

Brief Communication

Pink noise: a potential sound therapy for tinnitus

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Abstract: At present, traditional music therapy based on “white noise” is commonly used to treat tinnitus patients. This study aims to apply “pink noise”, which has a more balanced frequency distribution than white noise, to the field of tinnitus rehabilitation treatment to study its inhibitory effect on tinnitus. Fractal technology (fractal mathematics) was used to generate semi-repetitive tones as the basic tone of music therapy. This clinical study recruited 43 adult tinnitus patients with varying degrees of hearing loss as the study subjects. All patients received fractal music therapy with hearing aids. The study evaluated the Tinnitus Handicap Inventory (THI) of patients’ usage and tested the indicators with paired sample T-tests. The results indicate that “pink noise” is effective in the treatment of tinnitus, and the differences in the scores are statistically significant before and after treatment ($P < 0.05$). In addition, by comparing the tone spectra of “white noise” and “pink noise”, we found that the frequency component power of “pink noise” is mainly concentrated in the middle and low frequency range. Its slope is -3 dB/Oct, which means that the frequency decays downwards as the ratio increases. In this study, a tinnitus music therapy based on the “pink noise” tone was developed, which mainly solved the awkward problem of no specific drugs or special tinnitus treatment equipment. At the same time, it helps to accelerate the development of related medical devices and improve the quality of life of tinnitus patients.

Keywords: Pink noise, tinnitus, music therapy, treatment effect

Introduction

Epidemiologic studies in Europe and America show that the incidence of tinnitus is 10%~15% [1-3]. At present, in the field of audiology, the traditional therapies for treating tinnitus mainly include habituation therapy and tinnitus masking therapy [3-7], and research has shown that music therapy is more suitable for managing patient status [8-11]. However, current traditional therapies and music therapies are mostly based on “white noise” to interfere with tinnitus, which may lead to long-term hearing impairment. The frequency component power of “pink noise” is mainly distributed in the middle and low frequency range, with a slope of -3 dB/Oct (**Figure 1**), and its waveform is fractal, which has good effects in alleviating tinnitus troubles and obstacles [12]. Therefore, this study is the first to use music therapy based on semi-replicated “pink noise” as the basic tone to simulate the sound of waterfalls or rain, to

use hearing aids to generate fractal tones to optimize tinnitus rehabilitation performance; and to evaluate the therapeutic effect of “pink tone” by using the THI score before and after use.

Method

From 2014 to 2022, two institutions, the Otolaryngology Department of the Second Affiliated Hospital of Xinjiang Medical University and the Otolaryngology Hospital of Urumqi Ophthalmology Department, conducted multi-center clinical studies to evaluate the efficacy of hearing aids based on “fractal tones”. Zhongshan Hospital affiliated with Fudan University was responsible for overall experimental design and data analysis. This experiment selected 43 adult tinnitus patients with varying degrees of hearing loss as research samples. All patients in this experiment signed informed consent forms, and the experiment

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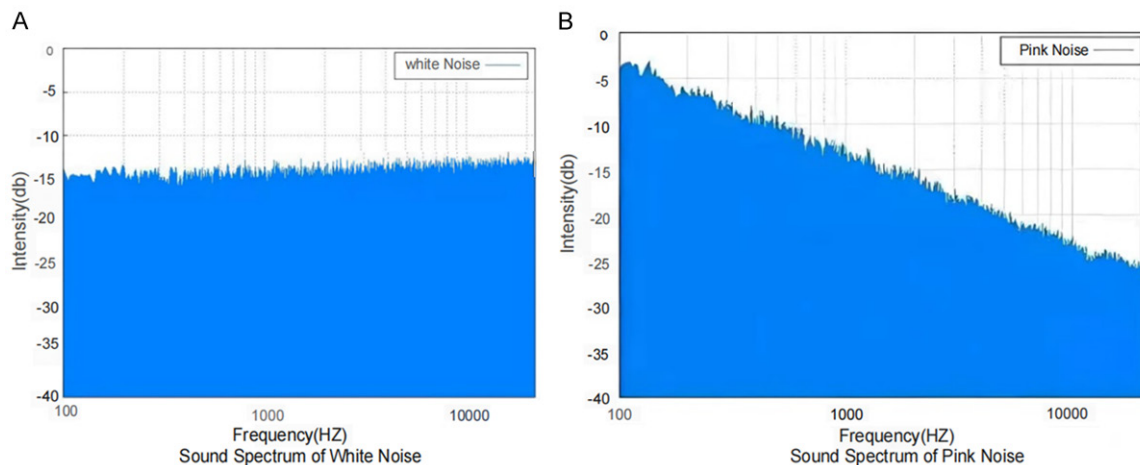


Figure 1. Image shows the sound spectrum using “white noise” (A) and “pink noise” (B) as the basic tunes.

has obtained ethical approval from the relevant ethics committee.

Firstly, we determined the basic information of the patient. The patient should be over 14 years old, regardless of gender. We inquired about the patient’s past disease history and relevant medication treatment records, whether they have used hearing aids, age of selection, and past wearing status, whether there are abnormalities in the ears, and whether they have undergone ear surgery. Secondly, pure tone audiometry, imaging diagnosis, and tinnitus scale diagnosis were performed on the patients to conduct preliminary screening. The patients were required to have no organic lesions, and the imaging diagnosis was subjective tinnitus. The average pure tone hearing loss was ≤ 70 dB HL, and the THI score was >18 points. Finally, the patient must not suffer from objective tinnitus caused by organic lesions, was not a patient with cochlear deafness disease, did not have congenital or traumatic ear deformities, was not experiencing earache, headache, auditory hypersensitivity, severe or chronic dizziness, was not a patient with external or middle ear inflammation or external ear canal eczema, did not undergo ear drainage surgery within 90 days, did not suddenly experience unilateral ear hearing loss within 90 days, and the patient should not have cognitive impairment Mental and psychological disorders, epileptic symptoms, serious infectious diseases, or participation in other similar studies or inability to cooperate with the study. The patient must have sufficient cognitive and

comprehension abilities for the experiment and sign an informed consent form. If any of the above conditions were not met, the experimental cases were not included.

We proposed corresponding targeted treatment programs for tinnitus patients with different levels of tinnitus. Targeted therapy is based on tinnitus retraining therapy (TRT) and cognitive behavioral therapy (CBT). The treatment procedure is as follows: (1) Hearing assessment and tinnitus assessment (THI survey assessment); (2) Judgement of tinnitus degree; (3) Formulation of appropriate treatment plans; (4) Consultation (tinnitus mechanism, relationship between tinnitus and deafness, factors affecting tinnitus, and answering user questions); (5) Adjustment (adjusting the volume of the hearing aid according to the patient’s hearing); (6) Stress management (guided relaxation exercises based on user experience); (7) Interviews (evaluating THI at 1, 3, and 6 months after treatment; providing guidance for the next steps based on the final results). Then we evaluated the efficacy of tinnitus in patients 1 month, 3 months, and 6 months after treatment (**Figure 2**).

This part of the experiment was analyzed using SPSS11.0 software. The THI score of tinnitus patients wearing trial insurance products was the main efficacy index. The THI scores at 1, 3, and 6 months after treatment were recorded as THI1, THI2, and THI3, respectively. The mean (M) and standard deviation (SD) of THI were calculated, and the measured values were

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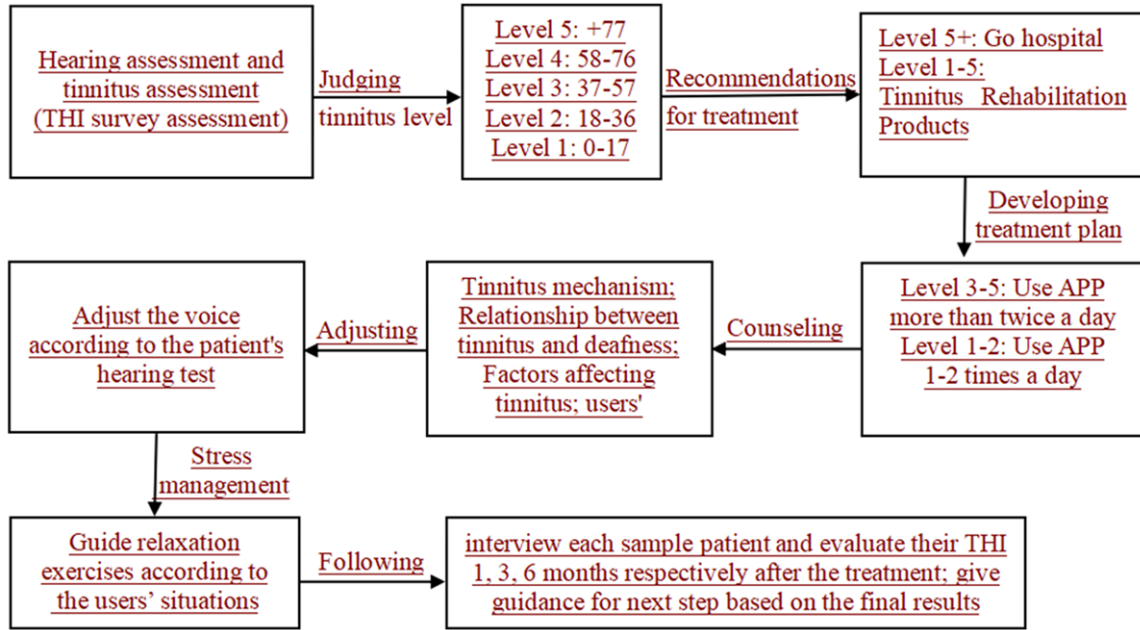


Figure 2. Flow chart of tinnitus rehabilitation treatment.

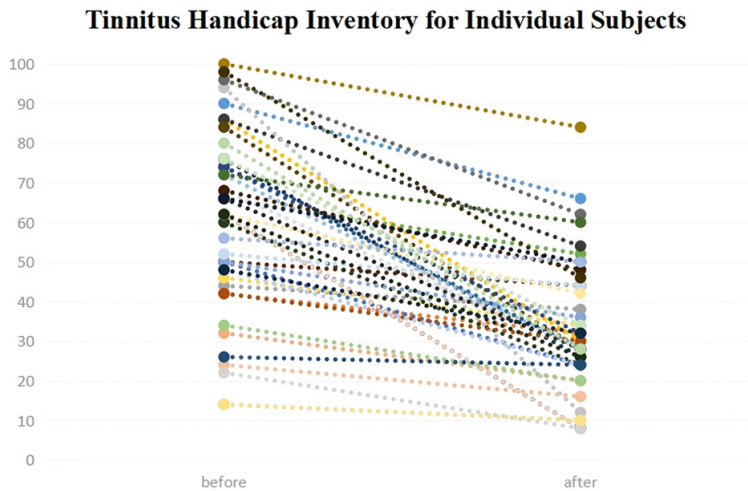


Figure 3. Tinnitus Handicap Inventory scores of individual patients at different stages.

expressed as mean \pm SEM. Paired sample t-tests were used to analyze the changes in THI scores of the subjects after treatment. A *P*-value of less than 0.05 was considered statistically significant.

Results

The THI scores of patients in each sample decreased significantly after treatment (Figure 3), and the *P* value by paired sample T-test of

THI scores at 1, 3, and 6 months after treatment showed a significantly lower *P*-value than 0.05 (Table 1).

Discussion

The music therapy based on “pink noise” in this study can effectively treat tinnitus, which is consistent with the conclusion recognized by international audiologists that fractal music is superior to “white noise” for tinnitus treatment [13].

This study focuses more on the development of tinnitus rehabilitation products based on semi-replicated “pink noise” as the basic tone. This tone exerts predictable pressure on music, but it is not repeatable. Its stimulating tone is similar but not completely the same, which can reduce the patient’s boredom during long-term use and provides good expected therapeutic effects. At the same time, this tone is designed based on fractal technology, which can meet the individual needs of tinnitus patients, such as the adjustment of music rhythm and sound intensity.

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Table 1. Results of paired t-test: 1 month after treatment (Th1), 3 months after treatment (Th2), 6 months after treatment (Th3)

	M	± SD	T value	P value
TH1	33.3	17.3	5.853	<0.001
TH2	22.0	11.0	8.742	<0.001
TH3	42.0	15.5	6.888	<0.001

The product of this study combines fractal tones with hearing aids, endowing it with wearable characteristics. This makes it convenient for patients to use anytime and anywhere. This device can also be shared by several people (not simultaneously). Before use, it is necessary to provide instructions for tinnitus products to patients so that the products can better meet their needs.

However, our study is not without limitations. First, we had access to a limited sample size, which may have affected the generalizability of this work. Second, further neurophysiologic research and extensive clinical observation are needed before this becomes a routine treatment for tinnitus in clinical diagnosis. In our future work, in order to rule out bias caused by unobserved characteristics to the greatest extent, we need to appropriately expand the sample size and improve the clinical observation.

In summary, this study extends the research on “white noise” and focuses on effectiveness of pink noise for treatment assistance for tinnitus patients and application innovation. The tinnitus treatment products and services developed in this study serve mainly to address the current lack of specific drugs for tinnitus treatment and the lack of specialized equipment. At the same time, it can accelerate the development of domestic medical devices in China, greatly reduce the cost of using equipment and instruments, make the product affordable for more people, and improve the quality of life for tinnitus patients.

Disclosure of conflict of interest

None.

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References

- [1] Yang X, Wang J and Lai WL. The application and progress of music therapy in the field of pain. *Int J Stomatol* 2013; 40: 513-515.
- [2] LENARZ and You XJ. Outline of tinnitus diagnosis and treatment (German Society of Otolaryngology, Head and Neck Surgery). *Sino-German J Clin Oncol (English Edition)* 2000; 17: 49-351.
- [3] Tunkel DE, Bauer CA, Sun GH, Rosenfeld RM, Chandrasekhar SS, Cunningham ER Jr, Archer SM, Blakley BW, Carter JM, Granieri EC, Henry JA, Hollingsworth D, Khan FA, Mitchell S, Monfared A, Newman CW, Omole FS, Phillips CD, Robinson SK, Taw MB, Tyler RS, Waguespack R and Whamond EJ. Clinical practice guideline: tinnitus. *Otolaryngol Head Neck Surg* 2014; 151 Suppl: S1-S40.
- [4] Lu YQ. Clinical efficacy of masking therapy and habitual therapy on chronic subjective tinnitus. *J Clin Exp Med* 2016; 15: 2275-2277.
- [5] Bauer CA and Brozoski TJ. Effect of tinnitus retraining therapy on the loudness and annoyance of tinnitus: a controlled trial. *Ear Hear* 2011; 32: 145-155.
- [6] Jsatreboff PJ and Jadtrebroff MM. Using TRT to treat hyperacusis, misophonia and phonophobia. *ENT Audiol News* 2013; 21: 88-90.
- [7] Mazurek B, Fischer F, Haupt H, Georgiewa P, Reissshauer A and Klapp BF. A modified version of tinnitus retraining therapy: observing long-term outcome and predictors. *Audiol Neurotol* 2006; 11: 276-86.
- [8] Krick CM, Grapp M, Daneshvar-Talebi J, Reith W, Plinkert PK and Bolay HV. Cortical reorganization in recent-onset tinnitus patients by the Heidelberg Model of Music Therapy. *Front Neurosci* 2015; 9: 49.
- [9] Sweetow RW and Jeppesen AMK. A new integrated program for tinnitus management: Windex Zen Therapy. *Hear Rev* 2012; 19: 20-27.
- [10] Zhang LP, Zhang M and Zhang BL. Analysis of music mechanism and its application in the treatment of insomnia. *Liaoning J Tradit Chin Med* 2010; 37: 420-422.
- [11] Zhou JY and Ma YM. Observation on the efficacy of 52 cases of chronic tinnitus in the treatment. *Chin J Otolaryngol Skull Base Surg* 2012; 18: 198-200.

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- [12] Johansen JD, Skellgaard PH and Caporali S. Effect of counseling, amplification and fractal tones in tinnitus management. *J Commun Disord* 2014; 2: 1-7.
- [13] Newman CW, Sandridge SA and Jacobson GP. Psychometric adequacy of the Tinnitus Handicap Inventory (THI) for evaluating treatment outcome. *J Am Acad Audiol* 1998; 9: 153-160.