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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Bimodal stimulation treatment in patients with somatic tinnitus: an experimental study

Nina Alaerts
Bente Claes

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij kinderen

PROMOTOR :
Prof. dr. Sarah MICHIELS

BEGELEIDER :
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RESEARCH CONTEXT

This master's thesis signifies the culmination of our study on 'Bimodal stimulation (BS) treatment in patients with somatic tinnitus (ST): an experimental study.' This experimental study can be classified within the research domain of 'Technology-supported rehabilitation'. It is part of several studies conducted by the Tinnitus department of the Antwerp University Hospital (UZA), in collaboration with their Ear, Nose, and Throat (ENT) department. Professor Sarah Michiels and her doctoral student Sara Demoen are supported by their team in this ongoing research. Efforts are being made to complete ongoing consultations and follow-up appointments. Subsequently, research will be conducted again to evaluate the results of the completed study.

In consultation with Professor Michiels and Demoen S., we have formulated the following research question: ‘Is BS a more effective rehabilitation strategy for patients with ST compared to standard physiotherapy treatment (PT)?’ Therefore, other research questions need to be answered: ‘Does BS and/or PT lead to an improvement in ST symptoms? What happens with the Tinnitus Functional Index (TFI) and Visual Analogue Scale (VAS) results through time?’ This is because tinnitus affects patients worldwide, which is often unknown or poorly understood by many. This experimental study aims to investigate the effect of BS on tinnitus symptoms and compare it with PT for ST.

Throughout this study, we have acquired a wealth of knowledge and skills related to tinnitus pathogenesis and its rehabilitation. It has been a profound learning experience, not only in our academic pursuits but also in personal growth, teamwork, and effective communication, especially during the challenges of a demanding academic year. We would like to express our gratitude to several individuals who played a pivotal role in helping us complete this master's thesis. Our sincere thanks go to our supervisor, Sarah Michiels, and our team members, Antonios Chalimourdas and Sara Demoen. Our involvement in this scientific research group over the past two years has been immensely rewarding. Professor Michiels offered invaluable guidance, providing constructive and beneficial feedback, addressing our inquiries, and continuously motivating us throughout our journey.

TABLE OF CONTENT

1.ABSTRACT

Background: In 20-40% of ST patients (10%-15% of people worldwide), there is an increased electrical activity in the fibers connecting the medullary somatosensory nuclei (MSN) and the dorsal cochlear nucleus (DCN). ST stems from physical factors like muscle contractions or joint disorders in the head and neck, intensifying the perception of ringing or buzzing in the ears.

Objectives: The objective of our study is to normalize this activity which could reduce the perception of tinnitus with the help of BS and investigate whether BS is a more effective rehabilitation strategy than PT.

Participants: Two groups were formed following consultations at the ENT department of the UZA. Patients were included if they had severe ST (TFI>25) and excluded from the study if they suffered from Menière's disease, inner or middle ear disorders, or tumors. The first group had 35 individuals receiving BS and the second had 36 undergoing PT targeting cervical spine or temporomandibular area/orofacial dysfunctions.

Method: Patients in the BS group received combined Transcutaneous Electrical Nerve Stimulation (TENS) and auditory stimulation, for four weeks and 30 minutes each day. Those in the PT group underwent nine weeks of treatment, including weekly sessions and daily home exercises. Primarily, a linear mixed model was used for TFI and a Wilcoxon-Rank Sum Test for VAS.

Results: TFI scores notably dropped over time, showing significant declines in both groups ($p < 0.0001$), this by 8.9 points in the BS group (mean = 41.4 points, SD = 4.3) and 9.4 points in the PT group (mean = 36.8 points, SD = 4.4) at three months follow-up. VAS scores showed significant decreases over time in the PT group for both left ($p = 0.0136$) and right ($p = 0.0224$) ears, whereas in the BS group, only the right ear ($p = 0.0143$) showed a significant decrease.

Conclusion: BS, much like multimodal PT, leads to a reduction in tinnitus severity. However, BS is not a superior treatment for ST.

Keywords: Somatic Tinnitus - Physiotherapy – Bimodal Stimulation – Tinnitus Functional Index

2.INTRODUCTION

Tinnitus is a phantom sensation of sound without effective overt acoustic stimulation (Landgrebe et al., 2012). That is, individuals with tinnitus perceive sound without there being an external sound in the environment. Tinnitus occurs in about 10% to 15% of adults worldwide. In this population, about 1.6% report experiencing it as extremely annoying (Baguley, McFerran, & Hall, 2013). Despite these numbers, we see that there is much variation in prevalence. This is due to the different ways in which tinnitus is defined, the age of diagnosis, and the population being assessed (McCormack, Edmondson-Jones, Somerset, & Hall, 2016). Tinnitus is described as a subjective experience, as only the patient perceives the sound. According to most patients, tinnitus can be described as constant hissing, sizzling, or ringing. In most cases, tinnitus is related to hearing loss or noise trauma. This will cause cochlear abnormalities at the level of the auditory system. Neural changes at the level of the central auditory system will then maintain this tinnitus sensation (Baguley et al., 2013).

The history of ST starts in the early nineties with the possible influence of the somatosensory system on tinnitus symptoms (Hiller, Janca, & Burke, 1997; Pinchoff, Burkard, Salvi, Coad, & Lockwood, 1998). Levine (1999) was the first to describe a hypothesis for this ST, which is a subtype of subjective tinnitus, where we see altered somatosensory information from the cervical spine or temporomandibular area. This change in information can cause or change the patient's tinnitus perception (Michiels et al., 2018). Further research was needed, for which scientists went to work with animal experiments to later apply the information found to new, more innovative studies with human subjects. Connecting fiber existence was established in rats by Zhan et al., (2006). In 2013, Koehler et al. conducted animal experimental studies in guinea pigs, demonstrating that BS, which combines electrical stimulation at the spinal trigeminal nucleus level with auditory stimulation, can suppress the spontaneous "firing rate" of the DCN. Subsequently, this research team revealed in 2018 that the same method, involving simultaneous electrical stimulation at the C2 level or in the jaw region along with auditory stimulation, also yields positive effects on tinnitus loudness and the severity of tinnitus as quantified by the TFI in humans (Michiels et al., 2018).
Upon examining individuals experiencing tinnitus, it is observed that approximately 20-40% exhibit heightened activity in the interconnecting fibers linking the MSN to the DCN. It is

important to note that these percentages are approximations and warrant further investigation for accuracy. The DCN, a crucial auditory nucleus situated in the brainstem, experiences heightened spontaneous firing rates due to increased activity in the connecting fibers from the MSN. This elevated activity contributes to the perception of tinnitus. Consequently, alterations in somatosensory input, originating from either the cervical spine or the temporomandibular region, can induce or modulate the perception of tinnitus, elucidating the intricate relationship between somatosensory input and the manifestation of tinnitus (Michiels et al., 2018). Spencer et al. (2022) conducted a pilot study at the UZA which indicates that this treatment approach holds promise, particularly for patients with ST. Nevertheless, it remains uncertain whether BS therapy outperforms the current best-evidence practice of PT in this specific patient group (Michiels et al., 2018).

Prior research predominantly concentrated on investigating the impact of PT on patients with subjective tinnitus. Michiels et al. (2016) demonstrated favorable effects of cervical interventions, including manipulations, exercises, and trigger point treatments, on the severity of tinnitus. These positive effects were confirmed by Wal et al. (2020) through a follow-up study with a larger number of participating patients.

The study aims to explore the efficacy of combining TENS with auditory stimulation to alleviate ST symptoms. Specifically, it investigates the impact of TENS applied at the C2 level or the jaw region alongside auditory stimulation. Furthermore, the study seeks to compare the effectiveness of this BS approach with the standard PT for ST. If successful, bimodal therapy could potentially serve as a valuable supplement to existing treatments for ST patients.

3.METHOD

3.1 STUDY DESIGN

During this longitudinal clinical trial, patients were followed up for approximately six months to investigate the effect of BS compared to PT in patients with ST. The period in which this study took place was mainly between 2020 and 2024. The Ethics Committee of Antwerp University Hospital and the University of Antwerp verified that this experimental study complied with the standards outlined in the legislation of May 7, 2004, with a favorable assessment received on July 20, 2020. Additional information on this can be found in the appendix.

3.2 PARTICIPANTS

The recruitment process for participants in this study was conducted through the ENT department during specialized tinnitus consultations at the UZA. These consultations specifically targeted individuals who were already identified as having some form of tinnitus within the UZA patient population. This study utilized two participant groups characterized by comparable demographic profiles. Both cohorts encompassed individuals of diverse ages and genders who exhibited symptoms of ST, spanning a spectrum of duration from several years to only a few months.

Following the identification of potential participants, a thorough screening process was employed. This involved the application of both inclusion and exclusion criteria to determine the eligibility of patients for participation in the study.

3.2.1 INCLUSION CRITERIA

For inclusion in the study, patients had to meet the diagnostic criteria for ST as outlined by Michiels et al. (2018). These criteria encompassed specific characteristics associated with ST, including the simultaneous onset of tinnitus alongside neck or jaw pain complaints. Additionally, the criteria acknowledged the exacerbation of both tinnitus and neck/jaw pain symptoms occurring in tandem. Notably, a history of head or neck trauma preceding the onset of tinnitus was considered, suggesting a potential link between traumatic incidents and the development of ST. Furthermore, the criteria took into account the influence of posture on tinnitus intensity, with an emphasis on instances where tinnitus increased during periods of poor postures. The dynamic nature of tinnitus perceptual aspects, such as pitch, loudness, and location, was also highlighted, acknowledging the reported variability in these characteristics by individuals with ST.

In cases of unilateral tinnitus, an additional criterion addressed the limitations of traditional audiograms. Specifically, the criteria noted that audiograms may not have fully captured the unilateral nature of tinnitus, emphasizing the need for a more comprehensive diagnostic approach to adequately assess and understand ST in its various manifestations. Therefore, adherence to these defined criteria ensured a more precise selection of participants whose experiences aligned with the distinctive characteristics associated with ST, contributing to the accuracy and relevance of the study's findings.

Additionally, the tinnitus symptoms had to be sufficiently severe. This meant that the score on the TFI had to be between 25 and 90 points. Otherwise, patients had to be excluded from this study.

3.2.2 EXCLUSION CRITERIA

Patients were excluded if they had one of the following three pathologies. Firstly, patients with tinnitus due to Menière’s disease were excluded. Secondly, patients with other active middle or inner ear disorders, such as conductive hearing loss or pressure and discomfort, were excluded. Lastly, patients with tumor processes were excluded from the study.

3.3 PROCEDURE

3.3.1 ALLOCATION

After patients met the inclusion criteria, they were allocated to one of the two groups based on the timing of the ENT consultation. In this study design, it was noted that both the patients and the physical therapist had knowledge of the treatment that the patients would follow. Therefore, it couldn't be considered a completely blinded study.

3.3.2 TREATMENT POSSIBILITIES

Following the previous process, patients were allocated into two distinct groups: the first group received BS and the second group received PT.

3.3.2.1 BIMODAL STIMULATION

Patients in this group were treated with BS, which is a combination of TENS and auditory stimulation. This TENS treatment could be applied to two different regions, depending on the region with the most complaints. Patients with neck complaints were given the C2-setup. This involved placing self-adhesive electrodes along the processus spinosus of C2 on both the left and right side. This procedure is the same for unilateral and bilateral tinnitus. If jaw complaints at the level of the temporomandibular joint (TMJ) took precedence, a TMJ-setup was chosen. Here, one self-adhesive electrode was placed on the jaw with the most complaints (this could be either the left or right side) and the other electrode was placed on the ipsilateral side of the processus spinosus of C2. When patients experienced unilateral tinnitus with jaw complaints, a TMJ-setup was automatically chosen on the side of the tinnitus. If patients experienced bilateral tinnitus with jaw symptoms, the TMJ-setup was placed on the right side in accordance with the protocol of Marks et al. (2018).

Each patient was given a ‘take-home device’. With this device, patients were able to apply both the TENS and the auditory stimulation to their designated region for four weeks, 30 minutes daily. The TENS was administered using an existing device: the EMPI TENS from Chattanooga, which was approved according to standard EN 60601-1 "Medical electrical equipment, Part 1: General requirements for safety" and also EN 60601-1-2 "Electromagnetic compatibility - medical electrical equipment."

During treatment, each patient used a high-frequency burst TENS. The parameters were set based on the protocol of Marks et al. (2018). That is, at a burst frequency of 150 Hz and a current (mA) that was self-adjusting. This ensured that the current was palpable, but certainly not painful.

The auditory stimulus was a tone burst adapted to the patient's tinnitus frequency. Regardless of whether the patient experienced unilateral or bilateral tinnitus, the auditory stimulus was delivered bilaterally through headphones. Additionally, another broadband noise was provided through the headphones. Broadband noise refers to noise whose sound energy is distributed over a wide section of the audible range. Based on Marks et al. (2018), the timing of auditory and electrical stimulation was chosen. The auditory stimulus was ten ms, followed five ms later by an electrical stimulus.

3.3.2.2 PHYSIOTHERAPY

Patients included in the PT group were treated for nine weeks instead of four weeks. They received treatment once a week by the physical therapist for 30 minutes, in addition to performing daily home exercises.

The content of this PT focused on addressing present dysfunctions, primarily located at the level of the cervical spine or the orofacial region. Rehabilitation took place through manual mobilizations and exercise therapy. The multimodal treatment program included exercises aimed at enhancing the strength, endurance, and coordination of the cervical spine, with a primary focus on deep neck flexors and extensor muscles. Additionally, muscles stabilizing the shoulder were integrated into the rehabilitation. Finally, exercises to improve mobility and posture were incorporated into the rehabilitation program.

3.4 OUTCOME MEASURES

3.4.1 PRIMARY OUTCOME MEASURES

TFI was used as the primary outcome measure. The TFI is a questionnaire designed for individuals with any form of tinnitus. This scale comprises eight subscales, each containing three to four questions per subscale. Each subscale represents a significant domain of the negative impact tinnitus can have, including intrusiveness-unpleasantness-persistence, sense of control, cognitive interference, sleep disturbance, auditory difficulties attributed to tinnitus, relaxation, quality of Life (QOL), and emotional distress. According to the findings by Meikle et al. (2012), a reduction of 13 points was established as an initial criterion indicative of a meaningful decrease in TFI outcome scores. It is noteworthy that a decrease of 13 points on the TFI is recognized as the “minimally clinically difference (MCD)”. This refers to the smallest change in the total TFI score considered clinically relevant. This means that a change of 13 points or more in the TFI score likely represents a noticeable improvement or worsening of tinnitus symptoms for the individual patient. Establishing this threshold helps researchers and clinicians assess treatment effectiveness and the clinical relevance of changes in TFI scores for individual patients.

3.4.2 SECONDARY OUTCOME MEASURES

The secondary outcome measures consisted of different questionnaires. Each questionnaire was briefly discussed. The full version of each questionnaire could be found in the appendix.

Hyperacusis Questionnaire (HQ)

Hyperacusis and tinnitus often share a comorbid relationship, with hyperacusis being a common accompanying condition in individuals experiencing tinnitus. Hyperacusis can arise due to alterations in auditory processing and central nervous system activity that may also precipitate tinnitus. Both conditions can disrupt auditory perception, resulting in heightened sensitivity to sound and significantly impacting individuals' daily functioning. For this reason, HQ was used. HQ consists of fourteen self-rating items. Each item allows respondents to provide their answers on a four-point scale, with the options of 'no' (zero points), 'yes, a little' (one point), 'yes, quite a lot' (two points), and 'yes, a lot' (three points). The HQ determines the presence of hyperacusis-related issues (Khalfa et al., 2002). The total score on the

questionnaire ranges from zero to 42. Scores equal to or exceeding 22 are considered indicative of the presence of hyperacusis (Aazh & Moore, 2017). The questionnaire has been validated in Dutch and has a good internal consistency with a Cronbach's alpha value of 0.85 (Meeus et al., 2010).

Visual Analog Scale Loudness (VAS)

The VAS consists of a straight line with a range from zero to 100. Participants were instructed that the scale is designed to evaluate the loudness level of their tinnitus in the past week. If they perceived their tinnitus as extremely loud, they were to mark the right side of the scale (corresponding to a score of 100). Conversely, if they felt their tinnitus was inaudible (VAS), they were instructed to place a mark on the left side (corresponding to a score of zero). In that way the scale allows a quantitative representation of a subjective measure. The VAS is established as a reliable and valid measure for capturing treatment-induced changes in individuals with chronic tinnitus (Adamchic et al., 2012). The MCD occurs when a person scores 30 points lower than the previous time. This indicates a meaningful difference in tinnitus loudness (Apaza et al., 2021).

Neck Bournemouth Questionnaire (NBQ)

The NBQ measures self-reported pain intensity, limitations in performing work-related and non-work-related activities, depression, and self-control. A high score indicates more pain and limitations in activities. NBQ comprises seven fundamental items, encompassing pain intensity, function in daily activities, function in social activities, anxiety, depression levels, fear avoidance behavior, and locus of control behavior (Bolton & Breen, 1999). Each item is assessed using a numerical rating scale (NRS) that spans from zero to ten. A higher score indicates a more pronounced impact on the patient's life. Additionally, for people with nonspecific neck pain, this self- administered questionnaire has displayed reliability, validity, and responsiveness. (Bolton & Humphreys, 2002). A Chronbach’s α of 0.90 and an ICC of 0.65 was observed for NBQ, thus indicating the reliability of the NBQ as a measurement instrument. With pretreatment correlations ranging from 0.37 to 0.62 and posttreatment correlations ranging from 0.44 to 0.83, the NBQ demonstrates validity by assessing its intended constructs. NBQ exhibited an SRM of 1.17, indicating its strong sensitivity to changes and consequently demonstrating good responsiveness (Bolton & Breen, 1999).

Temporomandibular Disorder Pain Screening (TMD-pain screener)

The TMD-pain screener is a seven-item questionnaire. This tool consists of four questions related to pain and three concerning functions. The first question in the questionnaire is scored on a three-point scale, while the remaining questions are yes-no questions, corresponding to zero or one point. A higher score, with a maximum of seven, corresponds to symptoms more frequently present in the patient (Gonzalez et al., 2011).

Hospital Anxiety and Depression Scale (HADS)

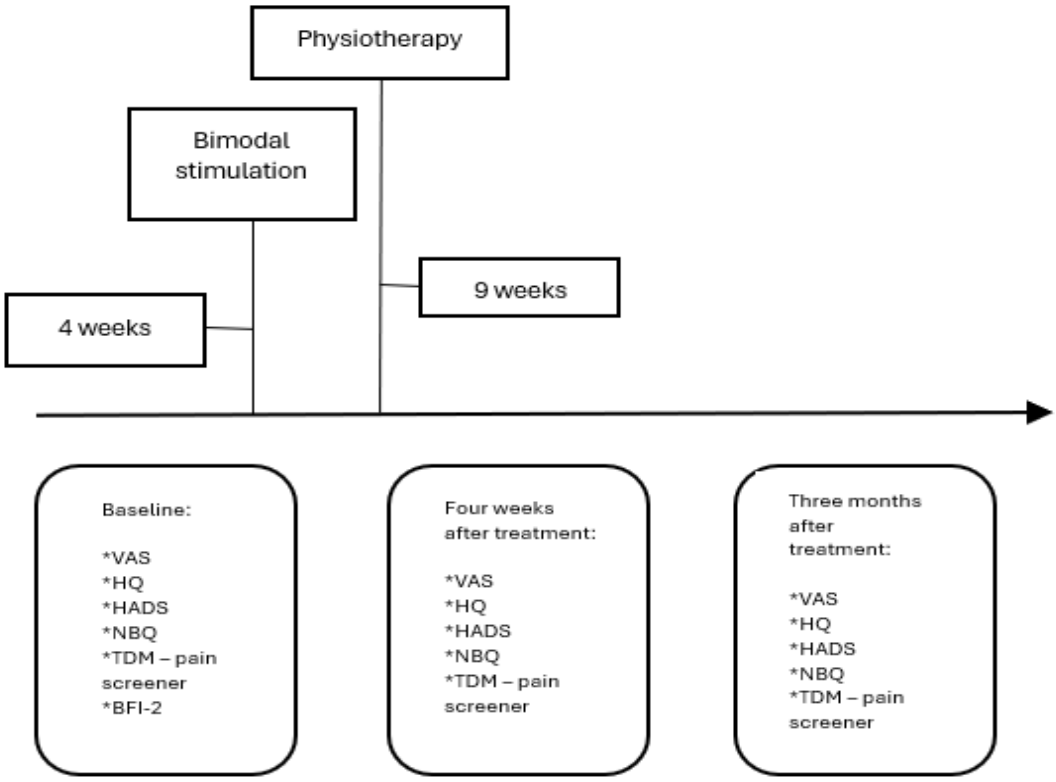
The HADS is a self-administered questionnaire, assessing the core symptoms of anxiety and depression without involving physical symptoms. It comprises 14 items, where each item offers four response possibilities. The HADS consists of a depression and anxiety subscale with each seven items. Indications of either depression and/or anxiety can be demonstrated when individuals exhibit a minimum score of eight out of 21 on one or both subscales (Wilkinson & Barczak, 1988).

The Big Five Inventory - 2 (BFI-2)

The BFI-2 is a concise questionnaire that uses succinct statements to assess the Big Five personality dimensions (Negative emotionality, Open-mindedness, Extraversion, Agreeableness, Conscientiousness) and the 15 facet scales. The good psychometric properties of the English BFI–2 are recreated in the Dutch adaptation of the BFI-2. The BFI-2 will only be completed during the baseline measurement (Denissen et al., 2020).

All of the secondary outcome measures, except the BFI-2, will be administered and completed at three measurement points. First during baseline measurement, then four weeks after the last treatment and finally three months after the last treatment as seen in **Figure 1**.

Figure 1: *Flowchart procedure of the study*



3.5 STATISTICAL ANALYSIS

JMP, statistical software (JMP Pro 17), was used for statistical analysis of the data. Given that the aim of our study was to assess whether BS yielded potential amelioration in tinnitus severity compared with the conventional physiotherapeutic intervention.

A linear mixed model analysis was used as it best suited the study design for the TFI scores, which involved the subjects undergoing either BS treatment or PT treatment with each subject undergoing three measurements: at baseline, one month follow-up, and three month follow-up. Next, the MCD for the TFI scores, defined as a decrease of 13 or more points, was examined.

To assess the difference in VAS scores, a non-parametric test was applied, due to the lack of confirmed normality in this test. The difference score of VAS was examined, namely baseline measurement minus the measurement at three month follow-up, and the decline within and between groups was assessed. Therefore, a Wilcoxon-Rank Sum Test was used. Similarly, for the VAS score, the MCD was investigated, representing a decrease of 30 or more points.

4.RESULTS

4.1 CHARACTERISTICS OF THE PARTICIPANTS

The BS group consisted of 36 participants, including ten women and 26 men. One participant withdrew from the study due to excessive stress caused by participating in the study and using the BS equipment. Within this group, six participants experienced tinnitus primarily on the right side, four participants on the left side, and 26 participants bilaterally. Participants in the BS group had been experiencing tinnitus for an average of 7.25 years, ranging from three months to 21 years. The mean age of the participants in this group was 52.4 years, with the youngest participant aged 25 years and the oldest aged 71 years.

The PT group consisted of a total of 35 participants. In the cohort of individuals undergoing PT, it was observed that three participants reported experiencing tinnitus exclusively on the right side, whereas nine participants reported experiencing it solely on the left side. Additionally, 22 participants reported experiencing tinnitus bilaterally. The analysis indicated that the mean tinnitus duration within this cohort was 6.625 years, with a range spanning from a minimum of two months to a maximum of 18 years. The average age of the group was 42 years, with a minimum of 21 years and a maximum of 66 years.

The examination of gender distribution shows that there are 24 male participants and 36 female participants. ***Table 1*** provides a description of the participants with respect to group, age, sex, side and duration of tinnitus.

The data was analyzed using JMP statistical software (JMP Pro 17). The significance level was consistently set at $p = 0.05$. Chi square test was used to determine differences between dichotomous variables, after assessing the assumptions. The results indicated that there is no statistically significant difference in the number of women across the therapy types X^2 (1, N = 70) = 3.644, $p = 0.0563$.

Furthermore, a chi-square test was performed to evaluate the difference in the distribution of tinnitus (unilateral vs. bilateral) between the groups. The results were not statistically significant, χ^2 (1, N = 70) = 0.458, $p = 0.4984$.

For the continuous data (tinnitus duration and mean age), a different test was required. The nonparametric Wilcoxon test was used for non-normally distributed data and independent samples t-tests for normally distributed data. First, the normality of the data was investigated using a Shapiro–Wilk test. Homoscedasticity was evaluated using the Brown-Forsythe test, and the assumption of independence was met. For tinnitus duration and age, the assumption of normality was not met. The Shapiro-Wilk test yielded a p-value of *0.0249** for mean age and *<0.001** for tinnitus duration. Both results are significant, indicating that we must reject the null hypothesis of normality for these data distributions. Therefore, a Wilcoxon rank-sum test was chosen. For tinnitus mean age the result was significant with a p-value of *0.0052* for a two-sided test. This significant p-value indicates that there is a statistically significant difference in age between the two groups. For tinnitus duration, the test results showed no significant effect, with a p-value of *0.1271*. Therefore, there is no statistically significant difference in tinnitus duration between the two groups.

Table 1: *Summary of characteristics*

	BIMODAL STIMULATION	**PHYSIOTHERAPY**	**SIGNIFICANCE**
PARTICIPANTS	36	35	/
WOMEN	10	23	P = 0.0563
MEN	26	12	P = 0.0563
TINNITUS DISTRIBUTION	UNILATERAL: 10 BILATERAL: 26	UNILATERAL: 12 BILATERAL: 22	P = 0.4984
TINNITUS DURATION (YEARS)	7.25	6.625	P = 0.1271
MEAN AGE (YEARS) / RANGE (YEARS)	52.4 (25-71)	42 (21-66)	*P = 0.0052**

*Note: * P < 0.05*

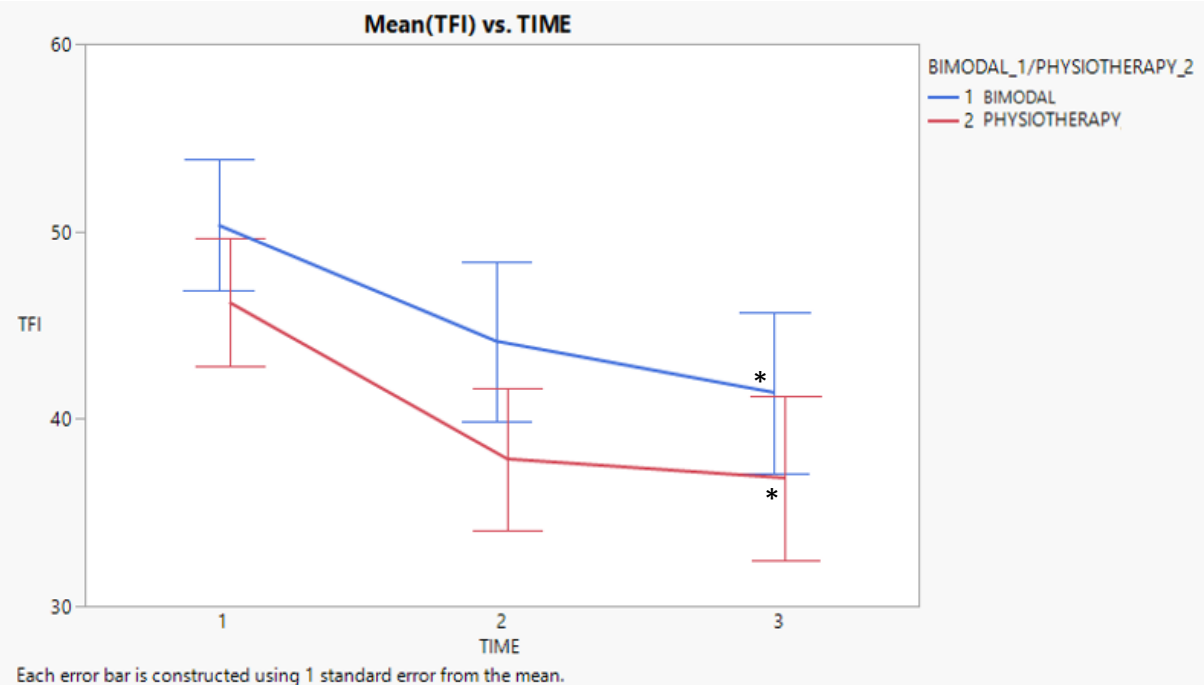
4.2 TFI

After analysis of the linear mixed model a statistically significant decrease in the total TFI score was observed ($p < 0.0001$), this by 8.9 points in the BS group (mean = 41.4 points, SD = 4.3) and 9.4 points in the PT group (mean = 36.8 points, SD = 4.4) at three months follow-up compared to baseline (mean BS = 50.3 points, SD BS = 3.5, mean PT = 46.2 , SD PT = 3.4)**.** From baseline to one month follow-up (mean BS = 44.1 points, SD BS = 4.3, mean PT = 37.9, SD PT = 4.4) the BS group had a decrease of 6.2 points and the PT group a decrease of 8.3 points as seen in **Figure 2**. This means there was no statistically significant reduction in the total TFI score ($p > 0.05$) from baseline to one month follow-up. Although some patients had not yet had their three month follow-up appointment, it was observed that the total TFI scores dropped by an average of 8.9 points in the BS group and 9.4 points in the PT group compared to the time before the treatment. Based on the model's results, it can be concluded that patients at the follow-up visit had significantly lower complaints about their tinnitus severity compared to before receiving the treatment. This indicates a positive outcome for the BS group as well as for the PT group. After using backwards model building no significant difference was observed after examining the interaction between group and time ($p = 0.8528$). Eliminating this interaction term allows it to focus solely on the main effects. The parameter 'group' was not significant ($p = 0.3145$) and was therefore also eliminated. No significant difference in score reduction between the groups was found. This resulted in only the significant parameter 'time' remaining ($p < 0.0001$) as previously mentioned.

The MCD was measured in three different ways. Looking at the PT group, twelve out of 35 participants achieved the MCD from baseline to one month follow-up. This with an average decrease of 10.3 points throughout the whole group. From baseline to three month follow-up, 16 out of the 35 participants achieve their MCD. Ten of them already achieved the MCD at one month follow-up but decreased even further at the three month follow-up meeting. The average decrease in the whole PT group was 14.5 points. From one month follow-up to three month follow-up only six people achieved their MCD, with an average decrease of 4.2 points in the whole group. Only one participant decreased significantly in the three different moments.

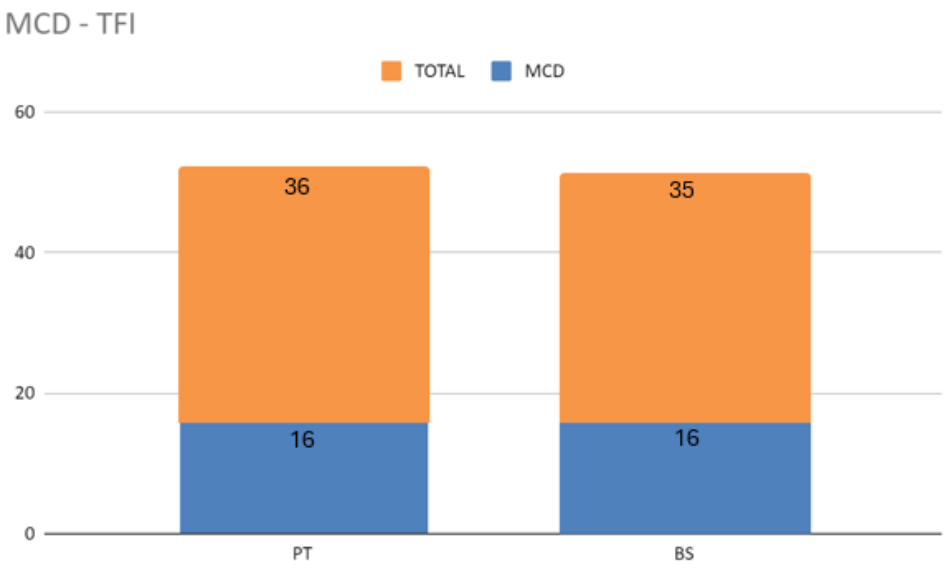
Compared to the PT group, twelve out of 36 participants from the BS group achieved their MCD. With an average decrease in the whole group of 11.1 points. Eight of these participants showed a further decrease by the three month follow-up. In total 16 out of 36 participants achieved their MCD from baseline to three month follow-up, with an average score of 18.1 throughout the whole group. From one month follow-up to three month follow-up only eight participants achieved their MCD, with an average of 7.0 points throughout the whole group. This information is summarized in **Figure 3**. The MCD is based on the study by Meikle et al. (2012).

Figure 2: *The temporal progression of TFI scores in both the BS and PT group*



*Note: 1 is baseline meeting, 2 is one month follow-up, 3 is three months follow-up, * P < 0.05*

Figure 3: *Number of individuals in both groups who achieve the MCD of the TFI from baseline to three month follow-up*



4.3 VAS

After conducting the non-parametric test (Wilcoxon-Rank Sum Test), a significant difference for both the left (*p = 0.0136*) and right (*p = 0.0224*) ears in the PT group was observed. In the group undergoing BS, a significance for the right ear (*p = 0.0143*), but not for the left ear (*p = 0.0511*) was found. Despite only seeing a significant decrease for the right ear, we see that the decrease for the left ear is only slightly above the *0.05* limit. This therefore concludes that overall decreases are present in the participants' VAS scores in both groups. Thus, this significant improvement means that participants achieved a lower score at their three month follow-up and therefore experienced less loudness from their tinnitus.

Figure 4 shows the results of the mean VAS score of the left ear. In the PT group, 15 out of 35 participants reached the MCD. In the BS group, it was a little less, with only 13 out of 36 participants reaching the MCD. In this BS group, an average decrease of 14.5/100 points for the left ear was measured. For the PT group, this average decrease amounts to 13.6/100 points. This decrease occurs between baseline measurement and three months of follow-up.

Figure 5 shows the results of the right ear, where ten participants of the PT group and ten participants of the BS group reached the MCD. The mean decrease for the BS group is 10.2/100, and for the PT group it is 8.3/100. Again, this was measured between baseline and the three month follow-up.

Figure 4: *Number of individuals in both groups who achieve the MCD of the VAS for the left ear*

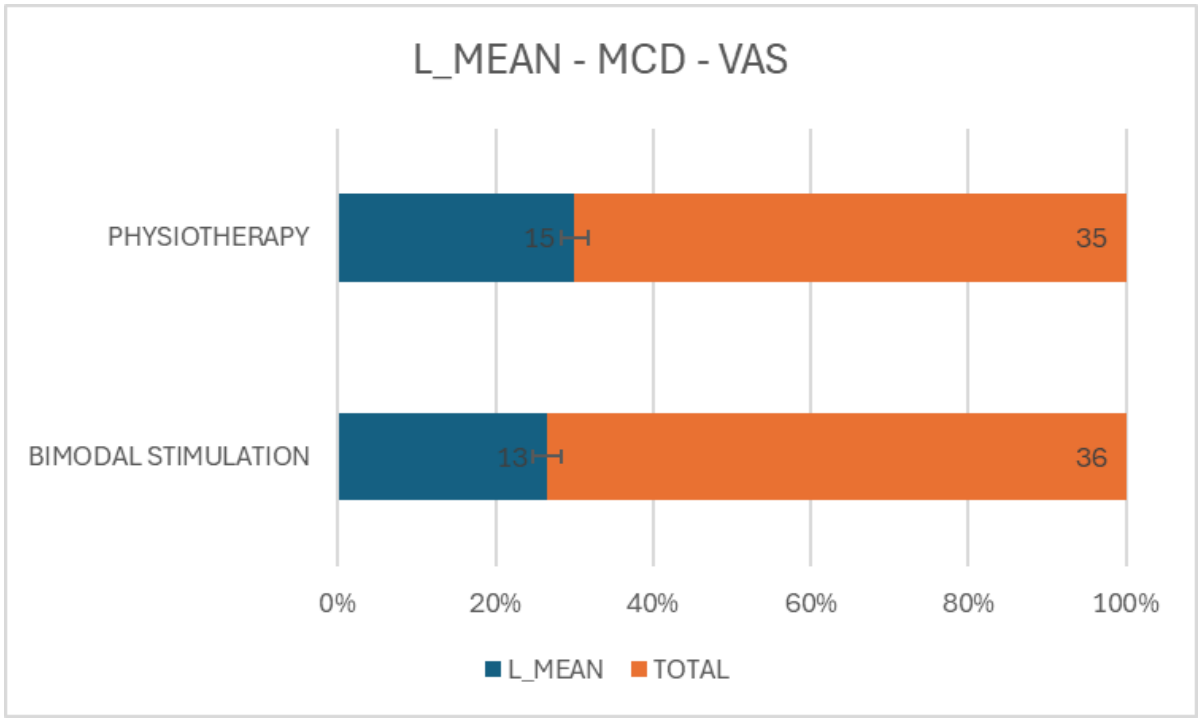
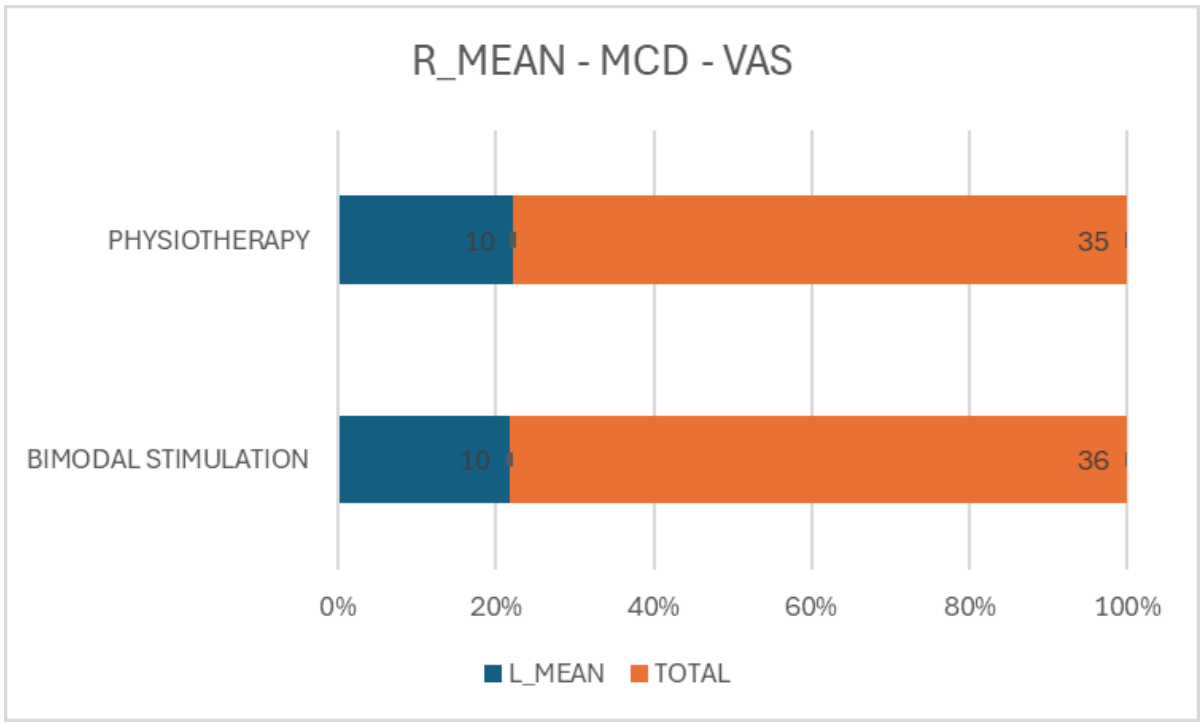


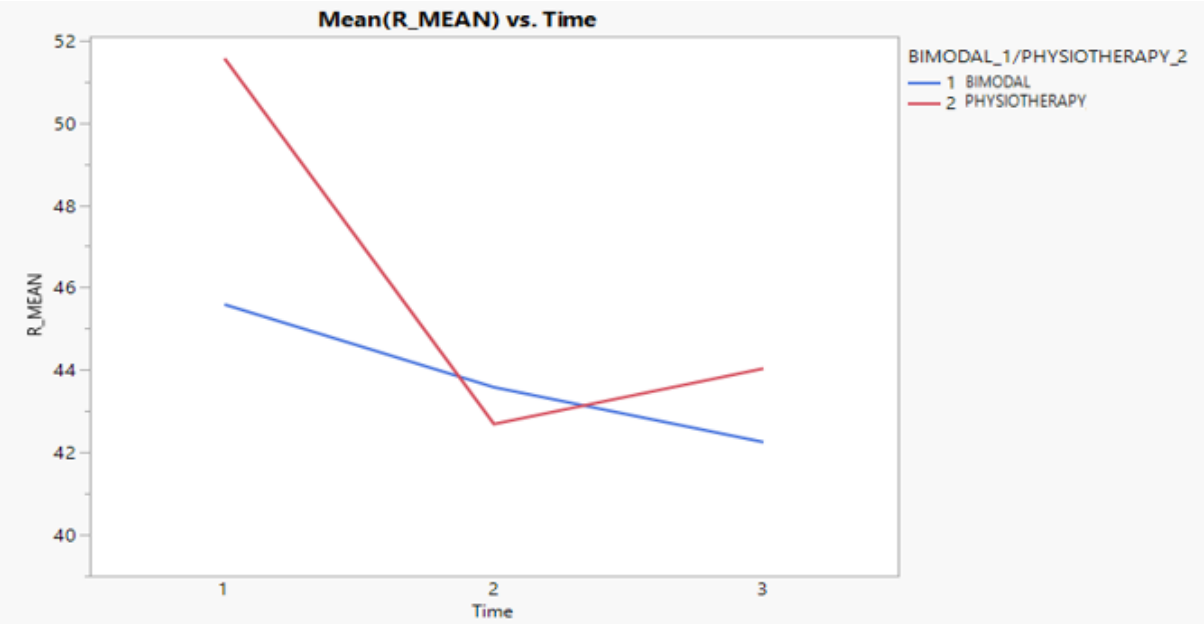
Figure 5: *Number of individuals in both groups who achieve the MCD of the VAS for the right ear*



After examining the data, it was clear that VAS scores typically decreased from the baseline assessment to the one month follow-up and continued to decline by the three month follow-up. This trend was validated through statistical plotting, wherein the time variable was plotted on the x-axis and the variable related to the VAS score was plotted on the y-axis. The four different parameters were individually examined and can be found in the figures below.

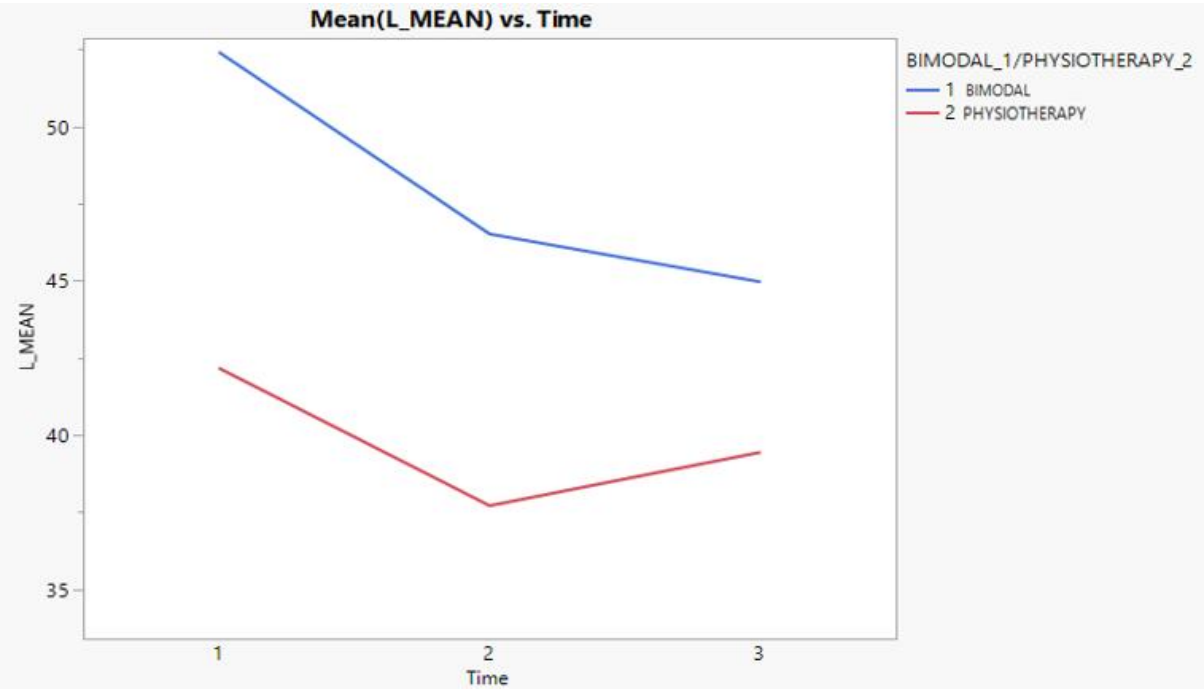
In **Figure 6**, the mean VAS score for the right ear was seen, which decreased over time in the PT group. Statistically, there was no significant decrease, but overall the score dropped from baseline to one and three month follow-up. For the BS group, a small decrease was seen, but only from baseline to one month follow-up. In **Figure 7**, the mean VAS score of the left ear was seen. There was a smaller decrease in score from baseline to one month follow-up in comparison to the right ear, in both the BS group and the PT group. Comparing the right and left ear, it was seen that the mean VAS in both groups was between 40 and 50 out of 100.

Figure 6: *Mean VAS right ear VS time*



Note: 1 is baseline meeting, 2 is one month follow-up, 3 is three months follow-up.

Figure 7: *Mean VAS left ear VS time*



Note: 1 is baseline meeting, 2 is one month follow-up, 3 is three months follow-up.

4.4 SECONDARY OUTCOME MEASURES

In this section, we discuss the different secondary outcome measures for the BS group, because the information is not yet available for the PT group. Starting with the BFI-2, in which the BS group scored highest on 'Agreeableness', 'Conscientiousness' and 'Open Mindedness'. Since they score highest on these categories, their personality is most compatible with these characteristics. In the category 'Emotional Volatility', they score the lowest, thus corresponding to the least compatible trait for their character.

Looking at the HADS, the group scored an average of 6.3 at baseline and 6.0 at three month follow-up on the depression subscale, corresponding to category 0-7 'no depression'. On the anxiety subscale, they score an average of 7.9 at baseline and 7.25 at three month follow-up, concretely, this means they belong to category 8-10 'possible anxiety disorder'.

At HQ, the BS group scores an average of 18/42 points at baseline and 17.6/42 points at three month follow-up. This value is below the cut-off value of 22, showing no significant indication of the presence of hyperacusis.

The average score on the NBQ is 23.5/70 at baseline and 20.3/70 at three month follow-up, a higher score indicates a more pronounced impact on the patient's life.

Lastly, the average score on the TMD-pain screener is 1.7/7 at baseline and 1.75/7 at three month follow-up.

An increase between the two measurement moments is visible, but this cannot be generalized as there are several patients who have not yet had their third measurement moment. As a result, several measurements are missing and therefore the mean is differently calculated. To conclude, it can be said that there are no major changes in the results of the secondary outcome measures for the BS group. Small decreases are present, but these do not indicate large differences in outcome.

4.5 MISSING DATA

Within the BS group, ten participants had not fully completed the study. Of the 36 participants, eight underwent only two measurement moments of the TFI, while two participants had only one measurement moment. The reasons for these incomplete measurement moments ranged from delays due to time constraints to problems with the BS equipment or skipping follow-up appointments after one month initiated by the patient himself. Regarding the VAS-score, nine participants had only two measurement moments instead of three, while three participants had only one measurement moment. Again, the reasons for this were postponement due to time constraints or skipping follow-up appointments after one or three months.

5.DISCUSSION

As previously mentioned, this study aimed to introduce a novel element by incorporating auditive stimulation alongside TENS to alleviate ST symptoms. Specifically, it explored the impact of TENS applied at the C2 level or the jaw region with auditory stimulation (Spencer et al., 2022). This approach sought to assess the efficacy of BS and compare its effectiveness with the standard PT for ST. This innovative approach could significantly enhance the therapeutic options available for ST patients, offering a promising strategy for improved symptom management.

In our study, patients were allocated based on the timing of their ENT consultation. Our analysis of patient characteristics found a significant difference in the mean age between the groups *(p= 0.0052)*. This difference may be due to the availability of patients of different ages during various times of the year. Additionally, patients in the BS group had a longer tinnitus duration, which could explain why they were older on average. The gender distribution approached significance *(p= 0.0563*). Because detecting a significant difference is more challenging with a small sample size, as seen in our study, it remains important to explore potential reasons why the result is nearly significant. This could be due to the timing of consultations which might vary based on gender-related factors (work schedules...). For upcoming studies, we strongly recommend ensuring that both genders are equally represented in each therapy group, as responses to these treatments may vary depending on gender.

Upon examining the TFI scores over time, a significant decrease was observed. Baseline scores were generally higher than those at the three month follow-up, reflecting a positive outcome. This finding was consistent with results from a previous study (Michiels et al., 2018). No significant difference was observed between the two groups. Similarly, no significant interaction effect between group and time was observed. This meant that the change in TFI-scores over time was similar between the BS group and PT group. Van der Wal et al. (2020) also examined the effect of PT on ST, where a significant decrease in TFI scores over time was observed. In this study 41% of the patients achieved their MCD right after completing the treatment, 61% of the patients achieved their MCD after follow-up. These results are a lot

higher than in this study. The improvement, seen later on instead of directly after treatment, might have been because the brain changes slowly over time, a process called neuroplasticity. Research by Markovitz et al. (2015) and Sathappan et al. (2019) confirmed this. After several treatment sessions that used two methods of stimulation, TENS and auditory stimulation, the brain adapted, and this effect built up over time.

Remarkably, among the participants in the PT group, 16 out of 35 individuals experienced a 13-point reduction on the TFI. In the BS group, this reduction was also observed in 16 out of 36 individuals. The decrease was measured between baseline and three month follow-up. This method - BS for ST - was previously used in other studies (Shim et al., 2015; Marks et al., 2018; Conlon et al., 2020; Spencer et al., 2022). It is therefore intended to compare the results of this study with those of the previously mentioned studies. However, there is much disagreement within the literature surrounding the MCD of the TFI.

Following the completion of the non-parametric test, specifically the Wilcoxon-Rank Sum Test, noteworthy findings emerged. In the PT group, a substantial difference for VAS score was noted for both the left and right ears. This suggested that the intervention had a discernible impact on both ears, with statistical significance indicating the validity of these observations. So, the VAS could be used as a measurement tool for the loudness of tinnitus, as confirmed earlier in Dode et al. (2021). In the PT group, 15 individuals achieved the MCD for the left ear, and ten individuals for the right ear. In the bimodal group, the numbers were slightly lower, with 13 individuals reaching the MCD for the left ear and again ten individuals for the right ear. A reduction in VAS score is associated with less suffering from the loudness of the tinnitus. Since it is looked at per ear in each group, it is necessary to make some observations here. First, it is seen that the right ear has a significant decrease in VAS score in both groups, this can be explained by the large number of bilateral tinnitus patients and a majority with unilateral tinnitus on the right side compared to the left. When a particular side is more prevalent in the population, it is more likely to improve then when a side is less prevalent and therefore it is more likely to be significant. Second, missing data should also be considered, for example, when data is completed, more individuals may achieve their MCD by scoring less on their VAS at three month follow-up compared to one month follow-up. Third, it is important to look at VAS scores at the individual level. It is person-dependent on

how much one experiences tinnitus. To then compare these results in group gives little additional information since these differences were also already present at baseline. It is therefore important in further research to look primarily at the individual differences in VAS scores at the three measurement times. Lastly, the aspect of neuroplasticity must be taken into account. When movements, exercises, rehabilitation goals… are performed repeatedly, neuroplasticity can occur in the central part of the brain. In this way, these previous mentioned exercises can be performed more easily due to frequent practice. BS is a combination of two strategies which can ensure that neuroplasticity is quickly present in the brain due to the cumulative effect of these two strategies compared to the single strategy PT.

A major strength of this study is the standardized approach in the field survey. For the parameter settings, we followed the same approach used in previous studies (Conlon et al., 2020; Marks et al., 2018; Spencer et al., 2022) employing shorter delays (five and ten ms) because these delays seemed to induce long-term depression more effectively and thereby achieve greater reductions in tinnitus. The same questionnaires, given by the same researchers, were used throughout. Auditory tests were administered by a group of audiologists, who consistently adhered to a standardized protocol throughout the testing process. This made the likelihood of measurement or procedural errors relatively low. However, this is also accompanied by a drawback of the study, namely that it is not a fully blinded study. Both patients and researchers are aware of the group assignments.

Another drawback of this study is that the results cannot be generalized to a broader population. This limitation arises from the study's precise inclusion and exclusion criteria, leading to a fairly homogeneous study population. As in the study by Marks et al. (2018), it is therefore not possible to generalize based on the results of this study, which is in contrast to the study by Spencer et al. (2022) as they used a very general study population. Specifically, our study focuses solely on patients with ST, meaning the findings do not apply to other forms of tinnitus, such as neurological or subjective tinnitus. Additionally, the results may not be transferable to patients with different demographic characteristics, such as age, gender, or underlying health conditions, which differ from those in this study.

Consequently, the narrow focus limits the study's conclusions' broader applicability and external validity. This limitation is also present in the study by Marks et al. (2018). This study

included only subjects with unilateral tinnitus with pure tone, which can be modulated by somatic maneuvers. This makes the study very specific, complicating the recruitment of a large population of subjects and resulting in an extended period to identify patients who meet these inclusion criteria.

Furthermore, the number of clinically relevant improvers in our study was limited. As cited earlier, this can be explained by the large amount of missing data at the three month follow-up. But also, studies like Meikle et al. (2012) confirm a drop of 13 points or more, however new studies such as Skarzynski et al. (2018) and Fackrell et al. (2022) report a drop of 8.8 and 14 points, respectively, as the MCD. Another cause can be found in the many secondary outcome measures, while only the TFI and VAS were used for this study. As a result, patients were maybe careless in completing the questionnaires or simply did not complete them attentively. This again can be a cause for a higher drop-out rate.

The final limitation of the study was that no post hoc tests were conducted for the demographic factors of the groups. Since demographic factors may affect our results, it would be interesting if this could be included in further research. For instance, the influence of age, gender, duration of tinnitus… could be looked at. Furthermore, it is quite interesting to include future consideration of various secondary outcome measures. These were only released for the BS group, making comparison between the two groups impossible. However, again, it is important to do further research on this. For example, personality, degree of hyperacusis... by themselves can have a positive or negative influence on tinnitus symptoms like loudness and severity. Without investigating this impact, it also seems less relevant to us to have this large number of questionnaires completed at the three measurement times.

Additional research is advisable, given the small sample sizes of the groups in this study. Thus, further investigation was warranted to enhance the reliability of findings by doing research in bigger groups; this could be in the same study design with the same methodology.

In further research, we recommend performing a specific power calculation to determine a precise sample size. The power of a statistical test is the probability of detecting a true effect if one exists. Power is usually set at 0.8 (or 80%), which means there is an 80% chance of detecting a real effect. Our power analysis was not conducted with JMP Pro 17, but in R using

the *simr* package. The model was fitted using the data from the completed study. Under these conditions, a total of 550 patients (275 per group) is required to achieve the predetermined power of 80%.

For clinical practice, it was important to consider that although no differences were observed between the groups after our data analysis, we could observe that more patients from the BS achieved the MCD compared to the PT group. This indicates that these patients seem to experience more clinical benefits than those in the PT group. Additional research could also be conducted on the user-friendliness and costs associated with implementing this technology in clinical practice.

Despite these positive results, it is still important to point out that physical therapy itself also has positive effects. Therefore, it is important to ask whether this effect is based purely on intervention or if time itself has an influence. Additionally, it is essential to determine whether these effects manifest exclusively after four weeks in the BS group or if these effects might be observable at an earlier stage. For PT, it has been previously investigated and confirmed whether the effects occur before the indicated nine weeks (Michiels et al., 2016). This further research could be investigated using a control group. This would involve having one group receive no intervention, allowing for comparison of the timing of results between the PT and BS groups against the control group. If the control group gets an improvement in results, this could mean that time also has an effect on tinnitus symptoms. If not, we would then examine when the BS and PT groups show significant improvements in their results, thereby determining whether the changes are attributable to the type of intervention. An important note is that this type of research is not ethical for the control group. This is because you are giving a part of the study population no intervention, even though it is scientifically proven by Michiels et al., (2016) that this intervention benefits these subjects. If you do work with a control group that initially receives no intervention, a solution would be that they will receive physiotherapy treatment after the study concludes to ensure they also benefit from improvements in their tinnitus symptoms.

Beyond that, a non-inferiority study can also be set up to examine the effect of BS on the severity of tinnitus symptoms. This non-inferiority study could demonstrate that BS is as effective as the existing PT treatment, while being easier to apply in the home setting. In doing

so, it is important to perform the power calculation again and use a different statistical model. This again must take into account the ethical aspect, as mentioned above.

Another factor to consider is the type of intervention. The BS group's intervention spans four weeks, with one session per day, whereas the physiotherapy intervention extends over nine weeks. The PT group only receives an intervention with the physiotherapist once a week but is required to perform daily home exercises. Here, the compliance aspect is hugely important. In this study, there is no control over the compliance of both groups. There is no control over whether the participants of the PT group do their home exercises daily and whether the participants of the BS group use the Audio TENS device daily. This may affect the results within an intervention group and the results between intervention groups. Further research may well take this into account or incorporate an additional outcome measure that investigates this. As an example, we would work with an app, which always carefully keeps track of all questionnaires with corresponding answers. This would also make it possible to check when patients miss follow-up appointments or when certain information/questionnaires have not been completed. In addition, the app can also be activated when exercises or BS are performed at home so that the physical therapist can always check later.

6.CONCLUSION

The study was designed to assess the efficacy of BS and PT in treating ST, focusing on primary and secondary outcome measures. The results indicated a statistically significant decrease in the total TFI scores in the BS and PT groups after three months of follow-up, with no significant difference between the groups. This suggests that both interventions effectively reduce tinnitus symptoms over time, aligning with previous research.

Despite the positive outcomes, the analysis did not find significant differences between the two groups regarding TFI score reduction, indicating that the efficacy of BS is comparable to that of PT. Furthermore, no significant interaction effect between the treatment group and time was observed, suggesting that the improvement in TFI scores was consistent across both groups.

The secondary outcome measures, particularly the VAS for tinnitus loudness, also showed significant improvements. The results from the Wilcoxon-Rank Sum Test indicated a notable reduction in VAS scores for both the left and right ears in the PT group and the right ear in the BS group, highlighting the potential of these interventions to reduce the perceived loudness of tinnitus.

However, the study had several limitations: the lack of a fully blinded design, the use of a homogeneous study population, and the absence of post hoc tests for demographic factors limit the generalizability of the findings. Additionally, missing data at the three month follow-up and the reliance on self-reported outcomes may have affected the reliability of the results.

The study also raises important considerations for future research. The impact of demographic factors, the role of neuroplasticity, and participants' compliance with the intervention protocols warrant further investigation. Moreover, the ethical implications of using a control group without intervention in future studies must be carefully considered.

While the BS intervention shows promise in clinical practice, it is crucial to recognize that PT also yields positive outcomes. The study's findings suggest that both interventions can benefit patients with ST, but additional research is needed to further validate these results, particularly in larger and more diverse populations.

In conclusion, this study contributes to the growing body of evidence supporting the use of BS and PT in treating ST. This approach could serve as an effective treatment for certain individuals with tinnitus who met our inclusion criteria. Although both interventions demonstrated efficacy, the study emphasizes the need for continued research to refine treatment approaches and improve patient outcomes with tinnitus.

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8.APPENDIX

1. Ethics Committee of Antwerp University Hospital and the University of Antwerp
2. VAS
3. HQ
4. TMD-pain screener
5. TFI
6. BNQ
7. HADS
8. BFI-2

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Bimodal stimulation versus physiotherapy treatment fwg @**afients *with* somafic** *tinnitus*

Belgisch Registratienummer: B3002020000145

datum	ons kenmerk	contactpersoon
20/07/2020	**20/27/367**	Secretariaat Ethisch Comité ethisch.comite@uza.be

DEFINITIEF GUNSTIG ADVIES

Geachte Collega,

Het Ethisch Comité van het Universitair Ziekenhuis Antwerpen en de Universiteit Antwerpen bevestigt dat bovenvermelde studie voldoet aan de criteria gesteld in de wet van 7 mei 2004 en geeft een gunstig advies dd. 20/07/2020.

De volgende bijlagen werden volgens de ICH-GCP richtlijnen door het Ethisch Comité goedgekeurd:

- Informatie- en toestemmingsformulier NL aangepaste versie dd. 16/07/2020
  versie 2.0

Protocol aangepaste versie dd. 16/07/2020
v2.0 + track changes

Vragenlijst(en)
bfi2 Nederlands
HADS nederlands
Hyperacusisvragenlijst nederlands
NBQ
Tinnitus functionerings index nederlands
TMD-Pain screener nederlands

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Universiteit Antwerpen

20/07/2020

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Secretariaat Ethisch Comité
ethisch.comite@uza.be

Deze goedkeuring is geldig tot een jaar na bovenvermelde datum. Wij verzoeken u ons te melden wanneer de eerste deelnemer werd gei"ncludeerd, wanneer en waarom de studie (vroegtijdig) werd stopgezet of nooit werd opgestart.
Indien de studie nog loopt na een jaar verwachten we een follow-up rapport waarin eventuele voorvallen worden gemeld.
Tot slot wijzen we er op dat voor in het UZA lopende studies de ernstige ongewenste voorvallen dienen gerapporteerd via het incidentenmeldingssysteem.

Met vriendelijke gr4eten,

Prof. dr.
Voorzitter Eth'isch 'Comité

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20/0'7/2020 20/27/367

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Samenstelling Ethisch Comité sinds 1/05/2020.
Deze studie werd besproken op vergadering van 20/07/2020.

	Functie	M/V	Aanwezig
Voorzitter			
MICHIELSEN Peter	Voorzitter/Gastro-enteroloog	M	+
Ondervoorzitter			
CRAS Patrick	Ondervoorzitter/Neuroloog	M	+
IEVEN Greet	Ondervoorzitter/Klinisch Bioloog	V	
Leden EC UZA			
BLAUMEISER Bettina	Medisch geneticus	v	
DE BAETSELIER Elyne	Verpleegkundige	v	
FIERENS Lina	Verpleegkundige	F	
HENS Kristien	Ethicus	V	
KWAKKEL-VAN ERP Hanneke	Pneum oloog	v	+
MICHIELS Barbara	Huisarts	V	
PAELINCK Bernard	Cardiochirurg	M	
SCHOETERS Veerle	Verpleegkundige	F	
VAN DE WIELE Miranda	Patiëntenbegeleiding	v	
VAN DEN BRANDE Jan	Oncoloog	M	
VAN DEN EEDE Filip	Psychiater	M	
VAN DYCK Pieter	Radioloog	M	
VAN PRAAG Dominique	Psychologe	F	
VANSWEEVELT Thierry	Jurist	M	+
VERLOOP Joris	Pediater	M	+
WYERS Griet	Apotheker	F	
Toegevoegde leden UA			
8ORTIER Hilde	Arts, emerita hoogleraar UA	V	+
DE MEESTER Ingrid	Farmacotoog / Onderzoeker UA	V	
GRANAAS Kristina	Medewerkster Dep. Onderzoek	V	
Uitgenodigde Experten			
IDES Kris	Kinesitherapeut	M	
LUYTEN Leon	Arts in het beheer van gezondheidsgegevens	M	
NIICHIELSENS Inge	Jurist	V	
MOONS Pieter	Coördinator bio- en weefselbank	M	
VAN DE WILDEBERGH Daphné	Jurist	F	
VAN HONSTE Guy	Patiëntenvertegenwoordiger	M	+

The Ethics Committee states that no individual member of the Ethics Committee who may have an affiliation with the study or sponsor, has voted in
the deliberations for this trial.
The Ethics Committee states that it is organised and operates according to the ICH/GCP guidelines, the applicable laws and regulations, and their own written operating procedures.

Visual Analogue Scale (VAS)
Hayes & Patterson, 1921

Naam:	Geb. dat.:
Datum van afname:	

Wij willen u verzoeken dadelijk één vraag te beantwoorden waarmee we uw pijnintensiteit willen meten.

Plaats een verticale streep op de lijn die het best de ernst van uw pijn weergeeft.

Hoe hevig was uw pijn gemiddeld de afgelopen week (7 dagen)?

Geen enkele pijn (0 mm) _____ **Meest voorstelbare pijn (100 mm)**

Hoe hevig was uw pijn op de slechtste momenten in de afgelopen week (7 dagen)?

Geen enkele pijn (0 mm) _____ **Meest voorstelbare pijn (100 mm)**

Toevoeging: Bij de scoring moet de VAS-lijn 10 cm lang zijn. De therapeut leest de score van de patiënt af met een liniaal.

Hyperacusis Intake Questionnaire

Patient Name: _____ Date: _____

Some people report that many sounds are too loud for them: however. these same sounds do not appear too loud to others. This is called hyperacusis.

	For questions that ask you to rate on a scule from 0 to 100, *0 —– strongly disof‹ree* and t00 = *strongly agree.*		
1.	Sounds that others believe are moderately loud are too loud to me.		_____(0—100)
2.	Which ear(s} seems to be affected by the hyperacusis? (circle une)		Left Right Both
3.	I-low long have you had hyperacusis?		_____months OR _____years
4.	What do you think originally caused your hyperacusis? (Please choose only ONE answer)		
	a. Accident b. Aging c. Infection/virus d. Hearing loss (long term) e. Hearing loss (sudden) f. Medications	g. Méniére's Disease h. Noise exposure—continuous i. Noise exposure—impulsive j. Surgery k. I don't know 1. Olher _____	
S.	Has it gotten worse, better, or stayed the same since it firsl started'' (circle one)		Same Better Worse
6.	Which of the following scunds or events are of\en too loud for you?		
	a. Baby crying/children squealing b. Crowds/large gatherings c. Dishes being stacked d. Dog barking e. High pilch voices/screaming f. Lawnmower g. Music (loud rock concerts) h. Music (religious servlce) i. Music (symphony, quartet. etc.)	j. Power tools k. Restaurants I. Sporting events m. Telephone ringing n. TV/radio o. Vacuum cleaner p. Whistle/horn/siren q. Other _____	

7.	Which of the following sounds or events are those that you arc •aaoyed by?		
	a. Baby crying/children squealing b. Crowds/large gatherings c. Dishes being stackcd d. Dog barking c. High pitch voices/screaming f. Lawnmower g. Music (loud rock concerts) h. Music (mligious scrvicc) i. Music (symphony, quartet, etc.)	j. Power tools L. Restaurants l. Sporting cvcnts m. Telephonc ringing n. TV/radio o. Vacuum cleaner p. Whistle/from/siren q. Other _____	
8.	Wkich of the following sounds or cvents are thosc that you would Year atteodiog or heiag acound because of your reaction to those sounds?		
	a. Baby crying/children squealing b. Crowds/large gatherings c. Dishes being stackcd d. Dog barking e. High pitch voices/scrcaming f. Lawnmower g. Music (loud rock concerts) h. Music (religious service) i. Music (symphony, quartet, etc.)	j. Power tools k. Restaurants l. Sporting cvcnts m. Telephone ringing n. TV/radio o. Vacuum cleancr p. Whistle/from/simn q. Other _____	
9.	How oRen do you experience headaches?		_____#/month
IO.	Rate the severity of these headaches from 0 to 100.		_____(0-100)
11.	How oRen do you experience balance problems?		_____#/month
12.	Rate the severity of your balance problems from 0 to 100.		_____(0—100)
13.	How oftea do bright lights bother you?		_____#/month
14.	Rate thc scveriry of how bothersome bright lights are from 0 to 100.		_____(0—100)
15.	How often do you cxpcricncc smell problems?		_____#/month
!6.	Rate the severity of these smell problems from 0 to 100.		_____t 100)

17.	Are you bothered by strong smells? If yes, please check those below that bother you.		Ycs No
	a. Bleaches, ammonia, cleaning solvents b. Car exhaust c. Cigarcne smoke d. Coffee e. Farm odors	f. Paini g. Perfume h. Pesticides/insecticides i. Spices j. Oher _____	
18.	Am you bothered by certain tastes? If ycs, please circle those below that bother you.		Yes No
	a. Cheese b. Coconut **c. Peppers** d. Salty foods	e. Sour foods (e.g., vinegar) **f. Spices** g. **Sweet foods** h. Other _____	
I9.	Are you bothered by touch?		Yœ No
20.	What makes your hyperacusis worse		
	a. Being in complete silence b. Dog barking c. Changes in pressure & humidity d. Lack of sleep, fatigue e. Large crowds f. Lawnmowcr/snow blower	g. Loud voices h. Medications i. Sharp noises j. Stress/tension k. TV/radio 1. Whistlefhorn/siren _____	
21.	What makcs your **hyporacusis** better'		
	a. Being aJone or with New others b. Being in a quiet environment c. Bting mlaxtd d. Getting a good nighi's sleep e. Low constant sounds (fan, car) f. Medications g. Reading	h. Removing self from noise i. Soft music/TV j. Stress reduction exercises k. Wvmüngeæp)ugJearmufFs l. Wcaring noise gcnerators m. When 1 wake up in the morning n. Othcr _____	

22.	In which ear do you wear hearing aids?	a. Left b. Right c. Both d. None
23.	Do you suffer from tinnitus?	a. Yes b. No

TMD-PAIN SCREENER

DATUM: NAAM:

1. Hoe lang duurde de pijn in uw kaak- of slaapregio in de laatste 30 dagen?
   a. Geen pijn
   b. Pijn komt en gaat
   c. Pijn is altijd aanwezig

2. Heeft u in de laatste 30 dagen pijn of stijfheid gehad in uw kaak bij het ontwaken?
   a. Nee
   b. Ja

3. Hebben in de laatste 30 dagen volgende activiteiten een invloed gehad op uw pijn (dit wil zeggen verergeren of verminderen van de pijn)?

   a. Kauwen van hard of taai voedsel
      i. Nee
      ii. Ja

   b. Uw mond openen of uw kaak zijwaarts of voorwaarts bewegen
      i. Nee
      ii. Ja

   c. Kaakbewegingen zoals: de tanden samen houden, klemmen, knarsen of kauwgom kauwen
      i. Nee
      ii. Ja

   d. Andere kaakbewegingen zoals: praten, kussen of geeuwen
      i. Nee
      ii. Ja

TINNITUS FUNCTIONAL INDEX

Today's Date _____ Your Name _____
Month / Day / Year Please Print

Please read each question below carefully. To answer a question, select ONE of the numbers that is listed for that question, and draw a CIRCLE around it like this: 10% or 1

I Over the PAST WEEK...

1. What percentage of your time awake were you consciously AWARE OF your tinnitus?

Never aware ► 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◄ Always aware

2. How STRONG or LOUD was your tinnitus?

Not at all strong or loud ►0 1 2 3 4 5 6 7 8 9 10 ◄ Extremely strong or loud

3. What percentage of your time awake were you ANNOYED by your tinnitus?

None of the time ► 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◄ All of the time

SC Over the PAST WEEK...

4. Did you feel IN CONTROL in regard to your tinnitus?

Very much in control ►0 1 2 3 4 5 6 7 8 9 10 ◄ Never in control

5. How easy was it for you to COPE with your tinnitus?

Very easy to cope ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Impossible to cope

6. How easy was it for you to IGNORE your tinnitus?

Very easy to ignore ►0 1 2 3 4 5 6 7 8 9 10 ◄ Impossible to ignore

C Over the PAST WEEK, how much did your tinnitus interfere with...

7. Your ability to CONCENTRATE?

Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

8. Your ability to THINK CLEARLY?

Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

9. Your ability to FOCUS ATTENTION on other things besides your tinnitus?

Did not interfere ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Completely interfered

SL Over the PAST WEEK...

10. How often did your tinnitus make it difficult to FALL ASLEEP or STAY ASLEEP?

Never had difficulty ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Always had difficulty

11. How often did your tinnitus cause you difficulty in getting AS MUCH SLEEP as you needed?

Never had difficulty ► 0 1 2 3 4 5 6 7 8 9 10 ◄ Always had difficulty

12. How much of the time did your tinnitus keep you from SLEEPING as DEEPLY or as PEACEFULLY as you would have liked?

None of the time ► 0 1 2 3 4 5 6 7 8 9 10 ◄ All of the time

Please read each question below carefully. To answer a question, select ONE of the numbers that is listed for that question, and draw a CIRCLE around it like this: 10% or (1).

A Over the PAST WEEK, how much has your tinnitus interfered with...	Did not interfere										Completely interfered
13. Your ability to HEAR CLEARLY?	0	1	2	3	4	5	6	7	8	9	10
14. Your ability to UNDERSTAND PEOPLE who are talking?	0	1	2	3	4	5	6	7	8	9	10
15. Your ability to FOLLOW CONVERSATIONS in a group or at meetings?	0	1	2	3	4	5	6	7	8	9	10

R Over the PAST WEEK, how much has your tinnitus interfered with...	Did not interfere										Completely interfered
16. Your QUIET RESTING ACTIVITIES?	0	1	2	3	4	5	6	7	8	9	10
17. Your ability to RELAX?	0	1	2	3	4	5	6	7	8	9	10
18. Your ability to enjoy “PEACE AND QUIET”?	0	1	2	3	4	5	6	7	8	9	10

Q Over the PAST WEEK, how much has your tinnitus interfered with...	Did not interfere										Completely interfered
19. Your enjoyment of SOCIAL ACTIVITIES?	0	1	2	3	4	5	6	7	8	9	10
20. Your ENJOYMENT OF LIFE?	0	1	2	3	4	5	6	7	8	9	10
21. Your RELATIONSHIPS with family, friends and other people?	0	1	2	3	4	5	6	7	8	9	10

22. How often did your tinnitus cause you to have difficulty performing your WORK OR OTHER TASKS, such as home maintenance, school work, or caring for children or others?

Never had difficulty	0	1	2	3	4	5	6	7	8	9	10	Always had difficulty

E Over the PAST WEEK...

23. How ANXIOUS or WORRIED has your tinnitus made you feel?

Not at all anxious or worried	0	1	2	3	4	5	6	7	8	9	10	Extremely anxious or worried

24. How BOTHERED or UPSET have you been because of your tinnitus?

Not at all bothered or upset	0	1	2	3	4	5	6	7	8	9	10	Extremely bothered or upset

25. How DEPRESSED were you because of your tinnitus?

Not at all depressed	0	1	2	3	4	5	6	7	8	9	10	Extremely depressed

INSTRUCTIONS FOR SCORING THE TINNITUS FUNCTIONAL INDEX (TFI)

1. PREPARATION FOR SCORING:

A. **Two items to be transformed:** Items #1 and #3 require a simple transformation from a percentage scale to a 0-10 scale, achieved by dividing the values circled by the respondent by 10. The examiner should write the transformed value in the margin beside the relevant item, preferably using ink of a different color than that used by the respondent.

B. **Ambiguous items:** Because respondents differ in regard to how clearly they circle or mark their answers on the 0-10 scale for each item, the examiner should review every item to resolve any ambiguities. It is helpful if examiners note their decision about each answer in the margin beside the given item, using the differently-colored ink. Some commonly-occurring ambiguities and how to handle them are as follows:

(1) **More than one value marked on the 0-10 scale for a given item**—Typically done by respondents whose tinnitus undergoes large variations over time. The clinic or the examiner should settle on a consistent procedure for all such responses, such as (a) averaging the multiple values indicated for a given item, or (b) marking the item "cannot code", thus removing that item from consideration in the overall TFI score. (The latter choice reduces the information available for calculating the respondent's overall score, and may be desirable only in extremely variable cases where the respondent's reliability is questionable.)

(2) **Respondent marks a value between the 0-10 values on the item scale**— Again, the clinic or the examiner should settle on a consistent procedure for handling all such ambiguous responses in the same way, such as (a) noting a value of 3.5 in the margin, for a respondent who marked the scale between 3 and 4, or (b) collapsing the intermediate value either to the right (to 4) or to the left (to 3).

(3) **Respondent does not make any response to a given item**—The clinic or examiner should decide beforehand how they will indicate missing values, and that notation (e.g. "NA" for "No Answer") should be entered in the margin. If the data will be entered into a computer database, a standard missing value such as "99" can be entered in the margin beside the relevant item. Of course, care must be taken to exclude "99" values if the examiner performs a manual calculation of the overall TFI score.

C. **Unambiguous items:** To facilitate rapid scanning and summing of all valid answers to obtain the respondent's overall TFI score, all of the unambiguous values indicated by the respondent should also be noted in the margin, each such value beside its corresponding item. The examiner can then quickly generate a valid score for the overall TFI.

2. CALCULATION OF OVERALL TFI SCORE:

(1) Sum all valid answers from both TFI pages (maximum possible score = 250 if the respondent were to rate all 25 TFI items at the maximum value of 10).
(2) Divide by the number of questions for which that respondent provided valid answers (yields the respondent's mean item score for all items having valid answers).
(3) Multiply by 10 (provides that respondent's overall TFI score within 0-100 range).

CAUTION—Overall TFI score is **not valid** if respondent **omits 7 or more** items. To be valid as a measure of tinnitus severity, the respondent must answer **at least 19 items** (76% of items).

3. CALCULATION OF SUBSCALE SCORES

The 8 subscales address 8 important domains of negative tinnitus impact as indicated below. Each subscale has a brief title (in capital letters) and a 1- or 2-letter abbreviation (e.g. I for Intrusive , SC for Sense of Control):

SUBSCALE NAME (and conceptual content)	ITEMS IN SUBSCALE
I: INTRUSIVE (unpleasantness, intrusiveness, persistence)	#1, #2, #3
SC: SENSE OF CONTROL (reduced sense of control)	#4, #5, #6
C: COGNITIVE (cognitive interference)	#7, #8, #9
SL: SLEEP (sleep disturbance)	#10, #11, #12
A: AUDITORY (auditory difficulties attributed to tinnitus)	#13, #14, #15
R: RELAXATION (interference with relaxation)	#16, #17, #18
Q: QUALITY OF LIFE (QOL) (quality of life reduced)	#19, #20, #21, #22
E: EMOTIONAL (emotional distress)	#23, #24, #25

Each of the 8 subscales consists of 3 items except for the Quality of life subscale, which consists of 4 items (SEE ITEMS LIST ABOVE). For valid subscale scores, no more than 1 item should be omitted. Computation of subscale scores is as follows:

1) Sum all of that respondent's valid answers for a given subscale.

2) Divide by the number of valid answers that were provided by that respondent for that subscale.

3) Multiply by 10. For the respondent in question, this procedure generates a subscale score in the range 0-100 for each valid subscale.

CAUTION—Do not attempt to compute a respondent's overall TFI score by combining that respondent's valid subscale scores, as the valid subscales may encompass a total number of items that is different from the number of items accepted as valid for the overall TFI score.

Bournemouth Neck Questionnaire

J.Bolton.

Geautoriseerde vertaling: M.A.Schmitt

Omcirkel svp. bij elke vraag één cijfer. Kies het cijfer dat het beste bij u past.

1. Hoeveel nekpijn had u, gemiddeld genomen, in de afgelopen week?											
Geen pijn	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Ondraaglijke pijn

2. In welke mate bent u in de afgelopen week door nekpijn gehinderd in uw normale dagelijkse activiteiten van het dagelijkse leven (huishouden, persoonlijke verzorging, aankleden, tillen, lezen, autorijden)?											
Geen hinder	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Niet in staat activiteiten uit te voeren

3. In welke mate bent u in de afgelopen week door nekpijn gehinderd in uw vrije tijd, bij sociale en gezinsactiviteiten?											
Geen hinder	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Niet in staat activiteiten uit te voeren

4. Hoe gespannen (onrustig, nerveus, angstig, prikkelbaar, moeite met concentreren/ontspannen) bent u in de afgelopen week geweest?											
Niet gespannen	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Zeer gespannen

5. Hoe depressief (somber, neerslachtig, in de put, ongelukkig) bent u in de afgelopen week geweest?											
Niet depressief	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Zeer depressief

6. In welke mate heeft uw werk in de afgelopen week (binnen- en buitenshuis) invloed gehad op uw nekpijn?											
Heeft geen invloed gehad	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Heeft erg veel invloed gehad

7. In welke mate bent u in staat geweest zelf uw nekpijn te beïnvloeden (verminderen/verbeteren) in de afgelopen week?											
Volledig beïnvloedbaar	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Helemaal niet beïnvloedbaar

Hospital Anxiety and Depression Scale

Wij willen graag weten hoe u zich de laatste tijd heeft gevoeld. Wilt u bij elke vraag het cijfer voor het antwoord dat het meest op u van toepassing is omcirkelen? Denk erom, het gaat bij deze vragen om hoe u zich de laatste tijd (in het bijzonder de afgelopen 4 weken) voelde, dus niet om hoe u zich in het verleden heeft gevoeld. Denk niet te lang na, uw eerste reactie is waarschijnlijk de meest nauwkeurige.

1. Ik voel me de laatste tijd gespannen	3 – meestal 2 – vaak 1 – af en toe, soms 0 – helemaal niet
2. Ik geniet nog steeds van de dingen waar ik vroeger van genoot.	0 – zeker zo veel 1 – wat minder 2 – duidelijk minder 3 – nauwelijks nog
3. Ik krijg de laatste tijd het angstige gevoel alsof er elk moment iets vreselijks zal gebeuren	3 – heel zeker en vrij erg 2 – ja, maar niet zo erg 1 – een beetje, maar ik maak me er geen zorgen over 0 – helemaal niet
4. Ik kan lachen en de dingen van de vrolijke kant zien.	0 – net zoveel als vroeger 1 – nu wat minder 2 – nu duidelijk minder 3 – helemaal niet meer
5. Ik maak me de laatste tijd ongerust.	3 – heel erg vaak 2 – vaak 1 – niet zo vaak 0 – heel soms
6. Ik voel me de laatste tijd opgewekt:	3 – helemaal niet 2 – niet vaak 1 – soms 0 – meestal
7. Ik kan de laatste tijd rustig zitten en me ontspannen:	0 – zeker 1 – meestal 2 – niet vaak 3 – helemaal niet

8. Ik voel me de laatste tijd alsof alles moeizamer gaat.	3 – bijna altijd 2 – heel vaak 1 – soms 0 – helemaal niet
9. Ik krijg de laatste tijd een soort benauwd, gespannen gevoel in mijn maag.	0 – helemaal niet 1 – soms 2 – vrij vaak 3 – heel vaak
10. Ik heb de laatste tijd geen interesse meer in mijn uiterlijk.	3 – zeker 2 – niet meer zoveel als ik zou moeten 1 – mogelijk wat minder 0 – evenveel interesse als voorheen
11. Ik voel me de laatste tijd rusteloos.	3 – heel erg 2 – tamelijk veel 1 – niet erg veel 0 – helemaal niet
12. Ik verheug me van tevoren al op dingen.	0 – net zoveel als vroeger 1 – een beetje minder dan vroeger 2 – zeker minder dan vroeger 3 – bijna nooit
13. Ik krijg de laatste tijd plotseling gevoelens van angst of paniek.	3 – zeer vaak 2 – tamelijk vaak 1 – niet erg vaak 0 – helemaal niet
14. Ik kan van een goed boek genieten of een radio- of televisieprogramma.	0 – vaak 1 – soms 2 – niet vaak 3 – heel zelden

De formulering van de vragen en antwoordmogelijkheden is voor 6 items positief (0-3), voor 8 items negatief (3-0).

Uitleg puntentelling HADS score

De oneven vragen (1, 3, 5, 7, 9,11, 13) hebben betrekking op ANGST → **Totale score** = _____

De even vragen (2, 4, 6, 8, 10, 12, 14) hebben betrekking op DEPRESSIE → **Totale score** = _____

Bij een score op de subschaal van:
0-7 : geen angststoornis of depressie
8-10 : een *mogelijke* angststoornis of depressie
11-21: een *vermoedelijke* angststoornis of depressie

The Big Five Inventory–2

Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others?* Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement.

1 Disagree strongly	**2** Disagree a little	**3** Neutral; no opinion	**4** Agree a little	**5** Agree strongly

I am someone who...

1. ___Is outgoing, sociable.
2. ___Is compassionate, has a soft heart.
3. ___Tends to be disorganized.
4. ___Is relaxed, handles stress well.
5. ___Has few artistic interests.
6. ___Has an assertive personality.
7. ___Is respectful, treats others with respect.
8. ___Tends to be lazy.
9. ___Stays optimistic after experiencing a setback.
10. ___Is curious about many different things.
11. ___Rarely feels excited or eager.
12. ___Tends to find fault with others.
13. ___Is dependable, steady.
14. ___Is moody, has up and down mood swings.
15. ___Is inventive, finds clever ways to do things.
16. ___Tends to be quiet.
17. ___Feels little sympathy for others.
18. ___Is systematic, likes to keep things in order.
19. ___Can be tense.
20. ___Is fascinated by art, music, or literature.
21. ___Is dominant, acts as a leader.
22. ___Starts arguments with others.
23. ___Has difficulty getting started on tasks.
24. ___Feels secure, comfortable with self.
25. ___Avoids intellectual, philosophical discussions.
26. ___Is less active than other people.
27. ___Has a forgiving nature.
28. ___Can be somewhat careless.
29. ___Is emotionally stable, not easily upset.
30. ___Has little creativity.
31. ___Is sometimes shy, introverted.
32. ___Is helpful and unselfish with others.
33. ___Keeps things neat and tidy.
34. ___Worries a lot.
35. ___Values art and beauty.
36. ___Finds it hard to influence people.
37. ___Is sometimes rude to others.
38. ___Is efficient, gets things done.
39. ___Often feels sad.
40. ___Is complex, a deep thinker.
41. ___Is full of energy.
42. ___Is suspicious of others' intentions.
43. ___Is reliable, can always be counted on.
44. ___Keeps their emotions under control.
45. ___Has difficulty imagining things.
46. ___Is talkative.
47. ___Can be cold and uncaring.
48. ___Leaves a mess, doesn't clean up.
49. ___Rarely feels anxious or afraid.
50. ___Thinks poetry and plays are boring.
51. ___Prefers to have others take charge.
52. ___Is polite, courteous to others.
53. ___Is persistent, works until the task is finished.
54. ___Tends to feel depressed, blue.
55. ___Has little interest in abstract ideas.
56. ___Shows a lot of enthusiasm.
57. ___Assumes the best about people.
58. ___Sometimes behaves irresponsibly.
59. ___Is temperamental, gets emotional easily.
60. ___Is original, comes up with new ideas.

Please check: Did you write a number in front of each statement?

Scoring Key

Item numbers for the BFI-2 domain and facet scales are listed below. Reverse-keyed items are denoted by "R." For more information about the BFI-2, visit the Colby Personality Lab website (http://www.colby.edu/psych/personality-lab/).

Domain Scales
Extraversion: 1, 6, 11R, 16R, 21, 26R, 31R, 36R, 41, 46, 51R, 56
Agreeableness: 2, 7, 12R, 17R, 22R, 27, 32, 37R, 42R, 47R, 52, 57
Conscientiousness: 3R, 8R, 13, 18, 23R, 28R, 33, 38, 43, 48R, 53, 58R
Negative Emotionality: 4R, 9R, 14, 19, 24R, 29R, 34, 39, 44R, 49R, 54, 59
Open-Mindedness: 5R, 10, 15, 20, 25R, 30R, 35, 40, 45R, 50R, 55R, 60

Facet Scales
Sociability: 1, 16R, 31R, 46
Assertiveness: 6, 21, 36R, 51R
Energy Level: 11R, 26R, 41, 56
Compassion: 2, 17R, 32, 47R
Respectfulness: 7, 22R, 37R, 52
Trust: 12R, 27, 42R, 57
Organization: 3R, 18, 33, 48R
Productiveness: 8R, 23R, 38, 53
Responsibility: 13, 28R, 43, 58R
Anxiety: 4R, 19, 34, 49R
Depression: 9R, 24R, 39, 54
Emotional Volatility: 14, 29R, 44R, 59
Intellectual Curiosity: 10, 25R, 40, 55R
Aesthetic Sensitivity: 5R, 20, 35, 50R
Creative Imagination: 15, 30R, 45R, 60

Citation for the BFI-2
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