Hearing fluctuation is not a predictor of vertigo attacks in Meniere's syndrome

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Abstract

This study aimed to determine if regular self-hearing tests would be useful as a predictor of vertigo in patients with Meniere's syndrome. The study group consisted of patients who had a clinical diagnosis of definite Meniere's syndrome according to the AAO-HNS criteria, a score on the Gibson scale of 7 or over and an enhanced negative summating potential on transtympanic electrocochleography. These patients were supplied with a programmable hearing aid and a portable programmer that allowed them to measure their own hearing in-situ. They were asked to measure their audiometric thresholds daily and if possible during the attacks of vertigo. Hearing fluctuation occurred more often than expected but did not usually correlate with vertigo episodes. Statistical analysis showed that it would not be possible to predict an attack based on changes in hearing thresholds in this group of patients with Meneire's disease.

Key-words: Self-hearing tests. Uhear. Vertigo. Hearing fluctuation.

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Introduction

The classic explanation for the attacks of vertigo due to Meniere's disease is that a rupture of Reissner's membrane has occurred with mixing of perilymph and endolymph. The influx of potassium is believed to cause a temporary block on afferent neural activity until ionic pumps restore the electrolyte balance [1]. Alternative theories of potassium leakage rather than a rupture have also been proposed. If potassium contaminates the perilymph there should be a loss of endocochlear potential causing a significant hearing loss [2].

Some patients with Meniere's syndrome report worse hearing just prior to a vertigo attack. The unpredictable nature of the condition, however, suggests that clinical audiograms are not sufficient to document the pattern of hearing fluctuation.

Vertigo attacks are the most disturbing symptoms of Meniere's syndrome. Reports suggest the possibility of preventing an attack by administration of Urea immediately prior to the onset of the vertigo[3]. If changes in hearing levels are a sign of an imminent vertigo attack, such episodes might be prevented with the monitoring of hearing thresholds. Early intervention would be possible if these episodes could be foreseen.

Current technology has made it possible for patients to monitor their own hearing by self-testing through their own hearing aids[4,5]. More recently, software companies have released applications such as Uhear™ [6], which are hearing tests performed via mobile phones and personal computers. Such products, if used under professional care, may prove to be a useful and convenient tool for self- hearing tests.

This study investigated the possibility of using self-hearing tests to predict vertigo attacks in a group of 50 patients with Meniere's disease.

Material and Method

Fifty patients who had a clinical diagnosis of definite Meniere's syndrome according to the AAO-HNS criteria[7] and scored 7 and over in the Gibson's 10 points scale [2] with an enhanced negative summating potential recorded with transtympanic electrocochleography[8] were recruited.

The patients were supplied with a custom programmable digital hearing aid (Widex Senso Diva or Inteo models) and a portable programmer (SP3 or IP5), which allowed them to measure their own hearing thresholds in-situ [4].

The aids were fitted in the clinic with a custom mould for behind the ear (BTE) or in-the-canal (ITC) or completely in the canal (CIC) hearing aid styles to suit the hearing loss at the time of fitting. The fitting protocol was based on the standard Widex fitting procedure using the expanded Sensogram. The Sensogram is measured with the hearing aid in-situ by using the Widex Compass software either via the HiPro/ or the Noah Link, or by using the SP3 or IP5 portable programmers. The "basic Sensogram" allows measurement of thresholds in 4 basic frequency bands; 500Hz and 1,2 & 4kHz and the software extrapolates the thresholds to the intermediate frequency bands of the 15 bands. In the "expanded Sensogram" the clinician

has the ability to measure 13 frequency bands in the BTE model and 14 frequency bands in the ITC and CIC models We used the 'expanded Sensogram' because in our experience, there can be up to 15dB difference between the threshold predicted by the software from the "basic Sensogram" and the thresholds measured at the intermediate frequencies. In this study the audiologist performed an "expanded Sensogram" via Compass software and Noah Link, measuring the in-situ hearing thresholds at up to 14 frequency bands depending on the model of hearing aid chosen.

The patients were then introduced to the portable programmer. They were taught how to connect it to the hearing aid and to perform their own "expanded Sensogram". The patients' ability to carry out this procedure was checked in the clinic, by asking them to repeat the measurements made by the audiologist earlier in the session.

The programmer was given to the patients who were instructed to perform their own Sensogram and to program their hearing aids at home. "Feedback test" was not part of the protocol for home measurements as the audiologist had already performed it in the clinic. The patients were strictly instructed not to change any other parameter in the hearing aids and not to use any functions in programmer other than the "expanded Sensogram" as shown by the audiologist.

These patients were asked to measure their audiometric thresholds three times a day for a period of 8 weeks and to grade their vestibular symptoms on a scale of 1 to 5 immediately prior to hearing testing. They were encouraged to have their hearing thresholds measured, if at all possible, during the attacks of vertigo. Vertigo grading is described in table 1. The results were recorded on a spreadsheet and analysed using SPSS software.

Table 1- Vertigo grading.

Grade	Vestibular symptoms
1	No symptoms
2	Off balance/ slight dizziness with no rotation
3	Mild vertigo with rotation
4	Moderate vertigo with rotation and nausea lasting for more than 1 hour
5	Severe vertigo with rotation and vomiting lasting (needed help to test hearing)

Control group for self-hearing test:

A total of 8 ears were used as control to ensure test-retest reliability of self measured hearing thresholds using this hearing aid system. One female subject with bilateral moderate mixed hearing loss due to otosclerosis and another with a congenital bilateral flat mild to moderate sensorineural hearing loss, measured their hearing in both ears 2 times a day for a period of 2 weeks. Four subjects of the study group were fitted with bilateral

hearing aids in spite of having Meniere's disease in one ear only and were also asked to measure their hearing bilaterally so that the contra-lateral ear could be used as a control.

No significant fluctuation, (greater than +/- 5dB) were recorded by the control group at any of tested frequencies, suggesting good test/ re-test reliability. This included the four participants who had unilateral Meniere's disease and recorded significant fluctuation in the contralateral ear. These participants recorded bilateral tests performed at the same time and so would have had similar test conditions. This suggests that the change in measured thresholds in the active ear reflects reliable hearing threshold fluctuations.

Results

Six participants measured their hearing thresholds around 24 hours before, during and after an attack of vertigo. The audiograms are shown in figures 1 to 6, as previously reported [9].

Figures 1 to 4 are the audiograms of 4 participants measured before, during and after a vertigo attack graded 4. The audiograms displayed in figures 5 and 6 were obtained by the participants who had graded their attacks as 5. Analysis of the data showed no consistency with the timing of the attacks of vertigo.

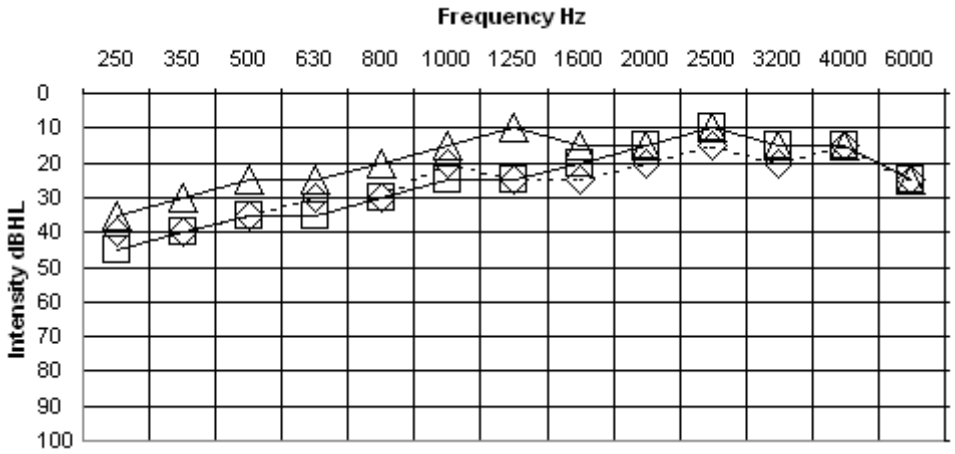


Figure 1. Patient 8: Audiograms ◊ prior (-21hr), □ during, Δ after (+24hr) an attack.

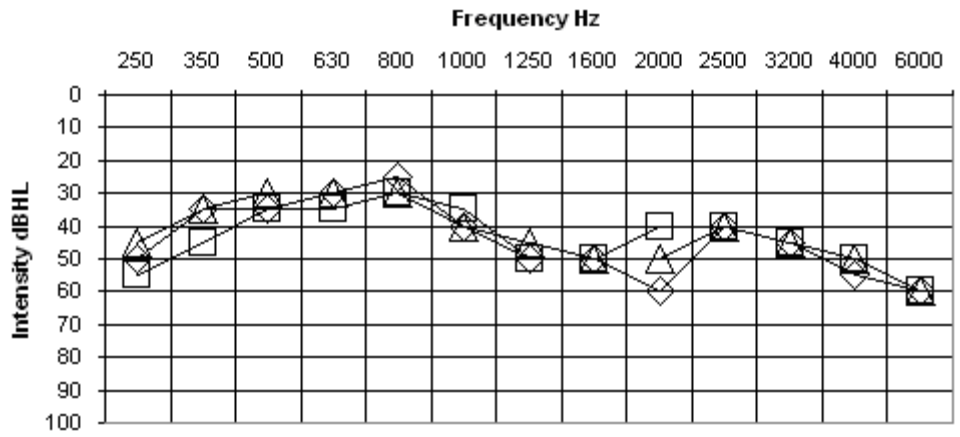


Figure 2. Patient 22: Audiograms ◊ prior (-24hr), □ during, Δ after (+24hr) an attack

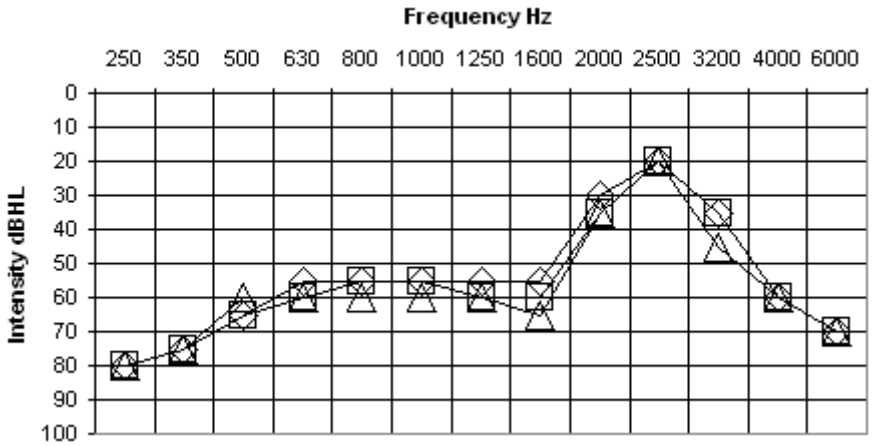


Figure 3. Patient 24: Audiograms ◊ prior (-15hr), □ during, Δ after (+20hr) an attack

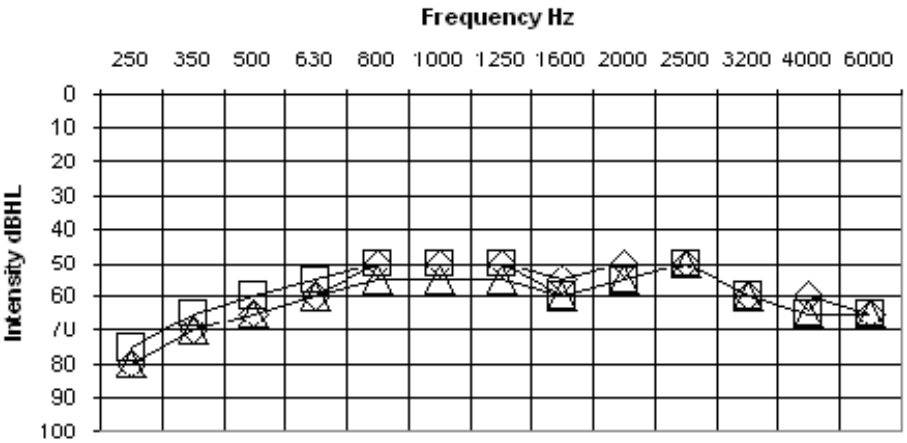


Figure 4. Patient 31: Audiograms ◊ prior (-22hr), □ during, Δ after (+25hr) an attack

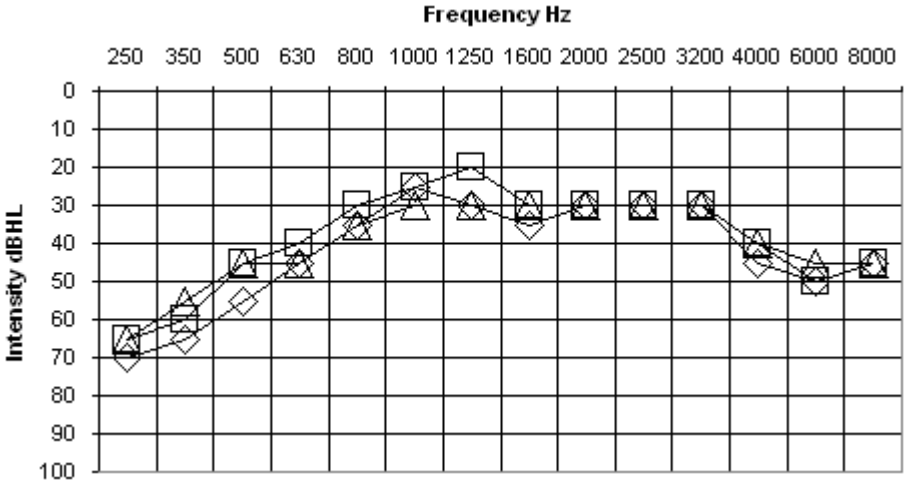


Figure 5. Patient 23: Audiograms ◊ prior (-31hr), □ during, Δ after (+24hr) an attack

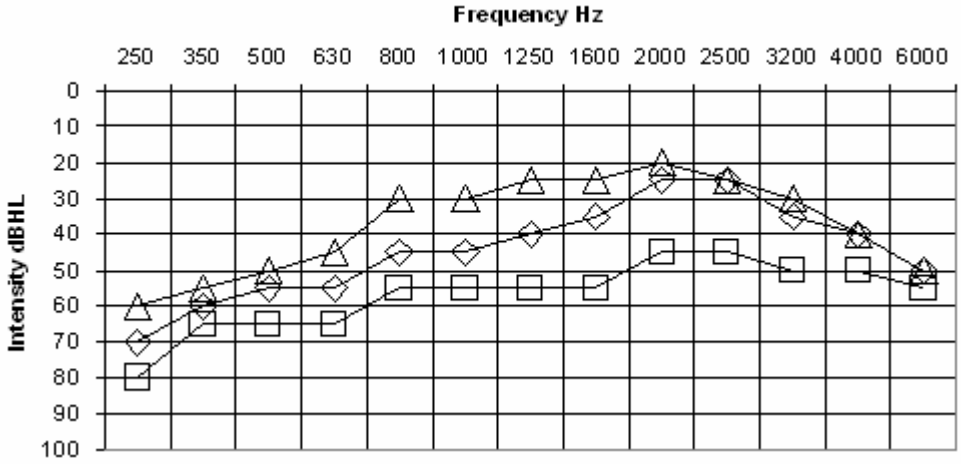
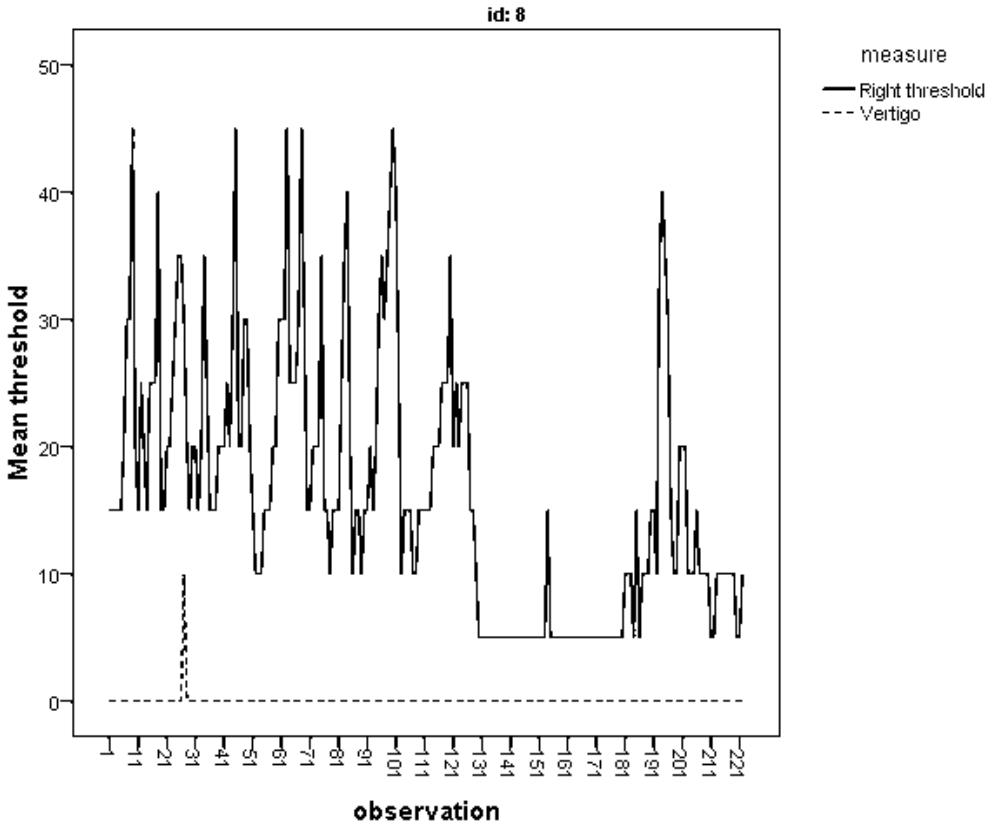


Figure 6. Patient 45: Audiograms ◊ prior (-22hr), □ during, Δ after (+25hr) an attack

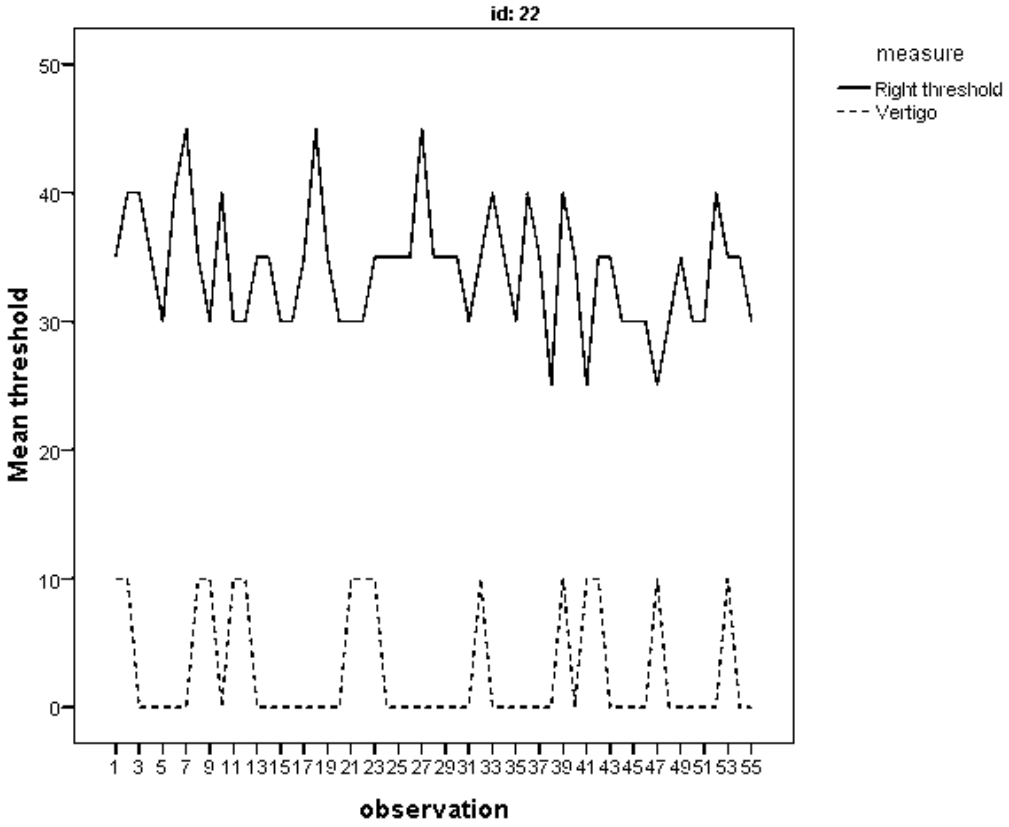
Figures 1A to 6A show the graphs from the same 6 participants displaying hearing thresholds at one single frequency (the one of maximum fluctuation for that individual participant), together with the number of vertigo attacks (graded 4 and/or 5) over the time period of data collection. Cross-correlations between hearing fluctuation and vertigo attacks are described at the bottom of each graph. A positive correlation indicates a tendency for hearing thresholds to deteriorate during vertigo episodes, while a negative correlation shows hearing improvement.

The results of these six participants indicated no consistent relationship between hearing fluctuation and episodes of vertigo.



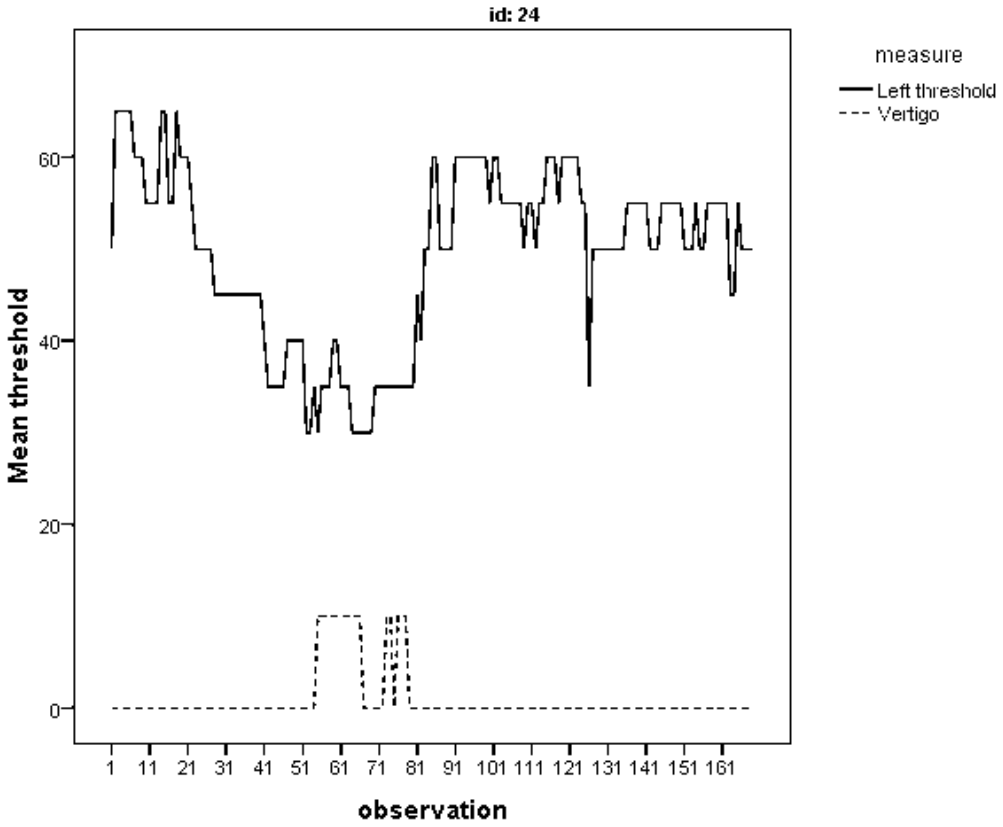
Correlation between threshold and vertigo was 0.027

Figure 1A. 1 episode of vertigo represented by the dotted peak and 221 hearing thresholds measured at 800Hz



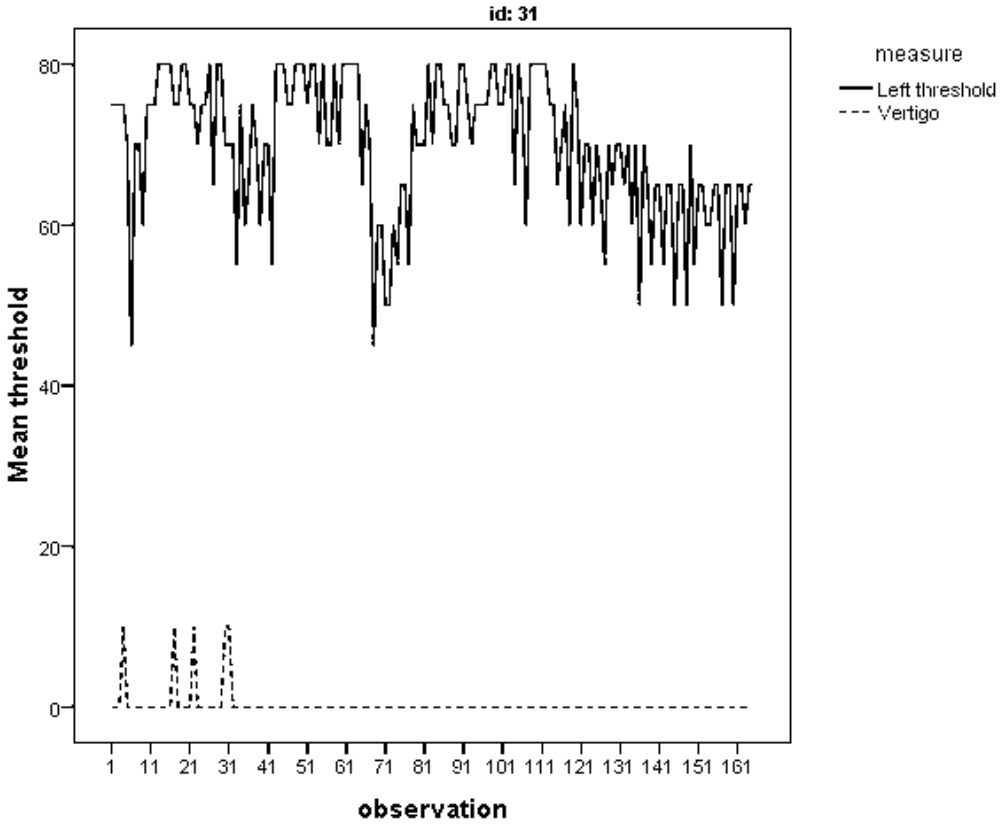
Correlation between threshold and vertigo was -0.2

Figure 2A. 9 vertigo episodes represented by the dotted peaks and 55 hearing threshold measured at 500Hz



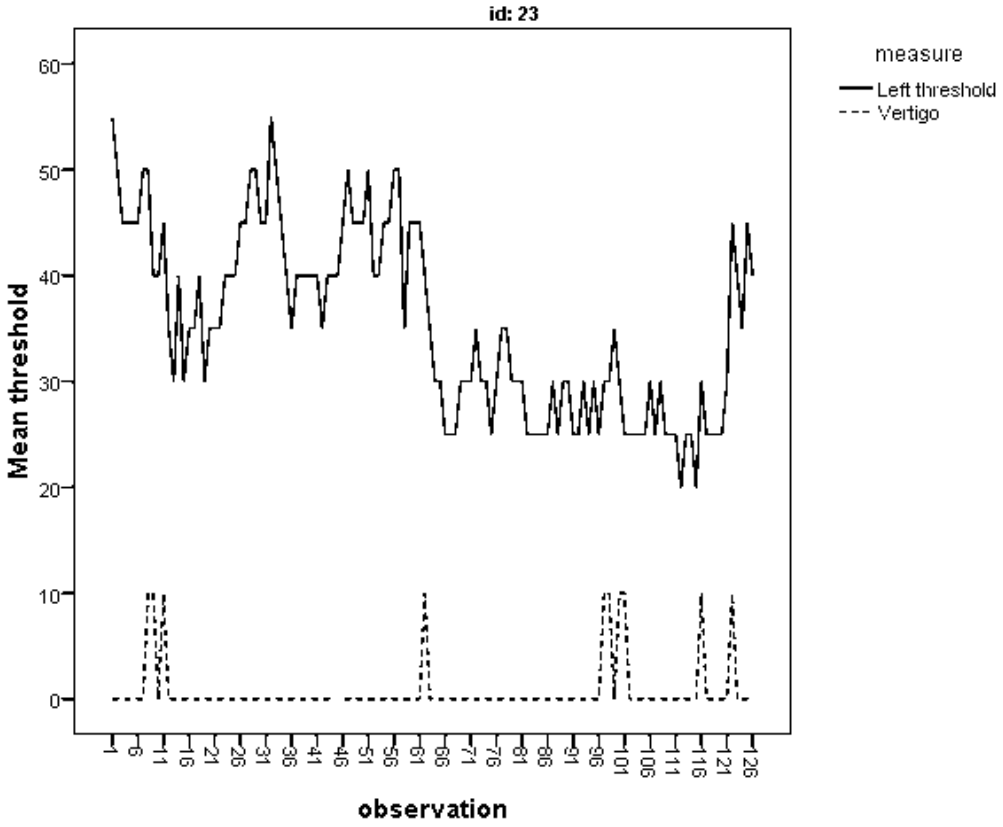
Correlation between threshold and vertigo was –0.065

Figure 3A. 6 vertigo episodes represented by the dotted peaks and 181 hearing threshold measured at 3200Hz



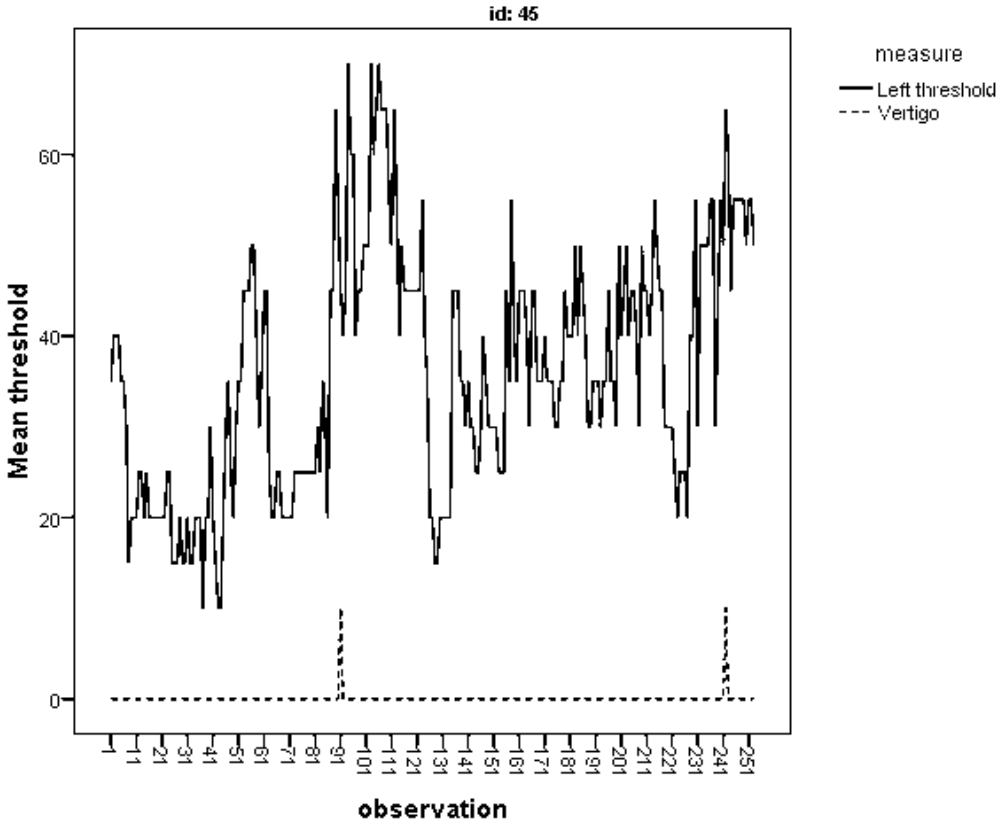
Correlation between threshold and vertigo was –0.031

Figure 4A. 5 vertigo episodes represented by the dotted peaks over 181 hearing thresholds measured at 250Hz



Correlation between threshold and vertigo was 0.214

Figure 5A. 7 vertigo episodes represented by the dotted peaks and 126 hearing thresholds measured at 1000Hz



Correlation between threshold and vertigo was 0.072

Figure 6A. 2 vertigo episodes represented by the dotted peaks and 251 hearing thresholds measured at 630Hz

Six participants who did not suffer any vertigo episodes during the study period were randomly selected and used in the control group. Their results are displayed in figures 7, 8, 9, 10, 11 and 12 illustrating the changes in hearing thresholds during periods of no vestibular symptoms.
These graphs show that hearing fluctuations occurred independent of vertigo attacks.

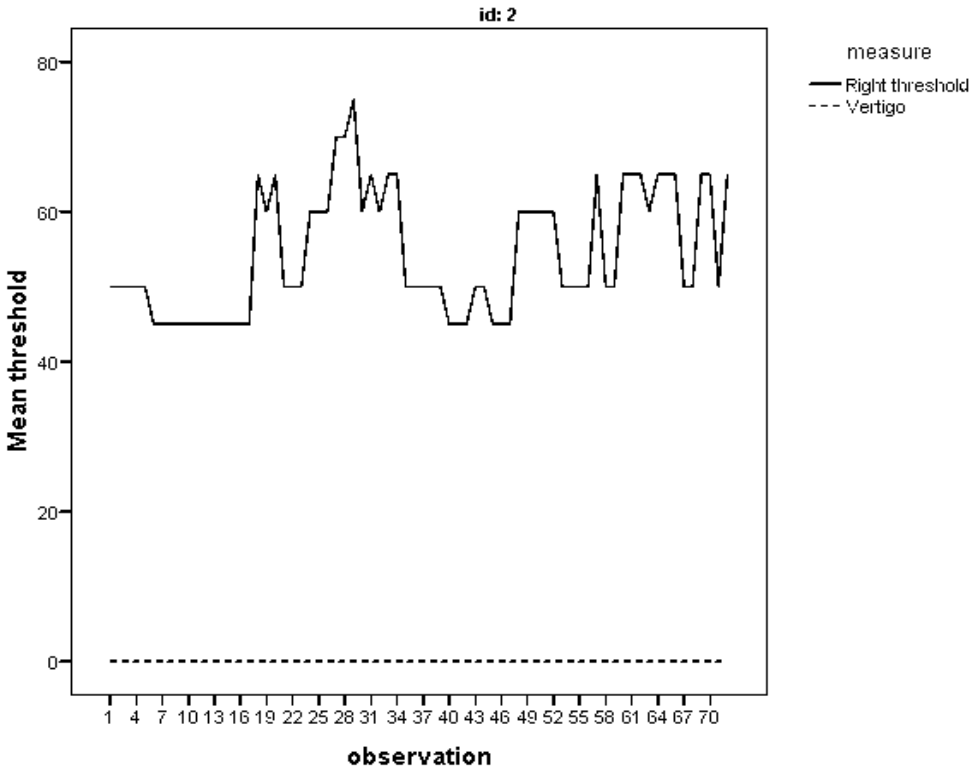


Figure 7. Hearing thresholds measured at 250Hz

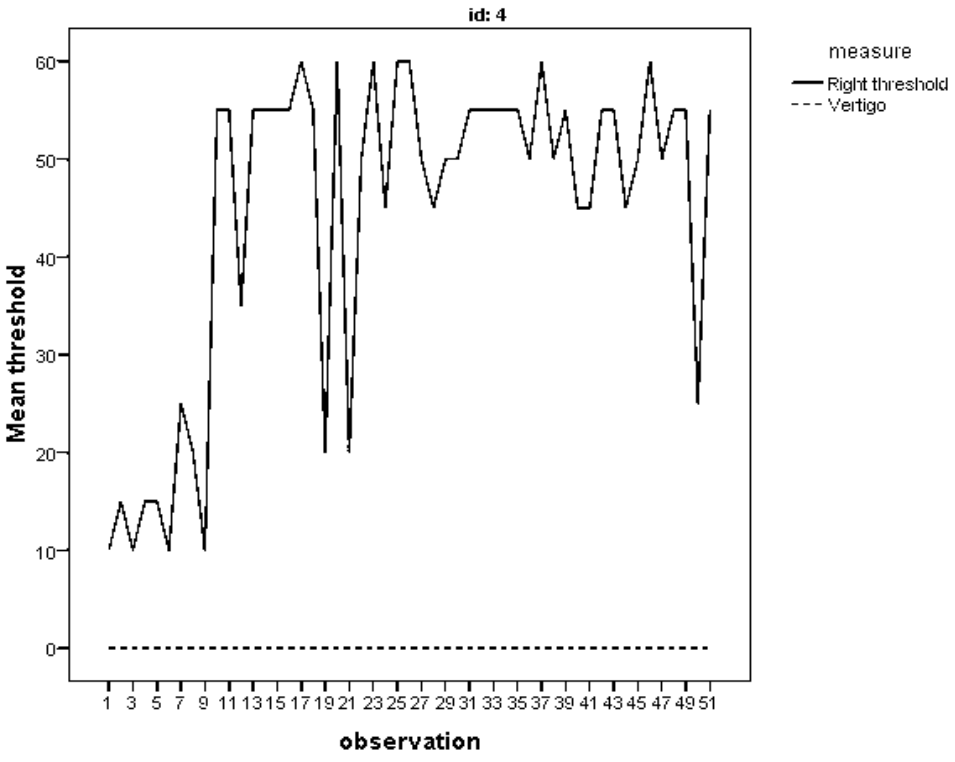


Figure 8. Hearing thresholds measured at 1000Hz

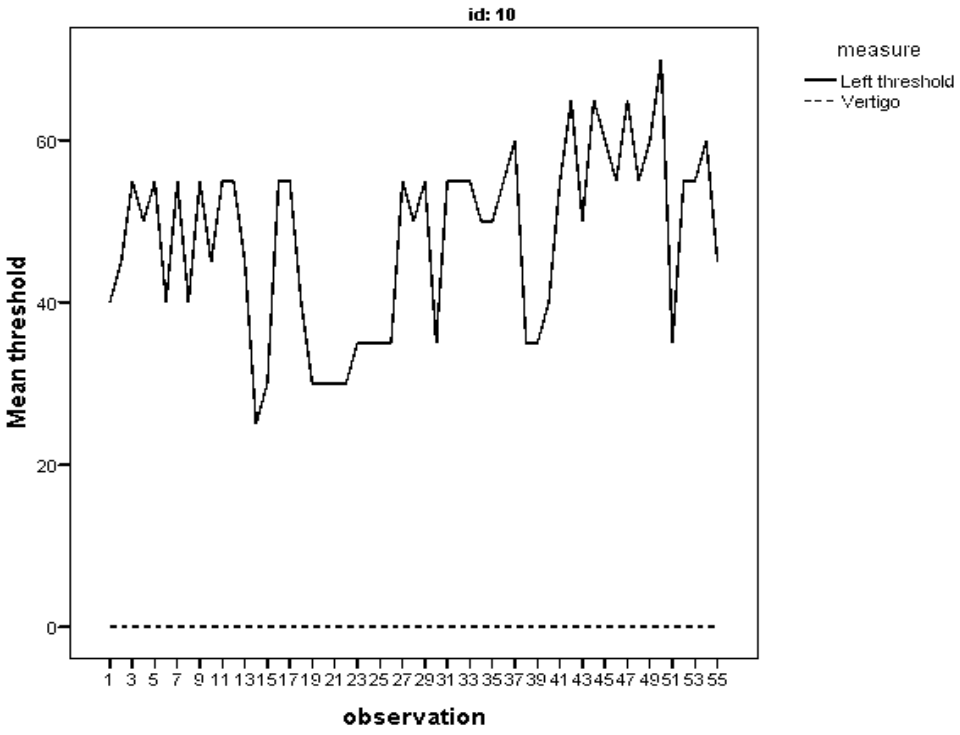


Figure 9. Hearing thresholds measured at 2000Hz

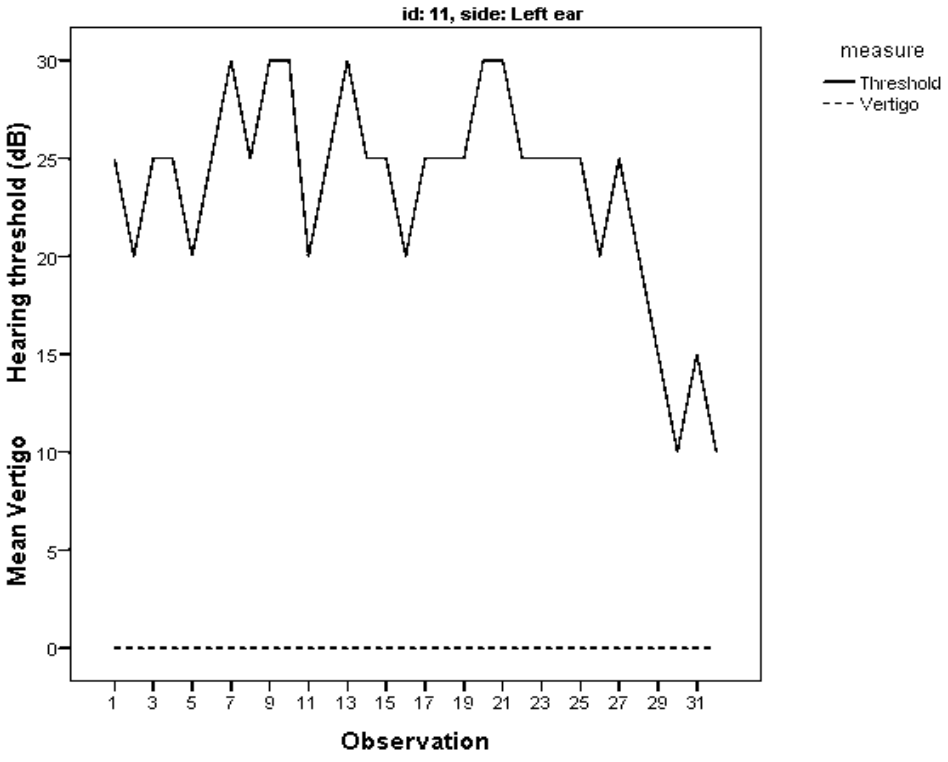


Figure 10. Hearing thresholds measured at 1250Hz

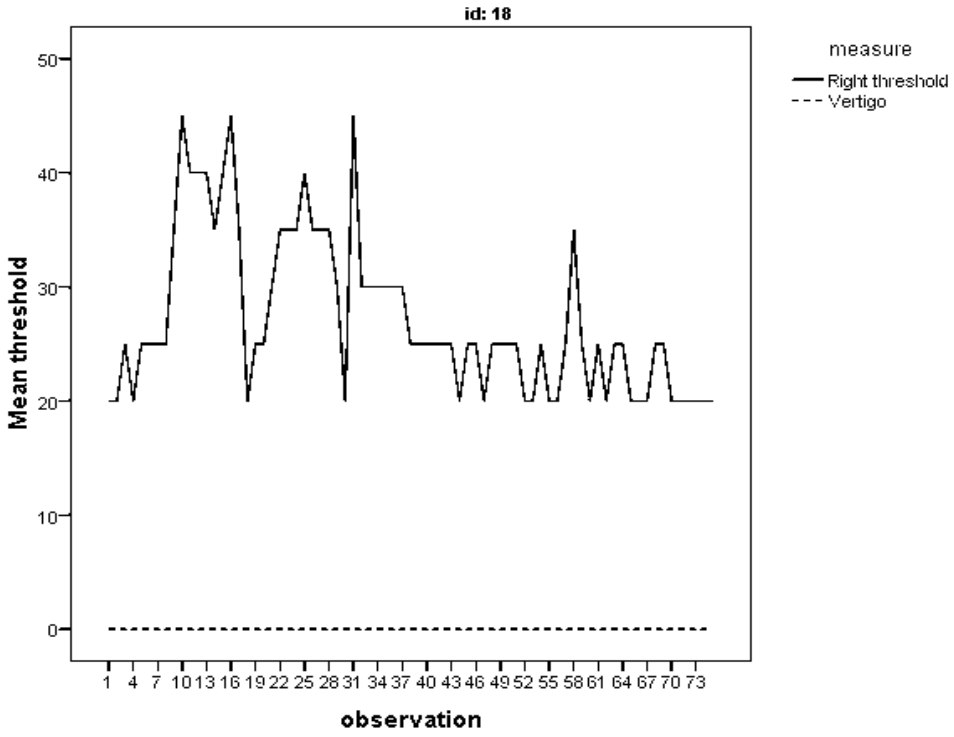


Figure 11. Hearing thresholds measured at 630Hz.

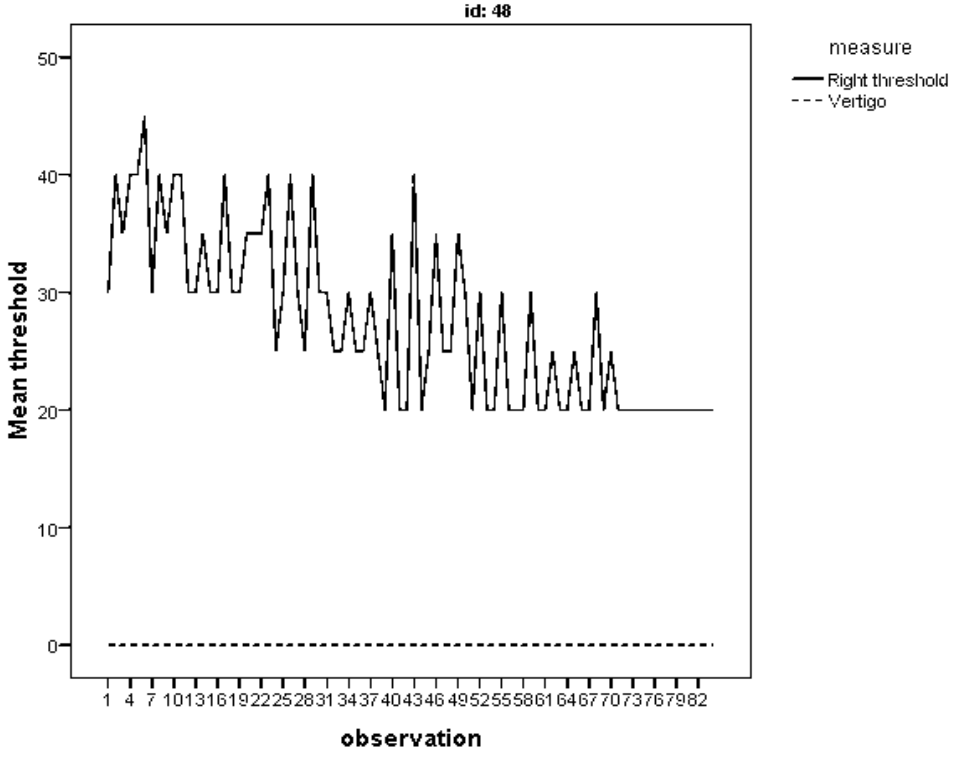


Figure 12. Hearing thresholds measured at 630Hz.

Statistical Analysis

The relationship between vertigo and hearing thresholds over time was further analysed by computing cross-correlations between the two measures for all participants who had at least one vertigo attack. These were calculated separately for each participant and for each ear. First-order difference was used to remove the effects of systematic changes over time in either of the measures on the correlations.

The mean, median, minimum and maximum of the correlations between hearing fluctuations and vertigo attacks, for each right and left ear of all participants who presented with vertigo during the study are shown in table 2. The coefficients varied from negative to positive. Both the mean and median values for the left ear tend to be greater than 0.1, while those for the right ear are closer to zero. In spite of the differences found between right and left ears, these results do not suggest any consistent relationship between vertigo episodes and hearing fluctuation. Nevertheless, this analysis does not necessarily mean that a relationship between vertigo and threshold did not exist for some individuals.

Table 2- Showing mean, median, minimum and maximum of the correlations between hearing fluctuations and vertigo attacks, for each right and left ear

Max threshold variation for ear with vertigo	**Mean**	**Std. Deviation**	**Minimum-Maximum**
Left ear	0.15688	0.195230	-0.65 – 0.562
Right ear	0.05601	0.194736	-0.200 – 0.524

Further statistical analysis was undertaken where data was sampled from the larger data set using the 50 participants to confirm those results. Hearing thresholds obtained during vertigo attacks and at approximately the same times before and after these episodes (using -24, -12 and +12 and +24 hour intervals) were selected and compared to a similar sample of times chosen for the same participant, during the occasions in which no vertigo occurred.

Because intervals between self-testing varied amongst participants, the selection criteria for time was that the observation of the attack had occurred at least within 10% of the designated times of +/-12 to 24 hours. If a participant reported vertigo on a number of consecutive observations, the "before" measurements were those which occurred 24 and 12 hours prior to the first vertigo attack in the sequence and the "after" were those which occurred 12 and 24 post the last attack in the sequence. The data were sampled from those participants who had reported at least one vertigo attack graded 3, 4 or 5.

Control data from the same participants were obtained by randomly selecting a sequence of observations ranging from 1 up to 5 for each of them, when no vertigo had been reported within the 24 hours preceding or following. Randomly selected observations were inspected looking for data meeting the criteria, which were then included in the dataset.

The above selections were carried out separately for right and left ear thresholds although vertigo reports were not identified with any specific ear.

A total of 734 hearing threshold observations for 18 subjects were obtained, 275 related to reports of vertigo and 459 for control events. There were 315 for the right ear and 419 for the left ear. The distribution of the thresholds was approximately normal. Of the 18 subjects, six had experienced at least one episode of vertigo grade 4 and 5, and the rest had reported only grade 3 episodes.

The resulting dataset was analysed with a mixed-model ANOVA as implemented in the SPSS 15 mixed linear model procedure. There were three fixed factors, time (-24, -12, 0, +12, +24), type (vertigo and control), and ear (right and left). Participants were treated as a random factor, so that the correlation of responses by the same subject was taken into account. The mixed model is tolerant of unbalanced data such as these and produces more efficient estimates in such cases than does the conventional ANOVA. The means for the initial analysis based on the full factorial model (time by type by ear) are shown in figure 13. As seen in table 3 none of the interactions were significant.

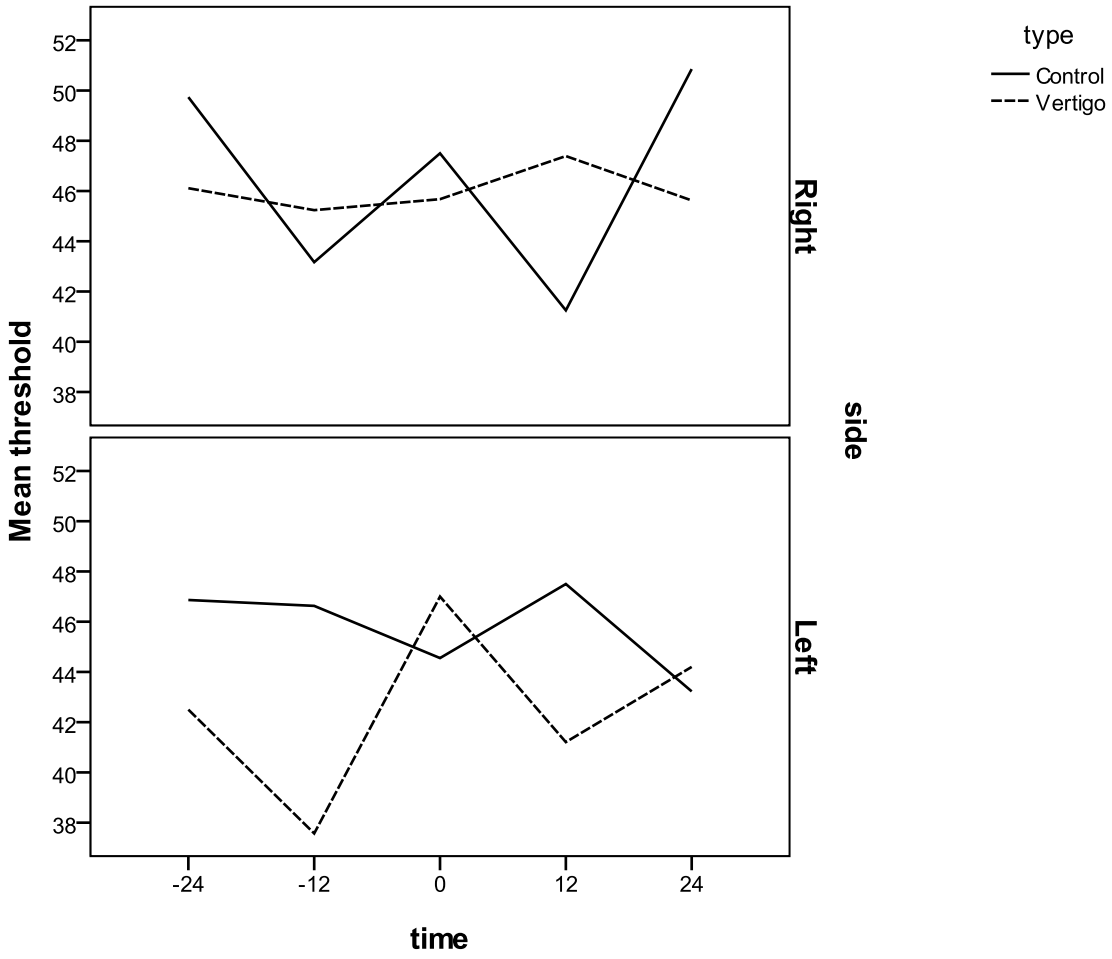


Figure 13

Table 3- Showing interactions by type and side

Interactions	p value
Time by Type	0.473
Time by Side	0.511
Type by Side	0.248
Time by Type by Side	0.617

In order to confirm that the time by type interaction, which was of particular interest, was not significant, it was tested alone with the main effects. The resulting *p*-value was approximately the same as that in table 2.

The effect size of the time by type interaction was assessed using the multilevel analysis method [10]. The variance accounted for was less than 0.01%, indicating that the lack of significance of the effect was due to the absence of any difference in the pattern of hearing thresholds during vertigo and non-vertigo events rather to lack of power due to inadequate sample size.

The intra-class correlation for the full factorial model was 0.73. This indicates that almost three-quarters of the random threshold variation in the sample were due to differences between participants.

Conclusion

Twelve patients with Meniere's disease recorded some degree of hearing fluctuation during the study period of which six experienced vertigo attacks. There was no significant difference in the fluctuation of hearing between those who had a significant attack and those who didn't have any vestibular symptoms at the time of data collection.

In summary, these results suggest that there is no overall relationship between hearing threshold fluctuations and the occurrence of vertigo attacks. According to the above analysis it was concluded that it is not possible to predict a vertigo episode based on the changes in hearing thresholds.

These results indicate that while hearing fluctuation is a characteristic of Meniere's disease it does not always correlate with a vertigo episode.

Acknowledgements

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