RESEARCH ARTICLE

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Effectiveness of Personalized Sound Therapy in Tinnitus Management: A preliminary results of Comparative of Three Masking Techniques

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ABSTRACT

Objective: The objective of this study is to conduct an in-depth comparative evaluation of three commonly used sound therapy techniques for managing chronic subjective tinnitus: pitch-matched masking, white noise, and audiogram-based masking. We aim to assess not only their clinical effectiveness but also patient tolerance and preference, using standardized tinnitus assessment tools.

Methods: A prospective study involving 10 adult patients with chronic subjective tinnitus was conducted. Each participant was fitted with hearing aids equipped with three custom masking programs: a pitch-matched tone corresponding to their tinnitus frequency, broad-spectrum white noise, and noise tailored to their audiogram profile. Over a 30-day period, patients rotated through the three programs, with data collected at three evaluation points (baseline, day 15, and day 30). Outcome measures included the Tinnitus Handicap Inventory (THI), visual analog scales (VAS) for tinnitus intensity and annoyance, speech intelligibility assessments, and subjective preference questionnaires. Paired statistical analyses were used to assess significance.

Results: The study demonstrated a clear improvement across all patients in tinnitus-related quality of life and symptom severity. THI scores showed a statistically significant mean reduction from 48.4 at baseline to 24.4 at day 30 ($p = 0.026$). VAS scores for both tinnitus intensity and annoyance similarly declined, particularly in users of the pitch-matched program, which was preferred by 60% of participants. In terms of speech comprehension, pitch-matched noise preserved intelligibility more effectively than the other two masking strategies.

Conclusion: The results suggest that individualized sound therapy, particularly pitch-matched masking, offers substantial clinical benefit and greater user satisfaction in managing chronic tinnitus. These findings highlight the value of patient-specific therapeutic strategies in audiological practice and support broader integration of personalized digital tools in routine care.

Keywords: Tinnitus, Sound therapy, Masking, Pitch-matched Noise, Vas, Thi, Speech intelligibility.

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INTRODUCTION

Tinnitus, often described as the perception of a phantom sound without an external source, affects an estimated 10% to 15% of the adult population globally[1]. While not always pathologic, tinnitus can become a persistent and disruptive condition, severely affecting sleep, concentration, communication, and emotional well-being[2]. For many sufferers, the condition is associated with elevated anxiety, depressive symptoms, and social withdrawal[3]. Despite its prevalence, the underlying pathophysiology of tinnitus remains incompletely understood, and therapeutic options often focus on symptom mitigation rather than definitive cure[4].

Among non-invasive treatment modalities, sound therapy has emerged as a leading option for symptom relief[5]. It involves the strategic use of external sounds-delivered through hearing aids, headphones, or sound generators-to either mask the tinnitus or promote habituation. The technique leverages neuroplasticity by retraining auditory pathways, thereby reducing the contrast between the phantom tinnitus and ambient noise[6]. However, the optimal type of sound stimulus remains a matter of clinical investigation. In this study, we explore three specific masking strategies-pitch-matched noise, white noise, and audiogram-based noise-to determine which is most effective in reducing the perceived burden of tinnitus while maintaining speech clarity and patient comfort.

METHODS

This single-center, prospective clinical study included 10 adult volunteers (aged 41–80 years) diagnosed with chronic subjective tinnitus of at least 3 months' duration. Participants were recruited from an otolaryngology outpatient clinic and provided written informed consent. The study adhered to ethical guidelines and was approved by a local research ethics board.

Inclusion criteria were: a diagnosis of non-pulsatile, subjective tinnitus; audiometric hearing loss correctable with hearing aids; cognitive ability to complete questionnaires; and willingness to participate through the 30-day study period.

Exclusion criteria included: objective or pulsatile tinnitus; history of otologic surgery; unstable hearing thresholds; otitis media or other active ear pathology; severe neurological or psychiatric disorders; and non-compliance with hearing aid use.

Participants were fitted bilaterally with modern micro-contour behind-the-ear (RIC) hearing aids, pre-programmed with four options: a default automatic amplification program and three tinnitus masking programs. These included:

1. **Pitch-matched masking**-a narrowband noise centered around the individual's tinnitus frequency[7].
2. **White noise masking**-a constant broadband sound covering a wide frequency range[8].
3. **Audiogram-based masking**-a sound spectrum tailored to the user's hearing loss profile[9].

Each program was worn for 10 consecutive days in a randomized crossover design. Assessments were performed at baseline (before intervention), day 15, and day 30.

Evaluation tools included:

- **Tinnitus Handicap Inventory (THI):** A 25-item validated questionnaire measuring tinnitus-related functional, emotional, and catastrophic distress. Scores range from 0 to 100, with higher scores reflecting greater perceived handicap[10].
- **Visual Analog Scales (VAS):** Two separate scales were used to measure perceived tinnitus intensity and annoyance. Participants marked a 10-cm line from 0 (no symptom) to 10 (worst imaginable symptom), and results were quantified in millimeters[11].
- **Speech Intelligibility Testing:** Conducted in quiet using standardized French word lists at varying decibel levels to assess auditory clarity under different masking conditions[12].
- **Patient Preference Survey:** A qualitative questionnaire gathered feedback on comfort, speech clarity, masking effectiveness, and overall satisfaction with each program.

Statistical analysis was performed using paired Student's t-tests to evaluate differences in THI and VAS scores across evaluation periods and between programs.

RESULTS

The mean age of our patients was 63 years with extremes of 42 and 82 years.

There were 6 females and 4 males.

For our sample, the average hearing loss was 33 dB in the right ear and 38 dB in the left ear, corresponding to mild hearing loss with a greater impact on high frequencies on both sides.

Three patients had unilateral tinnitus: two on the left side and one on the right side, while seven patients had bilateral tinnitus.

The average duration of tinnitus was 8 years, ranging from 24 months to 26 years. All participants were fitted with Phonak behind-the-ear hearing aids.

The baseline average THI score was 47± 22.8, indicating a moderate level of tinnitus-related disability. By the end of the study, the mean THI had dropped to 25.4 ± 19.3 ($p = 0.031$), suggesting a statistically and clinically significant reduction in perceived handicap.

Visual Analog Scale scores for tinnitus intensity began at an average of 8.1. Under the pitch-matched program, this score decreased to 3.65 at day 30. The white noise program showed a decline to 3.6, while the audiogram-

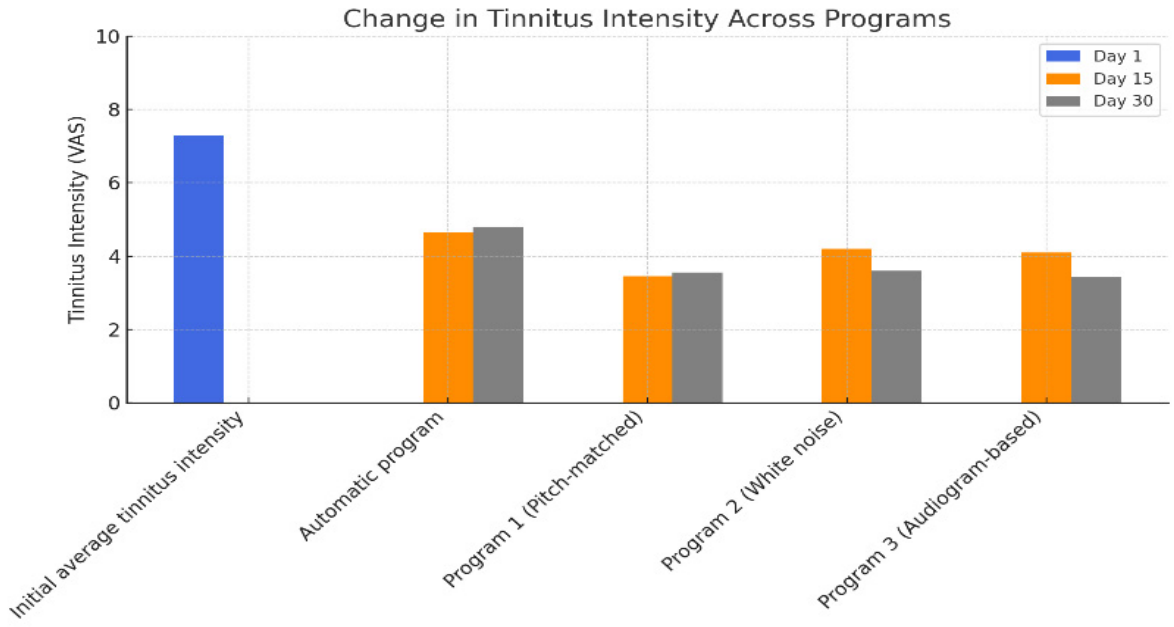

Figure 1: Evolution of Tinnitus Intensity (VAS) across Evaluation Points.

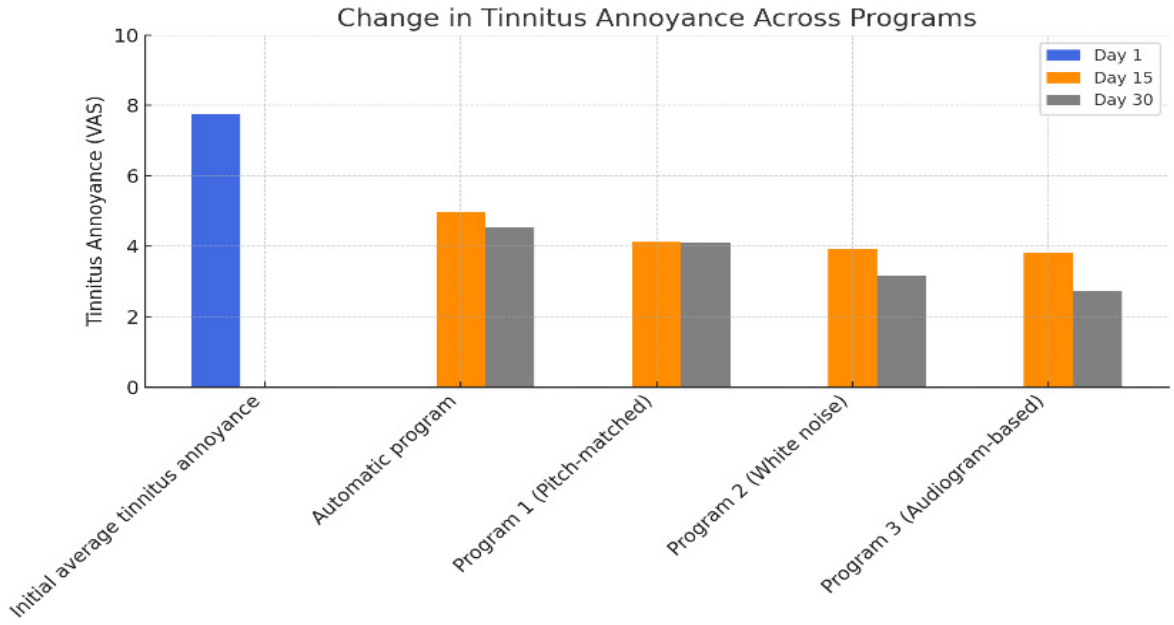

Figure 2: Evolution of Tinnitus Annoyance (VAS) across Evaluation Points.

based noise resulted in a final score of 3.63. Tinnitus annoyance followed a similar trend, declining from a baseline mean of 7.74 to between 2.71 and 4.54 across the three programs.

Speech intelligibility testing revealed the pitch-matched program preserved comprehension most effectively. Unlike white noise, which interfered with soft consonants and high-frequency speech cues, pitch-matched tones offered focused relief without masking verbal communication. This distinction was especially noted during group conversations or when using the phone.

Illustrate the decline in tinnitus intensity and annoyance scores across time points and programs (**Figures 1&2**).

Data logging from the hearing aids revealed longer average daily usage time for the pitch-matched program, reinforcing its practicality and user satisfaction.

DISCUSSION

This expanded analysis reinforces the growing consensus in tinnitus management that a personalized approach yields better outcomes[4, 5]. The superiority of pitch-matched masking in our study echoes findings from prior research suggesting that frequency-aligned stimuli can more precisely target the cortical regions involved in tinnitus perception[6, 7]. By matching the external sound to the internal tinnitus frequency, this strategy may achieve more efficient neural desynchronization or masking.

Our results also suggest that patient adherence and comfort are essential for therapy success[8]. Participants using the white noise or audiogram-based programs reported greater difficulty focusing during daily activities, likely due to the broader spectral interference. While both alternatives showed therapeutic benefits, they were less tolerated, indicating that perceived usability should be considered in treatment planning.

The inclusion of both subjective (THI, VAS) and objective (speech testing, usage logs) data enhances the robustness of our findings[10-12]. However, our sample size remains a key limitation. With only 10 patients, it is difficult to generalize these outcomes to more diverse populations. Additionally, longer-term follow-up would be necessary to determine whether these benefits persist beyond the immediate treatment period or translate into reduced reliance on masking.

Despite these limitations, the evidence supports integrating pitch-matched masking as a first-line option for patients with stable tinnitus frequency and sufficient hearing aid compatibility. Future studies could expand on these findings by incorporating neuroimaging, ecological momentary assessments, or comparisons with cognitive-behavioral interventions[3-5].

CONCLUSION

Tailored sound therapy using tinnitus pitch-matched masking demonstrated clear superiority in both subjective outcomes and patient satisfaction in this study. While white noise and audiogram-based strategies offered some relief, they were less comfortable and disrupted communication more frequently. These findings support a shift toward personalized tinnitus therapy using programmable hearing technologies, encouraging clinicians to assess individual patient profiles and preferences before selecting a masking strategy.

Conflict of Interest: None declared.

Ethical consideration: Anonymity and personal data were respected at all stages of the study. Signed consent was obtained from patients before the start of the study.

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