ORIGINAL RESEARCH

Effectiveness of Multimodal Sound Therapy with Fine Examination in the Clinical Diagnosis of Chronic Subjective Tinnitus

Weikang Cheng, MBBS; Jingjing Xia, MM; Xiaobing Hou, MBBS; Xiaoli Zhou, MBBS; Jun Wang, MBBS; Chongmin Liu, MM; Qinhua Dai, MBBS

ABSTRACT

Background • In chronic subjective tinnitus, existing therapeutic approaches often fall short. This study addresses this gap by exploring the efficacy of multimodal sound therapy guided by fine examination. The study focused on providing a scientific foundation for more accurate auditory evaluation, offering novel insights into managing tinnitus-related disabilities.

Objective • This study aimed to assess the effectiveness of multimodal sound therapy, guided by fine examination, in the clinical diagnosis of chronic subjective tinnitus.

Methods • A total of 100 patients with chronic subjective tinnitus treated in our hospital from March 2018 to March 2019 were selected as study subjects. They were divided into an experimental group and a control group based on the order of admission. The experimental group (n=50) received treatment involving various complex sounds, while the control group (n=50) received drug therapy. Fine examination was conducted in both groups, and tinnitus disability was compared. Additionally, the tinnitus disability scale score, Pittsburgh sleep quality index, and Hamilton depression and anxiety scale score were compared between the two groups.

Results • After three months of treatment, the experimental group demonstrated noteworthy improvements compared to the control group. Significant reductions in tinnitus disability ($P < .05$), along with notable enhancements in sleep quality ($P < .05$), and decreased scores for depression and anxiety ($P < .05$) were observed in the experimental group, highlighting the efficacy of multimodal sound therapy in addressing these aspects of chronic subjective tinnitus.

Conclusions • Fine examination serves as a scientific foundation for the auditory evaluation of tinnitus patients, facilitating more precise localization of the tinnitus point. Multimodal sound therapy demonstrates a notable impact on chronic subjective tinnitus, warranting further exploration and widespread application. (*Altern Ther Health Med.* [E-pub ahead of print.])

Weikang Cheng, MBBS; Jingjing Xia, MM; Xiaobing Hou, MBBS; Xiaoli Zhou, MBBS; Jun Wang, MBBS; Chongmin Liu, MM; Qinhua Dai, MBBS, Department of Otorhinolaryngology, Jiangyin Hospital of Traditional Chinese Medicine, Wuxi, Jiangsu, China.

Corresponding author: Qinhua Dai, MBBS
E-mail: fangzkjsyrl42006@163.com

INTRODUCTION

Subjective tinnitus refers to the patient's self-perception of abnormal sounds in the skull or ear without external interference.[1,2] With ongoing advancements in medical technology, researchers have established that chronic subjective tinnitus is associated with abnormal hearing and cognitive difficulties. However, there is currently a scarcity of studies on chronic subjective tinnitus, leaving the characteristics of cognitive impairment in tinnitus patients unclear.[3,4]

Currently, a majority of patients with chronic subjective tinnitus exhibit clinical symptoms such as anxiety, depression, insomnia, and other non-auditory manifestations. The inquiry into potential hearing impairment in tinnitus patients with normal hearing is a significant focus in the medical field. The conventional pure tone test is subject to various influencing factors during the detection process, leading to substantial controversy among medical practitioners regarding its accuracy.[5,6] Thus, this study explores a more refined examination method to address these concerns.

In this context, our study aims to offer a compelling rationale for the critical significance of diagnosing and treating chronic subjective tinnitus. Through a concise review of existing literature, we aimed to establish a framework for our research, highlighting the imperative for inventive diagnostic approaches in this complex domain. The current study focuses on examining the application of multimodal sound therapy in combination with fine examination for the clinical diagnosis of patients afflicted by chronic subjective tinnitus.

MATERIALS AND METHODS

Study Design

The research employed a comparative study design, and a total of 100 patients with chronic subjective tinnitus treated in our hospital from March 2018 to March 2019 were selected as study subjects. They were divided into an experimental group and a control group based on the order of admission. The experimental group (n=50) received treatment involving various complex sounds, while the control group (n=50) received drug therapy. This study received approval from the Ethics Committee of our hospital, marked by the ethics approval number ETH-2023-00789. Informed consent was obtained from all patients in the experimental group, and their families were briefed on the study's purpose, with signed confirmation of their willingness to participate.

Demographic and Clinical Characteristics of Patients

The control group consisted of 23 males and 27 females, with an age range of 41 to 72 years and a mean age of (56.39±2.71) years. The duration of the disease ranged from 6 months to 3 years, with an average duration of (1.09±1.31) years. On the other hand, the experimental group included 26 males and 24 females, with an age range of 43 to 77 years and a mean age of (57.16±2.22) years. The disease duration for the experimental group ranged from 9 months to 3 years, with an average duration of (1.06±1.24) years. This well-structured design allowed for a comprehensive examination of the impact of multimodal sound therapy, considering variations in age, gender, and disease duration between the control and experimental groups.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) patients meeting the diagnostic criteria for chronic subjective tinnitus; (2) demonstrating well-functioning middle ears; (3) lacking a history of surgical trauma; (4) exhibiting normal cognitive behavior were eligible for inclusion in this study. Exclusion criteria were as follows: (1) patients unable to undergo tinnitus and hearing tests; (2) those with objective tinnitus; (3) individuals with significant comorbidities were excluded from participation. These criteria aimed to ensure the suitability and reliability of the study's outcomes.

Sample Size Determination

A careful power analysis aimed at guaranteeing statistical robustness in identifying clinically significant differences between the experimental and control groups was conducted. The power analysis suggests the selection of a sample size of 100 patients. This chosen sample size strikes a balance between statistical rigor, the practicality of implementation, and the overarching goal of providing substantial and meaningful contributions to the field of chronic subjective tinnitus research.

Refined Pure Tone Detection for Accurate Tinnitus Assessment

Audiometric Precision. The refined pure tone detection process aimed for accurate audiometric precision in assessing tinnitus characteristics. All patients underwent pure tone audiometry, which involved incremental increases by 5 and decreased by 10, followed by a 1/24 octave adjustment. The initial tinnitus frequency was determined based on the examination results, setting the foundation for the subsequent steps in the process.[7,8]

Frequency Determination. Following the initial assessment, the refined examination focused on determining the central frequency of tinnitus. This critical step, informed by the examination results, further shaped the course of the investigation and allowed for precise identification.[8]

Testing Range Utilization. A testing range of 1/3 frequency doubling before and after the central frequency was strategically utilized to achieve accuracy. This approach provided a comprehensive exploration of the frequency spectrum, enhancing the effectiveness of the examination process.

Patient-Centric Testing. A 1/24 frequency doubling hearing test was performed within this range. Patients actively participated in the refined examination process. Guided by their examination results, they were presented with three test sounds at the central frequency, allowing them to select the sound that closely matched their perceived tinnitus sound. This patient-centric approach added a valuable dimension to the assessment.

Iterative Detection Process. The chosen test sound became the new center, initiating a repetitive detection process to narrow down the tinnitus frequency range further. This iterative method, guided by patient input, aimed to pinpoint the characteristics of the tinnitus precisely.

Loudness Determination. Patients played a crucial role in determining tinnitus loudness. Through active participation, they repeatedly confirmed the test sound that closely matched their perceived tinnitus frequency. This iterative approach facilitated a nuanced understanding of the loudness variations associated with tinnitus.

Adherence to Protocols: Ensuring Precision and Consistency. The entire refined examination process adhered thoroughly to established protocols [9-10]. This commitment ensured not only precision in the assessment but also consistency across all stages of the examination. Detailed information on the equipment used and testing protocols are included in this study. This transparency aims to enhance clarity for readers and researchers and promotes replicability of the refined pure tone detection process.

Experimental Group: Targeted Sound Therapy Approach

In the experimental group, a targeted sound therapy approach was implemented with the primary goal of alleviating tinnitus symptoms.

Therapeutic Protocol. The therapeutic protocol involved a thorough combination of distinct sounds, carefully curated to address the nuanced experiences of tinnitus. This multifaceted composition included narrow band noise dominated by the tinnitus frequency, natural sounds harmonizing with the primary tone of tinnitus, and personalized relaxation music chosen by patients themselves.

Creating Therapeutic Profiles. Guided by the results of a refined examination, compound sounds were intricately combined to form diverse therapeutic profiles. This innovative approach aimed to create a synergistic effect, tailoring the intervention to the individualized needs of each participant. Therapeutic sessions unfolded in serene and quiet environments, optimizing concentration. The deliberate duration of each session was set at 15 minutes, ensuring a focused intervention while maintaining a manageable and patient-friendly approach.

Post-Treatment Assessment. After each treatment session, patients' subjective experiences were carefully recorded. This post-treatment assessment served the dual purpose of capturing immediate impacts and gathering invaluable insights from patients. This ongoing feedback facilitated adjustments and optimization of the sound therapy approach for continuous improvement.[11-13]

Control Group: Pharmaceutical Intervention

In the control group, patients underwent treatment with pharmaceutical interventions, primarily encompassing drugs aimed at improving inner ear microcirculation and neurotrophic drugs. Patients in the control group received a daily dosage of 10ml of normal saline and 10 micrograms of alprostadil (manufacturer: Beijing Taide Pharmaceutical Co., Ltd.; Guo Yao Zhun Zi: H10980023; specification: 5mg). Additionally, they were administered 250ml of 50% glucose and 250mg of Xueshuantong (manufacturer: Guangdong Zhongsheng Pharmaceutical Co., Ltd.; Guo Yao Zhun Zi: Z20030017; specification: 0.5g × 30 capsules). Following two weeks of continuous administration of these drugs, patients received 250ml of glucose (50%) and 10mg of dexamethasone (manufacturer: Tianjin Tianyao Pharmaceutical Co., Ltd.; Guo Yao Zhun Zi: H20033; specification: 0.75mg*50 tablets) for three consecutive days.[14-16]

Observation Indicators

In evaluating the impact of tinnitus, a comprehensive set of observation indicators was employed. The comparison between the two groups encompassed (1) the tinnitus disability scale score, (2) the Pittsburgh sleep quality index (PSQI), and (3) the Hamilton depression (HAM-D) and anxiety (HAM-A) scale score. Additionally, the Tinnitus Handicap Inventory (THI) scale was utilized to analyze the degree of tinnitus, offering valuable insights into its multifaceted effects.

Tinnitus Handicap Inventory (THI) Scale. The THI scale played an important role in measuring the extent of tinnitus impact on individuals. This standardized and concise tool provided a systematic framework for individuals to articulate the influence of tinnitus on their emotional, cognitive, and functional well-being. Beyond its immediate clinical utility, THI scores guided personalized treatment plans, tracked changes over time, and contributed valuable data to ongoing research initiatives. Recognizing the diverse challenges posed by tinnitus, the THI scale emerged as an essential instrument for a nuanced understanding and effective addressing of these challenges.

Table 1. Distribution of Tinnitus Severity Grades in THI Scale [n (%)]

THI scale	Proportion
Grade 1 (Slight)	31% (31/100)
Grade 2 (Mild)	40% (40/100)
Grade 3 (Moderate)	23% (23/100)
Grade 4 (Severe)	4% (4/100)
Grade 5 (Catastrophic)	2% (2/100)

Note: THI: Tinnitus Handicap Inventory. The proportions represent the distribution of individuals in each grade on the THI scale, calculated as a percentage of the total sample size (n=100).

Table 2. Proportional Distribution of Individuals with Different Tinnitus Frequencies [n (%)]

Tinnitus Frequency	Proportion
Low Frequency (<1000Hz)	4% (4/100)
Intermediate Frequency (1000-3000Hz)	9% (9/100)
High Frequency (>3000Hz)	87% (87/100)

Note: The table presents the proportional distribution of individuals based on different tinnitus frequencies, calculated as a percentage of the total sample size (n=100).

Statistical Analysis

The entire dataset underwent comprehensive processing using SPSS 21.0. (International Business Machines, Corp., Armonk, NY, USA). Measurement data were rigorously examined through *t* tests and presented as mean ± standard deviation ($\bar{x} \pm s$). Counting data underwent χ^2 testing and were expressed as [n (%)]. A significance level (alpha) of 0.05 was established for hypothesis testing. Statistical significance was attributed to results with $P < .05$, ensuring a robust evaluation of the study's outcomes.

RESULTS

Tinnitus Impact Distribution Across THI Scale Categories

Examining the distribution proportion of the THI scale revealed that patients experiencing mild and moderate tinnitus constituted the largest proportion, contrasting with those facing catastrophic tinnitus (Table 1).

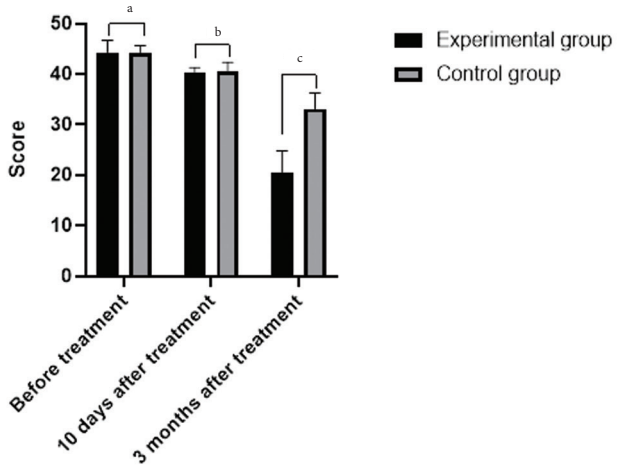
Distribution of Tinnitus Main Tone Frequencies

The analysis focused on the distribution of individuals according to their tinnitus main tone frequencies, revealing a predominant occurrence among those with high frequencies, refer to Table 2. This observation sheds light on the prevalence of tinnitus frequencies within the studied population, contributing valuable insights into the diverse tonal characteristics experienced by participants.

Tinnitus Disability Scale Scores

Initially, there was no significant difference in scores between the two groups before treatment. However, three months post-treatment, the scores of the Tinnitus Disability Scale in the experimental group showed a notable and statistically significant reduction compared to those in the

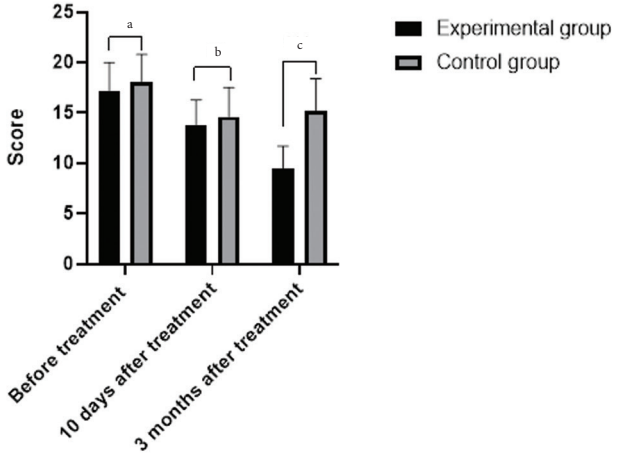
Figure 1. Comparison of Tinnitus Disability Scale Scores Before and After Treatment in Experimental and Control Groups



[a]no statistical difference before treatment (t = 0.249, P = .803)
[b]no significant difference at 10 days after treatment (t = 1.396, P = .165).
[c]significant differences in tinnitus disability scores between the two groups 3 months after treatment (t = 16.622, P = .000).

Note: The abscissa represents the treatment duration, while the ordinate indicates the score on the Tinnitus Disability Scale. The scores of the Tinnitus Disability Scale before treatment, at 10 days, and 3 months after treatment in the experimental group were (44.3 ± 2.4), (40.2 ± 1.1), and (20.5 ± 4.3), respectively. The corresponding scores in the control group were (44.2 ± 1.5), (40.6 ± 1.7), and (33.1 ± 3.2), respectively.

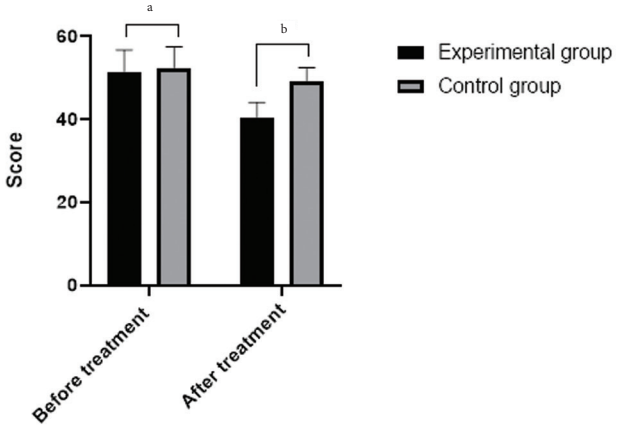
Figure 2. Comparison of Pittsburgh Sleep Quality Index Scores Before and After Treatment in Experimental and Control Groups



[a]no statistical difference before treatment (t=1.784, P = .077)
[b]no significant difference at 10 days after treatment (t=1.634, P = .105).
[c]denotes significant differences in PSQI scores between the two groups 3 months after treatment (t=10.407, P = .000)

Note: The abscissa represents the treatment duration, and the ordinate indicates the score on the Pittsburgh Sleep Quality Index (PSQI). The PSQI scores for patients in the experimental group before treatment, at 10 days, and 3 months after treatment were (17.1 ± 2.9), (13.7 ± 2.6), and (9.4 ± 2.3), respectively. The corresponding scores in the control group were (18.1 ± 2.7), (14.6 ± 2.9), and (15.2 ± 3.2), respectively.

Figure 3. Comparison of Hamilton Depression Scale Scores Before and After Treatment in Experimental and Control Groups



[a]no significant difference before treatment (t = 0.865, P = .389)
[b]significant difference in HAM-D scale scores between the two groups after treatment (t = 12.919, P = .000).

Note: The abscissa represents the treatment duration, while the ordinate indicates the score on the HAM-D Scale. The scores of the HAM-D Scale before and after treatment in the experimental group were (51.5 ± 5.3) and (40.5 ± 3.6), respectively. In the control group, the corresponding scores were (52.4 ± 5.1) and (49.3 ± 3.2), respectively.

control group (P < .05), as illustrated in Figure 1. This observation highlights the efficacy of the applied therapeutic interventions in mitigating tinnitus-related disability in the experimental group.

Pittsburgh Sleep Quality Index (PSQI) Scores

At the three-month mark post-treatment, the PSQI scores for the experimental cases demonstrated a significant decrease in comparison to the control cases (P < .05), as illustrated in Figure 2. This finding indicates a positive impact of the therapeutic interventions on sleep quality within the experimental group.

Hamilton Depression Scale (HAM-D) Scores

After treatment, the experimental group exhibited a markedly lower score on the HAM-D compared to the control group (P < .05), as depicted in Figure. 3. This significant reduction suggests a positive impact of the therapeutic interventions on alleviating depressive symptoms within the experimental group.

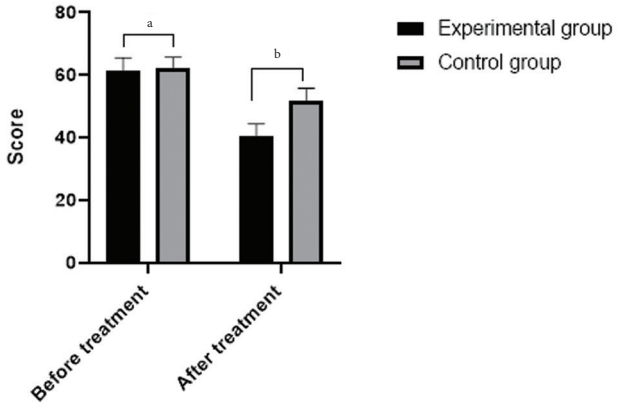
Hamilton Anxiety Scale (HAM-A) Scores

Patients in the experimental group demonstrated a significantly lower score on the HAM-A Scale compared to the control group (P < .05), as shown in Figure 4. This notable decrease highlights the effectiveness of the applied interventions in mitigating anxiety symptoms within the experimental group.

DISCUSSION

The emergence and diagnosis of tinnitus encompasses the auditory pathway and extends to the central nervous

Figure 4. Comparison of Hamilton Anxiety Scale Scores Before and After Treatment in Experimental and Control Groups



[a]No significant difference before treatment (t = 0.778, P = .439)
[b]indicates a significant difference in HAM-A Scale scores between the two groups after treatment (t = 13.902, P = .000).

Note: The abscissa represents the treatment duration, while the ordinate indicates the score on the Hamilton Anxiety Scale. The scores of the HAM-A Scale before and after treatment in the experimental group were (61.5 ± 4.1) and (40.3 ± 4.1), respectively. In the control group, the corresponding scores were (62.1 ± 3.6) and (51.7 ± 4.1), respectively.

system outside the auditory pathway.[17-19] While some researchers assert that audiological and psychological tests may not directly influence therapeutic outcomes, assessing these systems aids doctors in identifying the underlying causes of tinnitus, enabling targeted treatment for patients. Traditional audiological examinations, despite their utility, often fail to accurately assess the severity of tinnitus.[20,21]

Contrarily, fine examination proves efficient in detecting hidden hearing loss and precisely determining the sites of tinnitus in patients. This process enables doctors to formulate more accurate and tailored treatment plans.[22] Multi-compound sound involves the tinnitus sound by incorporating narrow band noise at its core, blending it with background music and natural sounds. This integration of three distinct frequencies results in a compound sound, allowing doctors to formulate diverse sound treatment schemes based on the specific tinnitus characteristics of individual patients. This treatment not only alleviates patients' perception of tinnitus and improves their mood but also achieves these outcomes within a short treatment period, contributing to higher patient satisfaction.

In this study, individuals with mild and moderate tinnitus constitute a larger proportion, whereas those with catastrophic tinnitus represent only a small fraction, comprising merely 2% of the total participants. Additionally, a substantial majority, accounting for 87% of the total, reported high-frequency tinnitus. The PSQI score and tinnitus disability score of the experimental group were significantly lower than those of the control group (P < .05), signifying a considerable improvement in both tinnitus symptoms and sleep quality within the experimental group.

However, the scores of the HAM-A Scale and HAM-D Scale in the experimental group were significantly lower than those in the control group (P < .05), indicating a notable alleviation of anxiety and depression following treatment. Parnell et al.[23] highlighted a significant reduction in the tinnitus disability score among patients with chronic subjective tinnitus after compound sound treatment, aligning with the findings of our study.

The results of our study hold substantial implications for clinical practice and patient care. The efficacy of multiple complex sound therapy, guided by fine examination, indicates the potential for adopting a patient-centered approach in managing chronic subjective tinnitus. Clinicians could contemplate the integration of this intervention to not only enhance auditory evaluation precision but also promote overall patient well-being. In addition to alleviating tinnitus symptoms, this approach has the potential to enhance both sleep quality and emotional well-being.

Our study presents a promising strategy to elevate the clinical management of chronic subjective tinnitus by ingeniously merging fine examination with multiple complex sound therapies. The observed improvements in tinnitus disability and overall well-being underscore the potential positive influence of this innovative intervention.

Study Limitations

While our study provides valuable insights into the clinical effectiveness of fine examination-guided multiple compound sound therapy for chronic subjective tinnitus, certain limitations should be acknowledged. Firstly, the study's sample size may impact the generalizability of the findings to a broader population. Additionally, the relatively short follow-up period of three months limits our ability to assess the long-term sustainability of the observed improvements. Furthermore, the absence of a placebo-controlled group could introduce potential biases. Future research with larger, diverse samples, longer follow-up durations, and rigorous control groups would contribute to a more comprehensive understanding of the intervention's effectiveness and its applicability in varied clinical contexts.

CONCLUSION

In summary, our study underscores the clinical efficacy of fine examination-guided multiple compound sound therapy for chronic subjective tinnitus. The pivotal findings reveal a noteworthy decrease in tinnitus disability, enhanced sleep quality, and reduced depression and anxiety scores within the experimental group. These outcomes underscore the significance of a personalized approach in addressing the multifaceted impact of tinnitus on patients' lives, highlighting the potential for improved quality of life through tailored interventions. The results advocate for the integration of fine examination into tinnitus management strategies, promoting a more patient-centered approach.

COMPETING INTERESTS
The authors report no conflict of interest.

FUNDING
None.

ACKNOWLEDGEMENTS
None.

AVAILABILITY OF DATA AND MATERIALS
The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES
1. Beukes E.W.,Baguley D.M.,Manchaiah V., et al. Positive experiences related to living with tinnitus: A cross-sectional survey[J].*Clinical otolaryngology: official journal of ENT-UK ; official journal of Netherlands Society for Oto-Rhino-Laryngology & Cervico-Facial Surgery*,2018,43(2):489-495.
2. Demirkol N, Demirkol M, Usumez A, Sari F, Akcaboy C. The potential etiologic factors influencing tinnitus intensity in patients with temporomandibular disorders. [J]. *Cranio*. 2018;36(6):360-365.
3. Jacquemin L, Shekhawat GS, Van de Heyning P, et al. Effects of Electrical Stimulation in Tinnitus Patients: Conventional Versus High-Definition tDCS. [J]. *Neurorehabil Neural Repair*. 2018;32(8):714-723. doi:10.1177/1545968318787916
4. Roberta W Scherer,Leonora D Sensinger,Craig Formby, et al.Lessons learned conducting a multi-center trial with a military population: The Tinnitus Retraining Therapy Trial[J].*Clinical trials: journal of the Society for Clinical Trials*,2018,15(5):429-435.
5. Yong X, Ahsan SF, Eric K, et al. An animal model of deep brain stimulation for treating tinnitus: A proof of concept study[J].The Laryngoscope: A Medical Journal for Clinical and Research Contributions in Otolaryngology, Head and Neck Medicine and Surgery, Facial. *Plast Reconstr Surg*. 2018;128(5):1213-1222.
6. Chandra N, Chang K, Lee A, Shekhawat GS, Searchfield GD. Psychometric Validity, Reliability, and Responsiveness of the Tinnitus Functional Index. [J]. *J Am Acad Audiol*. 2018;29(7):609-625. doi:10.3766/jaaa.16171
7. Kim YH, Park YG, Han KD, Vu D, Cho KH, Lee SY. Prevalence of tinnitus according to temporomandibular joint disorders and dental pain: The Korean National Population-based Study. [J]. *J Oral Rehabil*. 2018;45(3):198-203. doi:10.1111/joor.12604
8. Durai M, Kobayashi K, Searchfield GD. A feasibility study of predictable and unpredictable surf-like sounds for tinnitus therapy using personal music players. [J]. *Int J Audiol*. 2018;57(9):707-713. doi:10.1080/14992027.2018.1476783
9. Trifunovic M, Zivic L, Draskovic M, Corbic M, Sretenovic J. Is There a Relationship Between Audiogram Shape and the Intensity and Duration of Tinnitus? [J]. *Serb J Exp Clin Res*. 2018;19(3):237-242. doi:10.1515/sjecr-2017-0051
10. Husain FT, Gander PE, Jansen JN, Shen S. Expectations for Tinnitus Treatment and Outcomes: A Survey Study of Audiologists and Patients. [J]. *J Am Acad Audiol*. 2018;29(4):313-336. doi:10.3766/jaaa.16154
11. Lauer AM, Larkin G, Jones A, May BJ. Behavioral Animal Model of the Emotional Response to Tinnitus and Hearing Loss. [J]. *J Assoc Res Otolaryngol*. 2018;19(1):67-81. doi:10.1007/s10162-017-0642-8
12. El-Minawi MS, Dabbous AO, Hamdy MM, Sheta SM. Does changes in mismatch negativity after tinnitus retraining therapy using tinnitus pitch as deviant stimulus, reflect subjective improvement in tinnitus handicap? [J]. *Hear Balance Commun*. 2018;16(3):182-196. doi:10.1080/21695717.2018.1500003
13. Pryce H, Hall A, Marks E, et al. Shared decision-making in tinnitus care - An exploration of clinical encounters. [J]. *Br J Health Psychol*. 2018;23(3):630-645. doi:10.1111/bjhp.12308
14. El Beaino M, McCaskey MK, Eter E. Sulodexide Monotherapy in Chronic Idiopathic Subjective Tinnitus: A Randomized Controlled Trial. [J]. *Otolaryngol Head Neck Surg*. 2018;158(6):1107-1112. doi:10.1177/0194599818767618
15. Alice Eldridge,Patrice Guyot,Alison Johnston, et al.Sounding out ecoacoustic metrics: Avian species richness is predicted by acoustic indices in temperate but not tropical habitats[J]. *Ecological indicators: Integrating, monitoring, assessment and management*,2018,95P1(Dec.):939-952.
16. Hsieh W-H, Huang W-T, Lin H-C. Investigation of the effect of cochlear implantation on tinnitus, and its associated factors. [J]. *Acta Otolaryngol*. 2020;140(6):497-500. doi:10.1080/00016489.2020.1736338
17. Sheppard A, Stocking C, Ralli M, Salvi R. A review of auditory gain, low-level noise and sound therapy for tinnitus and hyperacusis. [J]. *Int J Audiol*. 2020;59(1):5-15. doi:10.1080/14992027.2019.1660812
18. Sereda M, McFerran D, Axon E, et al. A process for prioritising systematic reviews in tinnitus. [J]. *Int J Audiol*. 2020;59(8):640-646. doi:10.1080/14992027.2020.1733677
19. Brennan-Jones CG, Thomas A, Hoare DJ, Sereda M. Cochrane corner: sound therapy (using amplification devices and/or sound generators) for tinnitus. [J]. *Int J Audiol*. 2020;59(3):161-165. doi:10.1080/14992027.2019.1643503
20. Park JM, Kim WJ, Han JS, Park SY, Park SN. Management of palatal myoclonic tinnitus based on clinical characteristics: a large case series study. [J]. *Acta Otolaryngol*. 2020;140(7):553-557. doi:10.1080/00016489.2020.1749724
21. Aazh H, Heinonen-Guzejev M, Moore BCJ. The relationship between hearing loss and insomnia for patients with tinnitus. [J]. *Int J Audiol*. 2020;59(1):68-72. doi:10.1080/14992027.2019.1654621
22. van Zwieten G, Janssen MLF, Smit JV, et al. Inhibition of Experimental Tinnitus With High Frequency Stimulation of the Rat Medial Geniculate Body. [J]. *Neuromodulation*. 2019;22(4):416-424. doi:10.1111/ner.12795
23. Taylor LP, Sletten WO, Dumont TD. The effect of specially designed and managed occlusal devices on patient symptoms of tinnitus: A cohort study. [J]. *Cranio*. 2019;37(2):101-110. doi:10.1080/08869634.2017.1404285