# Speech Perception in Ménière Disease

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## Abstract

**Introduction** Ménière disease (MD) affects the inner ear, comprising the cochlea and semicircular canals. Symptoms include severe incapacitating vertigo, nausea, vomit, aural fullness, and sensorineural hearing loss – in which speech discrimination and intelligibility are impaired and can be quantified with speech audiometry.

**Objective** To investigate the influence of the stimuli presentation level in speech audiometry and the quality of life in adults with and without a diagnosis of MD.

**Method** Two groups were formed with nine individuals each – one with and the other without MD. The Speech Recognition Percentage Index was researched with stimuli presented above the self-reported comfort level or 5 dB below the discomfort level. Dizziness Handicap and Tinnitus Handicap Inventories were administered to individuals with tinnitus and vertigo complaints.

**Results** Speech recognition was better in the study group with higher presentation levels, as 75% of the sample improved their performance. The presence of vertigo significantly impacted the quality of life of individuals in the study group.

**Conclusion** Speech recognition improves with higher presentation levels. Also, MD impacts the quality of life, especially regarding limitations caused by vertigo.

**Keywords**
- meniere's disease
- tinnitus
- vertigo
- hearing
- speech discrimination tests

## Introduction

Ménière disease (MD) can be defined as a chronic multifactorial syndrome related to the inner ear, whose symptoms are not ascribed to any specific cause.[1] Individuals with this disease commonly have the symptom triad: hearing loss, vertigo, and tinnitus.

The disease was first described by Prosper Ménière in 1861, indicating that it affected the inner ear, not involving the central nervous system. Also, according to the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology-Head and Neck Surgery,[2] the presence of endolymphatic hydrops can be inferred from the recurring episodes of vertigo, lasting at least 20 minutes. However, endolymphatic hydrops alone does not explain the clinical characteristics (e.g., progressive hearing loss) that are among the main aspects of the syndrome.[3]

Unilateral MD does not exclude the possibility of the patient developing it bilaterally. The first symptom to be reported is usually vertigo, as 41.2% of patients present vertigo first, while in only 15% the initial symptom is hypoacusis[4]. In the initial stages of the disease, hypoacusis is episodic and can be reverted after the crisis. However, as the condition progresses, hypoacusis progressively worsens,

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and hearing loss becomes permanent.[5] The exact etiology of MD is still unclear, and its relationship with common comorbidities remains undefined.

Audiometric assessment is an obligatory procedure for all MD patients, as hearing loss is one of the characteristic symptoms of the disease. In audiological assessment, MD patients usually present impaired hearing in both pure-tone audiometry and speech intelligibility assessment.[6] Despite the assessment guidelines established by the American Speech-Language-Hearing Association,[7] studies indicate that to obtain maximum Word Recognition Score (WRS), stimuli should be presented in a wide range, both above the comfort level and 5 dB below the self-reported discomfort level.[8,9]

Establishing speech recognition scores at different presentation levels is important to audiological clinical practice. The discomfort level self-reported by patients with sensorineural loss does not necessarily indicate better performance in speech recognition tests.

Some questionnaires and studies have been proposed to investigate the impact of MD and its comorbidities on the quality of life of Brazilian populations. These include the Brazilian version of the Dizziness Handicap Inventory (DHI) [10] (which assesses the impact of vertigo) and the Tinnitus Handicap Inventory (THI): Cultural adaptation to Brazilian Portuguese[11] (which assesses the tinnitus-related quality of life).

Tinnitus is defined as sound perception in the absence of sound.[12] It affects about 15% of the world population,[13] and its severity cannot be measured with any objective method[14]; only the perception of discomfort can be described. Since it had been proved that no vibratory mechanical activity takes place in the cochlea or any other external stimuli[15] that might cause tinnitus, Kaltenbach demonstrated in his article that, due to changes in spontaneous neuronal activity, external noise activity is simulated,[16] thus causing tinnitus. Hence, one of the main methods to assess the impact of tinnitus on the patients' quality of life is the Tinnitus Handicap Inventory.

Vertigo is described as the most unpleasant of the other symptoms commonly associated with MD.[17] It can be incapacitating in the patients' usual occupational, social, and home activities, consequently impairing their quality of life.[18] According to the Brazilian Society of Otorhinolaryngology, topographic and etiologic diagnosis is the greatest challenge in patients with vertigo.[19] In this sense, the Brazilian DHI assesses the self-perception of incapacitating effects of dizziness.

Given the above, the present study aimed to investigate the influence of the stimuli presentation level in speech audiometry and to compare the impact of auditory and vestibular symptoms on adults with and without an MD diagnosis.

## Method

Participants diagnosed with MD were recruited. All participants signed an informed consent form.

The inclusion criteria for the study group (SG) were as follows: individuals of both sexes, between 20 and 65 years old, with a medical diagnosis of MD. As for the control group (CG), the selection criteria were individuals without hearing complaints, matched with SG for age and sex, not exposed to noise, chemotherapy, and/or radiotherapy, and not using ototoxic drugs.

The exclusion criteria for the CG were individuals with conductive hearing loss.

The SG comprised nine patients of both sexes, aged 20 to 65 years old, with a medical diagnosis of MD. Three of them were men with unilateral hearing loss, aged 61 to 65 years old, and 6 were women with unilateral or bilateral hearing loss, aged 21 to 60 years old.

For the CG, 9 individuals of both sexes, aged 21 to 65 years old, without hearing complaints, were selected and assessed, matching the SG for sex and age.

All participants were submitted to a thorough basic audiological assessment, including medical history, otoscopy, pure-tone audiometry, speech audiometry, and acoustic immittance measures. They also filled out the two self-assessment questionnaires – Brazilian DHI and THI: cultural adaptation to Brazilian Portuguese.

The medical history was surveyed in the initial interview with a closed-set questionnaire addressing patient identification, medical diagnosis, drugs taken throughout the treatment, drugs currently being taken, hearing complaint, presence of tinnitus and/or vertigo symptoms, previous noise exposure, use of ototoxic drugs, family history of hearing loss, and overall previous health history.

In the subjective hearing assessment, the participants were placed in a sound booth to research air-conduction (AC) hearing thresholds at 1,000, 2,000, 3,000, 4,000, 6,000, 8,000, 500, and 250 Hz – and/or bone-conduction (BC) hearing thresholds, at 500, 1,000, 2,000, 3,000, and 4,000 Hz), when indicated (that is, when AC hearing thresholds were abnormal). Audiometry was performed with an AD-229b (Ad 229 B interacoustics, Middelfart, Dinamarca) audiometer, manufactured by Interacoustics, and TDH-39 (TDH Telephonics, Nova Iorque, Estados Unidos da América) earphones in a sound booth, duly calibrated according to ANSI 3.6 standards (1969).

Air-conduction and BC thresholds were obtained with the descending-ascending technique (Katz, 1999), in which the sound stimulus was presented at an intensity level that the individual easily perceived. After detecting it, the presentation level decreased 10 dB at a time until no response was obtained and then increased back 5 dB at a time until the individual perceived the presence of sound again.

When it was necessary to research BC after obtaining AC thresholds, stimuli were presented through a bone vibrator positioned on the mastoid, while the tested ear was free, and the external acoustic meatus was not occluded.

The lowest sound intensity detected by the patient defined the hearing threshold, which was recorded in the audiogram.

Masking was used when the response obtained in the tested ear could be influenced by the untested ear, according to interaural attenuation definition – that is, AC interaural attenuation of 40 dBHL and BC interaural attenuation of 0 dBHL.

The degrees of hearing loss were classified according to criteria proposed by Lloyd and Kaplan (1978), who defined normal AC hearing thresholds for adults up to 25 dBHL. Audiometric configuration followed the criteria by Silman and Silverman (1997), adapted from Carhart (1945) and Lloyd and Kaplan (1978).

Speech recognition was assessed with the speech recognition threshold (SRT) test and WRS. The SRT was determined as the lowest intensity at which the individual could recognize 50% of the speech stimuli presented.

The WRSI was tested with a list of 25 monosyllable words proposed by Pen and Mangabeira Albernaz (1973), in which each item corresponds to 4% of speech recognition. The list was initially spoken out loud at 40 dBSL, considering the AC 3-frequency mean. When the individual had difficulties recognizing spoken monosyllables (that is, performed below the expected, with $<$ 88% correct answers), a list with 25 disyllabic words was presented to verify whether the patient would benefit from greater acoustic cues. Masking was used when one ear could respond in place of the other, according to a 45-dBHL interaural attenuation.

After determining the WRS, the word list was again presented at a higher level, either at the equipment limit or the highest level the patient tolerated. Lastly, participants were asked to fill out the following self-assessment questionnaires:

1. Brazilian DHI: The questionnaire has 25 questions, of which 7 assess physical aspects, 9 assess emotional aspects, and 9 assess functional aspects. Each question can be answered with "yes", "no", or "sometimes". Each "yes" answer is given 4 points; "sometimes" is given 2 points; "no" is given 0 points. The final score is the sum of the points obtained in each aspect. The maximum score is 100 points (maximum perceived incapacity), and the minimum score is 0 (no perceived deficiency).
2. Brazilian THI: cultural adaptation to Brazilian Portuguese: The questionnaire has 25 questions that assess emotional, functional, and catastrophic aspects regarding the presence of tinnitus and/or vertigo. Each "yes" answer adds 4 points; "sometimes" adds 2 points; "no" adds 0 points. The final sum of the answers indicated mild or nonexistent disadvantage (0 to 16 points), mild disadvantage (18 to 36 points), moderate disadvantage (38 to 56 points), severe disadvantage (58 to 76 points), and catastrophic disadvantage (78 to 100 points).

The researcher read the questionnaires out loud after the medical history survey and otoscopy. The researcher first explained the objective of the questionnaires and then read each question. In the end, she summed the scores and explained the result to the patient. During administration, participants were asked to pay attention to what was read; if they had any questions, the researcher answered by either explaining or rephrasing the questions, so that they could understand and reliably answer them.

The procedures were carried out in single 1-hour individual sessions.

The following tests were used for statistical analysis:

- Student independent samples t-test: Descriptive values and comparative group analysis regarding age and comparative group analysis regarding WRS per ear.
- Student paired samples t-test: Comparative group analysis per condition and condition analysis per group regarding WRS per ear.
- Fisher exact test: Group comparison regarding sex, group comparison regarding the presence of auditory symptoms, and group comparison regarding WRS improvement with higher presentation levels.
- Shapiro-Wilk test: Distribution analysis of WRS data differences between test and retest per group.
- Mann-Whitney U test: Descriptive values and comparative group analysis regarding WRS per ear and descriptive values and comparative group analysis regarding THI and DHI scores.
- Effect size.
- Wilcoxon signed-rank test: Comparative group analysis per condition and condition analysis per group regarding WRS per ear.

Statistical significance was set at 5% ($p \leq 0.05$). IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA) was used. The theoretical basis used for the statistical analysis reported in the present study is described in detail by Field (2017).

The 95% confidence intervals (CIs) were calculated with the bias-corrected and accelerated method based on 1,000 bootstrap samples. Values in brackets in the tables indicate the upper and lower limits of the 95% CIs.

Effect sizes were interpreted with the classification proposed by Cohen (1992).

The following criteria were used for coefficient d:

- Small: between |0.200| and |0.499|.
- Medium: between |0.500| and |0.799|.
- Large: above |0.800|.

For coefficient r, the following criteria were used:

- Small: between |0.100| and |0.299|.
- Medium: between |0.300| and |0.500|.
- Large: above |0.500|.

## Results

The results demonstrated no statistically significant differences between the groups regarding age and sex. In the CG, the mean age was 51 years old; 66.67% were females and 33.33% were males. In the SG, the mean age was 50 years old; 66.67% were females and 33.33% were males. Hence, the groups were similar regarding age and sex, with more women in both groups. Comparison results regarding sex and age between the groups were expected, as the samples were matched in the research (►**Table 1**).

The results in ►**Table 1** demonstrate statistically significant differences between the groups regarding tinnitus,

 

**Table 1** Group comparison regarding the presence of auditory symptoms

| Variable | Categories | Group | | | | | | *p-value* |
|---|---|---|---|---|---|---|---|---|
| | | Control | | Study | | Total | | |
| | | *n* | % | *n* | % | *n* | % | |
| Tinnitus | No | 4 | 44.44 | 0 | 0.00 | 4 | 22.22 | **0.041*** |
| | Yes | 5 | 55.56 | 9 | 100 | 14 | 77.78 | |
| Aural Fullness | No | 9 | 100.00 | 0 | 0.00 | 9 | 50.00 | $<$ **0.001*** |
| | Yes | 0 | 0.00 | 9 | 100 | 9 | 50.00 | |
| Vertigo | No | 8 | 88.89 | 0 | 0.00 | 8 | 44.44 | $<$ **0.001*** |
| | Yes | 1 | 11.11 | 9 | 100 | 10 | 55.56 | |

Fisher's exact test.

aural fullness, and vertigo distribution. In all cases, there was a greater proportion of individuals with these symptoms in SG than in CG. Thus, there was a greater occurrence of tinnitus, aural fullness, and vertigo, which are symptoms characteristic of MD.

Regarding drugs, results show that all SG individuals took betahistine. Also, hearing loss in the SG was mostly unilateral, with no predominance of either ear.

The results in ►**Table 2** demonstrate a difference between CG and SG test and retest mean values in both ears; retest results were better. There was a greater difference in the right ear (RE) standard deviation (SD) between the groups in the test and retest.

The Results in ►**Table 3** demonstrate statistically significant differences regarding test-retest values for RE between the groups and the left ear (LE) in the CG.

**Table 2** Descriptive values regarding WRS per ear, condition, and group, presented as the percentage of correct answers

| Variable | Group | n | Mean | SD | Median | Min. | Max. |
|---|---|---|---|---|---|---|---|
| WRS – RE – Test | CG | 9 | 94.67 [93.78–95.56] | 2.00 | 96.00 [96.00–96.00] | 92.00 | 96.00 |
| | SG | 9 | 79.56 [67.56–89.78] | 16.55 | 88.00 [88.00–88.00] | 48.00 | 92.00 |
| WRS – RE – Retest | CG | 9 | 99.11 [98.22–100] | 1.76 | 100 [100–100] | 96.00 | 100 |
| | SG | 9 | 83.56 [72.08–93.78] | 16.79 | 92.00 [72.00–96.00] | 56.00 | 100 |
| WRS – LE – Test | CG | 9 | 94.67 [92.89–96.44] | 3.46 | 96.00 [96.00–96.00] | 88.00 | 100 |
| | SG | 8 | 91.00 [85.00–95.50] | 7.33 | 92.00 [88.00–96.00] | 76.00 | 100 |
| WRS – LE – Retest | CG | 9 | 98.67 [96.89–100] | 2.83 | 100 [100–100] | 92.00 | 100 |
| | SG | 8 | 92.50 [85.00–99.00] | 10.13 | 96.00 [88.00–100] | 72.00 | 100 |

Abbreviations: CG, control group; LE, left ear; Max., Maximum; Min., Minimum; RE, right ear; SD, standard deviation; SG, study group; WSR, Word Recognition Score.

**Table 3** Distribution analysis of WRS data differences in test and retest per group

| Ear | Group | Group | Test statistics | Shapiro-Wilk *p-value* |
|---|---|---|---|---|
| Right | CG | Test – Retest | 0.390 | $<$ **0.001*** |
| | SG | Test – Retest | 0.753 | **0.009*** |
| Left | CG | Test – Retest | 0.693 | **0.001*** |
| | SG | Test – Retest | 0.866 | 0.139 |

Abbreviations: CG, control group; SG, study group.
*: Statistically significant value at 5% ($p \leq 0.05$).

 

**Table 4** Comparative group analysis per condition and condition analysis per group regarding WRS values per ear

| | Test | | Retest | | CG | | SG | |
|---|---|---|---|---|---|---|---|---|
| | CG x SG | | CG x SG | | Test x Retest | | Test x Retest | |
| | *p-value* | ES | *p-value* | ES | *p-value* | ES | *p-value* | ES |
| WRS – RE | **0.001**$^{*b}$ | 0.780$^{r}$ | **0.012**$^{*b}$ | 0.615$^{r}$ | **0.004**$^{*e}$ | 0.680$^{r}$ | 0.172$^{e}$ | 0.340$^{r}$ |
| WRS – LE | 0.199$^{a}$ | 1.058$^{d}$ | 0.172$^{b}$ | 0.356$^{r}$ | **0.008**$^{*e}$ | 0.640$^{r}$ | 0.549$^{c}$ | 0.170$^{d}$ |

Abbreviations:: CG, control group; ES, effect size; LE, left ear; RE, right ear; SG, study group; WRS, Word Recognition Score.
*: Statistically significant value at 5% ($p \leq 0.05$).
Student independent samples t-test (a), Mann-Whitney U test (b), Student paired samples t-test (c), Wilcoxon signed-rank test (e).

The results in ►**Table 4** demonstrate a statistically significant difference between the groups in both test and retest regarding RE WRS; in both cases, the SG had lower WRS than the CG. No statistically significant differences were found between the groups regarding LE WRS in either test or retest. Thus, the groups were similar regarding LE WRS in both test and retest.

There was a statistically significant difference between the test and retest for the CG; in both cases, RE and LE WRS improved in the retest. No statistically significant differences were found in the SG between the test and retest regarding either RE or LE WRS. Thus, SG WRS in both ears were similar in the test and retest.

The results in ►**Table 5** demonstrate no statistically significant difference between the groups regarding the proportion of individuals with and without WRS improvements with higher presentation levels. Thus, the groups were similar regarding WRS improvements with such higher levels. However, all CG individuals improved their performance with higher presentation levels, in contrast with 75% of the SG who performed likewise.

The results in ►**Table 6** demonstrate a statistically significant difference between the groups regarding DHI scores; SG scored higher than CG. No statistically significant difference was found between the groups regarding THI scores. Thus, the groups had similar THI scores.

## Discussion

Descriptive values and comparison group analysis showed that MD patients were 21 to 65 years old, with a mean age of 50.67 years old, predominantly females (66.67%), similar to studies in the literature.[20]

**Table 5** Group comparison regarding WRS improvement with higher presentation levels

| Variable | Category | | Group | | | | | | *P-value* |
|---|---|---|---|---|---|---|---|---|---|
| | | Control | | Study | | Total | | | |
| | | *n* | % | *n* | % | *n* | % | | |
| WRS improvement with higher presentation levels | Yes | 9 | 100 | 6 | 75.00 | 15 | 88.24 | 0.206 | |
| | No | 0 | 0.00 | 2 | 25.00 | | 2 | | 11.76 |

Fisher exact test.
Abbreviation: WRS, Word Recognition Score.

**Table 6** Descriptive values and comparative group analysis regarding THI and DHI scores

| Variable | Group | *n* | Mean | SD | Median | Min. | Max. | *p-value* | ES |
|---|---|---|---|---|---|---|---|---|---|
| THI (points) | CG | 9 | 1.89 [1.22–2.78] | 1.36 | 1.00 [1.00–2.00] | 1.00 | 5.00 | 0.055 | 0.471 |
| | SG | 9 | 3.22 [2.44–4.00] | 1.39 | 3.00 [2.00–4.00] | 1.00 | 5.00 | | |
| DHI (points) | CG | 9 | 0.67 [0.22–1.11] | 1.41 | 0.00 [0.00–0.00] | 0.00 | 4.00 | $<$ **0.001*** | 0.868 |
| | SG | 9 | 36.00 [21.78–52.89] | 24.49 | 38.00 [12.00–42.00] | 8.00 | 82.00 | | |

Abbreviations: CG, control group; DHI, Dizziness Handicap Inventory; ES, effect size; Max., Maximum; Min., Minimum; SD, standard deviation; SG, study group; THI, Tinnitus Handicap Inventory.
Mann-Whitney U test.
*: Statistically significant value at 5% ($p \leq 0.05$).

 

The symptom triad – tinnitus, aural fullness, and vertigo – are characteristic of MD and have been included in the diagnosis criteria proposed by Lopez-Escamez et al. (2015) and adopted by the Bárány Society. It was observed (►Table 1) that all SG individuals in the present research had all three symptoms. This finding shows the reliability of both the clinical parameters used to define MD and its diagnosis.

Studies indicate that MD initially affects one of the ears, possibly becoming bilateral as it progresses.[21] Data in the present study are similar to what is described in the literature, as 66.66% of individuals in the sample had unilateral sensorineural hearing loss, predominantly in the LE (44.44%).

In individuals with hearing loss, especially sensorineural, presentation levels used in speech tests that coincide with the best performance are highly variable and not always the most comfortable ones reported by patients.[22] Performing the test at the most comfortable sound presentation level to the patient seems to be the most feasible strategy, as this is the means employed in electronic device fitting. On the other hand, studies indicate that, when testing speech recognition in individuals with hearing loss, the highest level must be used, nearing the uncomfortable level, to find the maximum speech recognition performance.[9] Based on this principle, it is recommended that WRS be researched at a presentation level either above the patient's comfort level or 5 dB below the self-reported discomfort level.

The present study verified that the above-mentioned conditions improved in WRSI retest in both right and left ears, in both groups (►Tables 3 and 4). Hence, 75% of MD patients (as well as all CG individuals, who did not have hearing loss) improved the percentage of correct answers with higher presentation levels (►Table 5).

On the other hand, Ullrich et al.[23] conducted a study on 15 individuals with normal thresholds and 10 individuals with sensorineural hearing loss. In the study results, individuals with normal thresholds obtained maximum discrimination as stimuli were presented at maximum comfort levels – unlike those with sensorineural hearing loss, who performed worse at such levels, obtaining a mean maximum discrimination score of 78.8%.

Romero Sánchez et al. (2010)[24] researched 88 patients diagnosed with MD, investigating the impact of tinnitus on their quality of life (QOL). They verified that the presence of tinnitus was an incapacitating factor to the point of affecting the QOL. This was likewise verified in the present study, which confirmed the presence of tinnitus in both groups (►Table 6). Sample Group and CG individuals had similar scores, which agrees with the literature.[25] The mean value obtained from summing the questionnaire scores indicated mild or nonexistent disadvantage in both groups (degree 1).

The same was not true for vertigo. As it was reportedly more incapacitating than tinnitus, the group scores diverged regarding interference with the QOL. Those who self-reported vertigo also reported greater interference with the QOL – the maximum questionnaire score is 100 points, and the mean obtained in the present study was 36 points in the SG and 0.67 in the CG, which corroborates other findings in the literature.[24]

## Conclusion

Speech recognition improves as the stimuli are presented above the patient-reported comfort level or 5 dB below the discomfort level. Moreover, MD impairs different spheres of QOL, especially when vertigo is an important symptom.

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