
<td>5,5</td>
<td>5,7</td>
<td>36,09</td>
<td>36,87</td>
</tr>
<tr>
<td>Day 50</td>
<td>5,5</td>
<td>5,4</td>
<td>35,55</td>
<td>37,01</td>
</tr>
<tr>
<td>Day 53</td>
<td>5,5</td>
<td>5,6</td>
<td>36,23</td>
<td>37,09</td>
</tr>
<tr>
<td>Day 56</td>
<td>5,3</td>
<td>5,9</td>
<td>35,69</td>
<td>38,31</td>
</tr>
<tr>
<td>Day 60</td>
<td>6,7</td>
<td>6,8</td>
<td>35,40</td>
<td>35,74</td>
</tr>
<tr>
<td>Day 63</td>
<td>6,3</td>
<td>6,9</td>
<td>46,33</td>
<td>42,01</td>
</tr>
<tr>
<td>Mean</td>
<td>5,3</td>
<td>6,2</td>
<td>32,76</td>
<td>36,67</td>
</tr>
<tr>
<td>Note: Johnson sample with daily</td>
<td>(2000) is in the reports</td>
<td>process of collecting such data</td>
<td>on larger</td>
<td></td>
</tr>
</tbody>
</table>
Item analysis. Responses were examined with reference to three categories of questions, using a similar method to other comparable internet studies (Coulson, 2005) for support: such as affective, informational/factual, networking and professional or paramedical help). Most women mentioned interest in better understanding the relation of hormones to their auditory dysfunctions. About 10% provided systematic daily ratings of tinnitus loudness and distress perception for 90 days. The majority presented weekly ratings for two months in relation to their menstrual cycle. Reports were quantified with the same rating scale for all participants with the standard TRS, from 0 to 10 for each factor: loudness perception and distress rating.

Comparisons of contents between questionnaire methods showed no significant difference between women 45 to 65 from the younger age group in the Baribeau (2006) study, which confirms equivalences reported earlier. In the open-ended questions section, item analysis shows that primary contents were concerned with the communication of factual information between hormones and auditory dysfunctions, particularly with questions about symptom quality, intensity, duration, prognostic factors, and medical causative variables. Secondary contents invoked a theme related to the interpretation of evolution of symptoms over time. The 3rd category related to requests for references to medical and health practitioners; the 4th theme referred to issue of care, to ways of handling symptoms and related impact on stress tolerance, depression, anxiety, and fear of aggravations.

Comparisons of demographic data (age, education, location) between the mailed and Internet reports showed the following. As expected, the main factor discriminating participants involved by Internet and those involved by mail was age, followed by education level. The Internet group was 12 years younger with a higher level of education of 2 years. As expected, the main factor discriminating participants involved by Internet and participants not available on the Internet were age and location, followed by educational level. Age was confounded by the location variable since a large pool of younger subjects were recruited via internet addresses distributed at the music events, as opposed to the community group web sites.

There were no differences in number of females between age groups or regions. There was no significant difference in frequency in reports or in number or nature of questions about distressing symptoms of tinnitus and/or hyperacusis. The large majority of women could not dissociate tinnitus from hyperacusis in their ratings. Thus the values for the 2 dysfunctions were averaged and merged. All data about these 2 dysfunctions were pooled for future analyses. In the following figures, the reported values refer to frequency counts measured for each group. Reference to distress was counted only once according to one or the other of 24 items of the questionnaire, most items referring to how tinnitus/hyperacusis affected daily domestic, familial, work and social activities. The total count is reported here as an index of distress. Participants reported tinnitus/hyperacusis-related distress, depression, and daily annoyance with the percentages illustrated below. Immediately following the support-groups, about half the participants showed appreciation of reassurance and satisfaction at the information obtained. The same ratio of appreciation was expressed in the Internet group. There was no significant difference between women assessed via Internet versus mailed questionnaires.

Content analyses showed some heterogeneity amongst factors of tinnitus/hyperacusis intensity. Hearing acuity was defined as a “significant problem” by 25% of respondents. Many women had experienced tinnitus or hearing impairment following excessive use of walkman types of devices (33%) or in relation to hearing distress in a noisy environment (receptionist, telephone operator, machine operator). Approximately half of the women asked for information about ear protection if they were aware of the potential for permanent hearing loss (50%) or were advised by a medical professional (50%). In summary, the analysis of
women’s responses suggested that approximately a third of them have experienced tinnitus after exposure to loud sounds. This was the main difference with the older female age group reported in the literature (Baribeau, 2005). According to Figure 2, the mean counts of distress reports were comparable between mailed (38) and internet/phone reports (39).

The temporal changes in mean and variance of tinnitus perception is presented in table 1 for the subgroup of women (n=35) who reported regular ratings. Trend analyses will be presented in a future report, which will take into account missing values. For this reason, significance tests are not considered statistical estimates but p values are rather reported as trend indicators and for their exploratory value. It is apparent that on days –1 to day 3 of the menstrual cycle at time of menses, mean values and correlations between tinnitus and hyperacusis loudness and distress ratings indicate that women report perception of significantly higher tinnitus/hyperacusis intensity. This is a trend indicating that middle-aged women indeed present monthly variability in their report of auditory dysfunctions. The variability in the hyperacusis responses and its interaction with tinnitus loudness and distress indicates that future studies must address the issue of dissociating such interactions.

**DISCUSSION and CONCLUSION**

Despite age and educational differences between the two women groups, these results suggest that women responding via the Internet refer to similar contents and symptoms to the larger sample accessible via standard traditional mailing approaches.

This Internet based approach generated more responses than via community organizations. It thus appears as a feasible method to obtain tinnitus data from this segment of the female population. High dropout rates or delay in communication can be a characteristic of studies using the Internet with the older age group, but should be contrasted with the cost effectiveness and accessibility of the Internet.

The most frequently invoked theme in the open-ended questionnaire related to the interpretation of evolution of symptoms and to obtain advice in handling symptoms and related impact on stress tolerance, depression, anxiety, fear of aggravations, stress and insomnia. Before contact, few individuals were informed of relevance of hormonal condition on their experience of tinnitus. Most women mentioned interest in better understanding the relation of hormones to their auditory dysfunctions. This provides the basis for the offering of an internet-based service for women suffering from tinnitus and hyperacusis.
REFERENCES


