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Research Article

Therapeutic Efficacy of Acupuncture Combined with Low-Frequency Repetitive Transcranial Magnetic Stimulation in Chronic Subjective Tinnitus: A Prospective Clinical Study

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Abstract:

Objective : Chronic subjective tinnitus is frequently accompanied by anxiety, insomnia, and reduced quality of life. Effective treatment strategies remain limited. This study aimed to investigate the clinical efficacy of acupuncture combined with low-frequency repetitive transcranial magnetic stimulation (rTMS) in patients with chronic subjective tinnitus.

Methods : A total of 72 patients with chronic subjective tinnitus were prospectively enrolled between June 2025 and April 2026. All participants received acupuncture combined with 1-Hz low-frequency rTMS for 12 consecutive treatment sessions over 2 weeks. Primary outcomes included the Tinnitus Handicap Inventory (THI) and Visual Analogue Scale (VAS). Secondary outcomes included the Self-Rating Anxiety Scale (SAS) and Athens Insomnia Scale (AIS). Assessments were conducted at baseline, immediately after treatment, and at one-month follow-up.

Results : The results demonstrated that after two weeks of acupuncture combined with repetitive transcranial magnetic stimulation (rTMS) in 72 patients with chronic subjective tinnitus, both tinnitus loudness and tinnitus-related sleep disturbances were significantly improved, with an overall response rate of 88.9% (64/72). The Tinnitus Handicap Inventory (THI) score decreased significantly from（41.16±11.14）before treatment to（25.25±11.23）after treatment. The Visual Analogue Scale (VAS) score for tinnitus loudness decreased from（3.44±1.36）to（1.61±0.88）. In addition, the Self-Rating Anxiety Scale (SAS) score decreased from（55.03±3.06）to（45.06±5.44, while the Athens Insomnia Scale (AIS) score decreased from（4.85±3.03）to（2.96±2.43. All differences were statistically significant ($p<0.01$). Stratified subgroup analysis revealed that among patients with mild tinnitus handicap, both the 3–12 months duration group and the>12months duration group exhibited lower questionnaire scores after treatment compared with baseline; however, no statistically significant differences were observed between the two groups immediately after treatment ($p>0.05$). At the one-month follow-up, patients with disease duration>12 months demonstrated significantly higher questionnaire scores than those with disease duration <12months, and the differences were statistically significant ($p<0.05$). These findings suggest that patients with longer disease duration (>12months) and mild tinnitus handicap may experience short-term symptom rebound after treatment, with relatively shorter maintenance of therapeutic efficacy and poorer long-term stability. Among patients with moderate tinnitus handicap, although scores in both the 3–12months duration group and the>12months duration group decreased after treatment compared with baseline, no statistically significant between-group differences were identified ($p>0.05$). At the one-month follow-up, scores in both groups increased slightly compared with post-treatment levels; however, the differences remained statistically insignificant ($p>0.05$).

Conclusions: Acupuncture combined with low-frequency rTMS significantly improved tinnitus severity, anxiety symptoms, and sleep quality in patients with chronic subjective tinnitus. This combined neuromodulatory intervention may represent a promising noninvasive therapeutic strategy for tinnitus management.

Key words: chronic subjective tinnitus; acupuncture; repetitive transcranial magnetic stimulation; neuromodulation; anxiety; insomnia

Introduction

Subjective tinnitus is defined as the perception of sound in the absence of an external auditory stimulus [1]. The intensity and acoustic characteristics of tinnitus vary considerably among individuals and may present as high- or low-frequency sounds that are pulsatile, continuous, or intermittent in nature [2]. Patients may perceive tinnitus unilaterally, bilaterally, or deep within the head [3]. In recent years, the prevalence of tinnitus has continued to increase worldwide. Epidemiological studies indicate that approximately 14.4% of adults globally experience tinnitus, among whom nearly 2.3% suffer from severe tinnitus symptoms [4, 5]. According to the 2014 American Clinical Practice Guideline for Tinnitus, tinnitus persisting for longer than six months is classified as chronic tinnitus [6]. Chronic tinnitus not only causes persistent auditory discomfort and dysfunction of the auditory system but is also frequently associated with psychological and neurological disorders, including anxiety, depression, and insomnia, thereby significantly impairing patients' quality of life [7-9]. Furthermore, chronic tinnitus imposes a substantial economic burden on healthcare systems, accounting for billions of dollars in annual medical expenditures worldwide [10]. Previous studies have demonstrated that the severity of tinnitus symptoms is positively correlated with disease duration [11].

Although the precise pathophysiological mechanisms underlying tinnitus remain incompletely understood, accumulating evidence suggests that tinnitus may arise from maladaptive neuroplastic changes within central auditory system regions responsible for processing auditory information under conditions of auditory deprivation [12-14]. Current tinnitus management strategies, including cognitive behavioral therapy, sound therapy, and health education, mainly focus on symptom control rather than eliminating the underlying neural mechanisms responsible for tinnitus perception [15]. Consequently, therapeutic outcomes remain suboptimal.

Acupuncture has been shown to effectively alleviate subjective tinnitus symptoms, potentially through modulation of central nervous system plasticity induced by acupuncture stimulation [16, 17]. In recent years, an increasing number of physiological studies have confirmed that neuromodulation techniques exert therapeutic effects by regulating neuronal activity and functional connectivity [18]. Repetitive transcranial magnetic stimulation (rTMS), a promising noninvasive neuromodulatory approach, has demonstrated favorable safety and efficacy profiles in regulating neural activity and enhancing neuroplasticity [19, 20]. Therefore, rTMS may provide a potential therapeutic strategy for tinnitus and other neurological disorders [21-23], with no severe adverse events reported to date [24, 25].

Therefore, the present prospective clinical study aimed to evaluate the efficacy of acupuncture combined with low-frequency rTMS in patients with chronic subjective tinnitus.

Materials and Methods

Participants

This prospective study enrolled 72 patients with chronic subjective tinnitus treated at the China–Kazakhstan Traditional Medicine Center between June 2025 and April 2026. The cohort consisted of 38 males and 34 females aged 29–82 years (mean age: 62.94±10.64 years).

Inclusion Criteria : 1. Age ≥18 years; 2. Persistent unilateral or bilateral tinnitus lasting ≥3 months; 3.THI score >18

Exclusion Criteria: 1. Objective tinnitus or acoustic neuroma; 2. Severe sensorineural hearing loss; 3. History of epilepsy or severe systemic disease; 4. Acute ear infection within one month;5. Contraindications to rTMS, including implanted metallic devices

6.Current use of vestibular suppressants, antipsychotics, anxiolytics, antiepileptic drugs, or ototoxic medications;7. History of alcohol or substance abuse

Acupuncture Intervention: Selected acupoints included Ermen (TE21), Tinggong (SI19), Tinghui (GB2), Yifeng (TE17), Fengchi (GB20), Yanglingquan (GB34), Taichong (LR3), Zhongzhu (TE3), and Waiguan (TE5). Disposable sterile acupuncture needles (0.25 mm × 25 mm) were used. Needles were retained for 30 minutes per session. Treatment was administered once daily, six times weekly, for two consecutive weeks.

rTMS Protocol: Low-frequency rTMS was delivered using the NTK-TMS-II200 stimulator. Stimulation targets were localized between T3 and P3 according to the international 10–20 EEG system. All patients received left temporoparietal stimulation regardless of tinnitus laterality.

Stimulation parameters were as follows:Frequency: 1 Hz;Intensity: 80%–120% resting motor threshold;Pulses: 960 per session;Intertrain interval: 3 seconds

Outcome Measures

Primary outcomes: Tinnitus Handicap Inventory (THI), The Tinnitus Handicap Inventory (THI) consists of three domains, including functional, emotional, and catastrophic subscales, comprising a total of 25 items with a maximum score of 100 points. According to the total THI score, tinnitus severity can be classified into five grades. Scores ranging from0to 16 indicate slight tinnitus (Grade I), suggesting no significant impact on daily life. Scores of 18–36indicate mild tinnitus (Grade II), characterized by occasional interference with daily activities. Scores of 38–56 indicate moderate tinnitus (Grade III), reflecting a noticeable impact on daily life. Scores of 58–76 indicate severe tinnitus (Grade IV), associated with substantial impairment in daily functioning. Scores of 78–100 indicate catastrophic tinnitus (Grade V), characterized by severe disruption of daily activities accompanied by psychological distress.

Visual Analogue Scale (VAS), The Visual Analogue Scale (VAS) is a subjective assessment tool used to evaluate patients' perceived tinnitus loudness. The scale ranges from 0 to 10, where 0 indicates the complete absence of tinnitus perception and 10 represents extremely severe and intolerable tinnitus loudness. The grading criteria are defined as follows: a score of 0 indicates no tinnitus symptoms; scores of 1–3 indicate mild tinnitus, characterized by tolerable symptoms without significant interference with daily activities or sleep; scores of 4–6 indicate moderate tinnitus, associated with obvious discomfort and sleep disturbance, often requiring pharmacological or physical intervention; and scores of 7–10 indicate severe tinnitus, characterized by intense and unbearable

symptoms resulting in inability to perform normal daily activities or sleep, thereby requiring urgent clinical management.

Secondary outcomes: Self-Rating Anxiety Scale (SAS), The Self-Rating Anxiety Scale (SAS) has a raw total score ranging from 20 to 80. Prior to evaluation, the raw score is multiplied by 1.25 and rounded to obtain the standard score. According to the standardized scoring criteria, scores below 50 indicate the absence of clinically significant anxiety symptoms; scores of 50–59 indicate mild anxiety, characterized by slight symptoms without substantial impairment of daily functioning; scores of 60–69 indicate moderate anxiety, associated with more pronounced symptoms that may require pharmacological intervention; and scores ≥70 indicate severe anxiety, characterized by significant psychological distress requiring clinical evaluation and treatment.

Athens Insomnia Scale (AIS), The Athens Insomnia Scale (AIS) was used to evaluate sleep quality, with total scores ranging from 0 to 24 points. According to the scoring criteria, a total score of 0–4 indicates the absence of sleep disturbance, while scores of 4–6 suggest mild insomnia. Scores ≥6 are considered indicative of clinically significant insomnia. Scores ranging from 7 to 10 indicate moderate insomnia, characterized by obvious symptoms that interfere with daytime functioning and may require psychological or pharmacological intervention. Scores ≥11 indicate severe insomnia, characterized by serious symptoms that markedly impair quality of life and warrant systematic treatment.

Efficacy Evaluation: Therapeutic efficacy was evaluated according to the relevant criteria described in the 2014 American Clinical Practice Guideline for Tinnitus [6]. The evaluation criteria were defined as follows: complete recovery was defined as complete disappearance of tinnitus symptoms; marked improvement was defined as a reduction in tinnitus severity by two or more grades; improvement was defined as a reduction in tinnitus severity by one grade; and no improvement was defined as no observable change in tinnitus severity after treatment. The overall response rate was calculated using the following formula: Overall response rate (%) = (number of recovered cases + number of markedly improved cases + number of improved cases) / total number of cases × 100%.

Statistical Analysis: Statistical analyses were performed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD). Independent-sample t-tests and paired-sample t-tests were used where appropriate. A two-sided P value <0.05 was considered statistically significant.

Results

Baseline Characteristics

A total of 72 patients with chronic subjective tinnitus were enrolled in the present study, including 38 males and 34 females. The participants ranged in age from 29 to 82 years, with a mean age of 62.94±10.64 years. The mean total Tinnitus Handicap Inventory (THI) score was 41.25±10.98, indicating a moderate degree of tinnitus-related handicap. The mean Visual Analogue Scale (VAS) score for tinnitus loudness was 3.44±1.36. In addition, the mean Self-Rating Anxiety Scale (SAS) score was 40.91±9.08, while the mean Athens Insomnia Scale (AIS) score was 4.81±3.05, suggesting varying degrees of anxiety symptoms and sleep disturbance among the study population.

Variable	Value
Age (years)	62.94 ± 10.64
Male, n (%)	38 (52.8%)
Female, n (%)	34 (47.2%)
Duration of tinnitus (months)	27.57 ± 19.56
THI score	41.25 ± 10.98
VAS score	3.44 ± 1.36
SAS score	40.91 ± 9.08
AIS score	4.81 ± 3.05

Table 1: Baseline Characteristics of Patients with Chronic Subjective Tinnitus (n = 72)

Data are presented as mean ± SD unless otherwise indicated.

Changes in THI and VAS Scores

Regarding the primary outcome measures, changes in THI scores before and after treatment in patients with tinnitus were analyzed. At baseline, the mean total THI score was（41.16±11.14, indicating mild-to-moderate tinnitus-related distress. Following the intervention, the total THI score significantly decreased to（25.25±11.23, with the difference reaching statistical significance (P<0.01). At the 1-month follow-up, the THI score was（26.36±10.98, showing no significant difference compared with the immediate post-treatment assessment; however, it remained significantly lower than the baseline value (P < 0.01).

With respect to the Visual Analog Scale (VAS), the mean baseline score was（3.44±1.36）, which decreased to（1.61±0.88）after treatment. At the 1-month follow-up, the VAS score was（1.69±0.983）. No statistically significant difference was observed between the post-treatment and follow-up assessments; nevertheless, the score remained significantly lower than the pretreatment level (P < 0.01).

Analysis of the THI subdomains demonstrated significant improvements across all dimensions. The functional subscale score decreased from（19.14±4.16）before treatment to（12.39±4.61）after treatment (P < 0.01). At the 1-month follow-up, the functional score was（14.21±4.47, showing no significant difference compared with the post-treatment value, while remaining significantly lower than baseline (P < 0.01).

Similarly, the emotional subscale score decreased significantly from（15.75±4.81）to （10.36±4.60）after treatment (P < 0.01). One month later, the emotional score was （11.36±2.87）, with no significant difference compared with the immediate post-treatment assessment; however, the difference remained statistically significant relative to baseline (P<0.01).

The catastrophic subscale score also showed a significant reduction, decreasing from（6.28±2.58）at baseline to（2.98±2.77）after treatment (P<0.01). At the 1-month follow-up evaluation, the score was（3.06±2.99）, which did not differ significantly from the post-treatment level but remained significantly lower than the pretreatment value (P < 0.01).

Collectively, these findings suggest that acupuncture combined with low-frequency transcranial magnetic stimulation may exert beneficial effects in improving tinnitus-related functional impairment, emotional distress, and catastrophic responses in patients with chronic subjective tinnitus (Table 2, Figure 1).

Catastrophic Subscale	Emotional Subscale	Functional Subscale	VAS	THI	Time Point
6.28 ± 2.58	15.75 ± 4.81	19.14 ± 4.16	3.44 ± 1.36	41.16 ± 11.14	Baseline
2.98 ± 2.77**	10.36 ± 4.60**	12.39 ± 4.61**	1.61 ±0.88**	25.25 ± 11.23**	Post-treatment
3.06 ± 2.99**	11.36 ± 2.87**	14.21 ± 4.47**	1.69 ± 0.98**	26.36 ± 10.98**	1-Month Follow-up
**P < 0.01 versus baseline.					

Table 2: Comparison of THI and VAS Scores Before and After Treatment

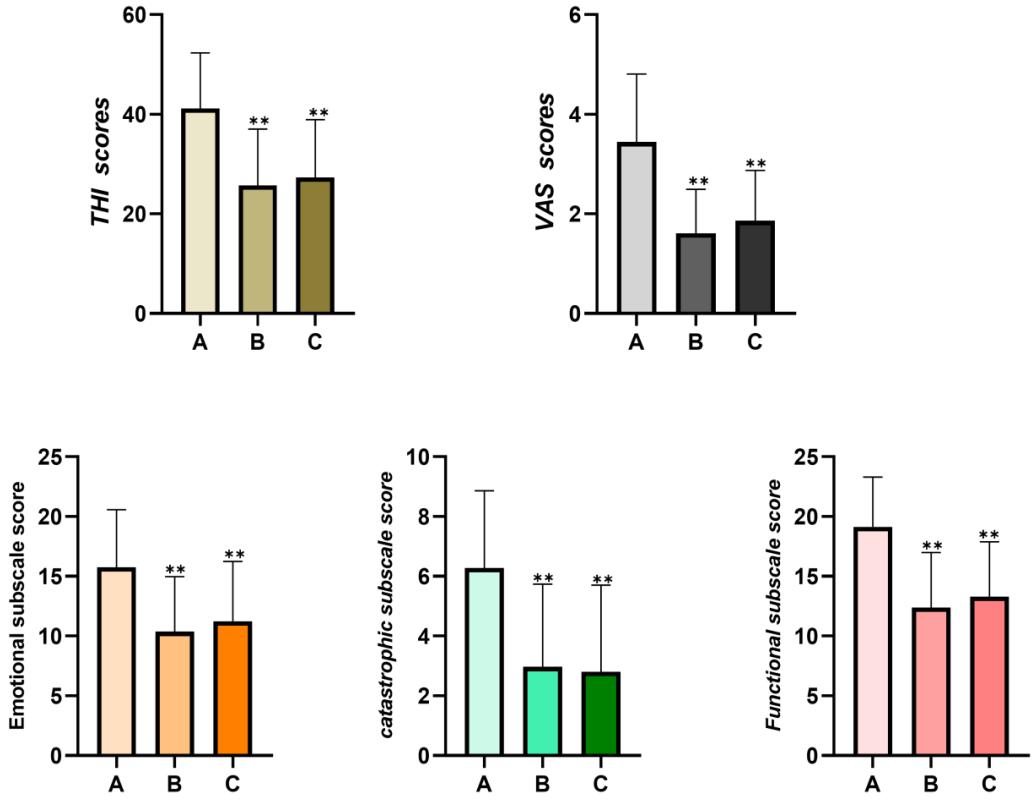

Figure 1: (A)Baseline; (B) Post-treatment; (C) One-month follow-up.

Changes in THI and VAS scores before treatment, immediately after treatment, and at one-month follow-up.

Changes in SAS and AIS Scores

Compared with baseline, both anxiety and insomnia symptoms were significantly improved following treatment. SAS scores decreased from（55.03±3.06）at baseline to （45.06±5.44）after treatment (P<0.01). At one-month follow-up, SAS scores slightly increased to（47.13±4.96）but remained significantly lower than pretreatment levels (P < 0.01). AIS scores significantly decreased from（4.85±3.03）before treatment to（2.96±2.43）after treatment(P<0.01). At follow-up, AIS scores were （3.02 ± 2.44） and remained significantly lower than baseline values (P<0.01). These findings indicated that the combined intervention effectively alleviated tinnitus-related anxiety and sleep disturbances (Table 3, Figure 2).

Time Point	SAS	AIS
Baseline	55.03 ± 3.06	4.85 ± 3.03
Post-treatment	45.06 ± 5.44**	2.96 ± 2.43**
1-Month Follow-up	47.13 ± 4.96**	3.02 ± 2.44**

Table 3: Comparison of SAS and AIS Scores Before and After Treatment

**P < 0.01 versus baseline.

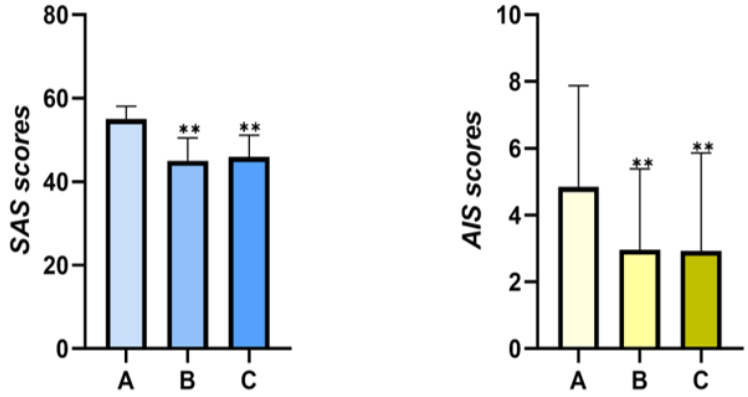

Figure 2: (A)Baseline; (B) Post-treatment; (C) One-month follow-up.

Changes in SAS and AIS scores before treatment, immediately after treatment, and at one-month follow-up.

Correlation Between Disease Duration and Therapeutic Efficacy

Among patients with mild tinnitus handicap, both the 3–12 months duration group and the >12 months duration group demonstrated reductions in all questionnaire scores after treatment compared with baseline values; however, no statistically significant differences were observed between the two groups immediately after treatment (P>0.05). At the one-month follow-up assessment, patients with disease duration >12 months exhibited significantly higher questionnaire scores than those with disease duration <12 months, and the differences were statistically significant (P<0.05). These findings suggest that patients with mild tinnitus handicap and longer disease duration (>12 months) may experience short-term symptom rebound following treatment, with relatively shorter maintenance of therapeutic efficacy and poorer long-term stability. (Table 4, Figure 3).

Among patients with moderate tinnitus handicap, both the 3–12 months duration group and the >12 months duration group showed reduced scores after treatment compared with baseline values; however, no statistically significant between-group differences were identified (P>0.05). At the one-month follow-up, scores in both groups increased slightly compared with those measured immediately after treatment, although the differences remained statistically insignificant (P>0.05). These results indicate that therapeutic efficacy in patients with moderate tinnitus handicap could be maintained for at least one month after treatment, with no significant differences in short-term efficacy maintenance between patients with different disease durations. (Table 5, Figure 4).

Time Point	EXAM
3–12 months group (Post-treatment)	14.57 ± 1.66
>12 months group (Post-treatment)	7.82 ± 4.33
3–12 months group (1-Month Follow-up)	15.52 ± 5.13
>12 months group (1-Month Follow-up)	20.81 ± 5.81*

Table 4: Correlation Between Disease Duration and THI Severity in Mild Tinnitus Patients

**P < 0.05, versus 3–12 months group at one-month follow-up.*

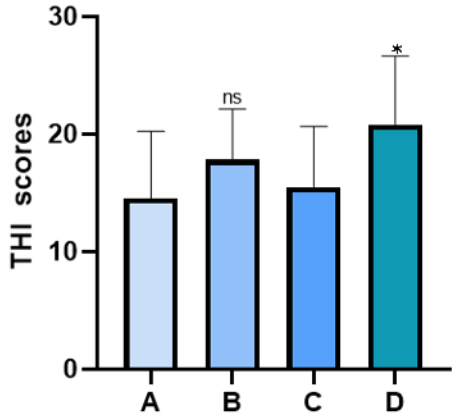

Figure 3: Correlation analysis between disease duration and THI severity in mild tinnitus patients.

(A)3–12 months group after treatment;

(B)12 months group after treatment;

(C)3–12 months group at one-month follow-up;

(D)12 months group at one-month follow-up.

Time Point	EXAM
3–12 months group (Post-treatment)	27.00 ± 1.41
>12 months group (Post-treatment)	34.76 ± 6.89
3–12 months group (1-Month Follow-up)	27.00 ± 4.24
>12 months group (1-Month Follow-up)	36.54 ± 7.00

Table 5: Correlation Between Disease Duration and THI Severity in Moderate Tinnitus Patients

No statistically significant difference was observed between groups (P > 0.05).

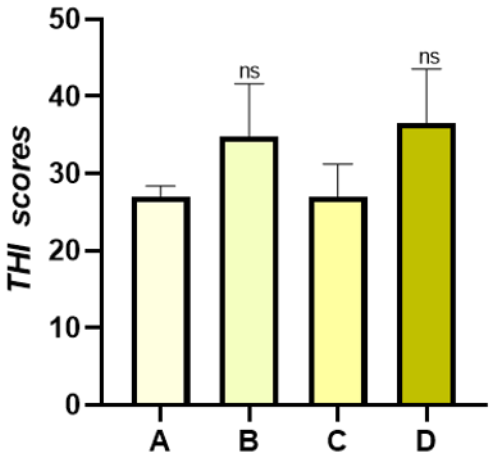

Figure 4: Correlation analysis between disease duration and THI severity in moderate tinnitus patients.

(A)3–12 months group after treatment;

(B)12 months group after treatment;

(C)3–12 months group at one-month follow-up;

(D)12 months group at one-month follow-up.

Discussion

The present study aimed to investigate the therapeutic efficacy of acupuncture combined with low-frequency repetitive transcranial magnetic stimulation (rTMS) in patients with chronic subjective tinnitus. A short-term 2-week treatment protocol was adopted, consisting of one session per day for 6 days per week. The rationale for selecting this regimen was primarily based on substantial evidence indicating that rTMS exerts significant therapeutic effects in reducing the severity of chronic tinnitus and improving associated comorbidities, including depression, anxiety, and insomnia. Some studies have even suggested that the evidence supporting rTMS for tinnitus may be stronger than that for depression treatment using rTMS [26-28].

Previous studies have demonstrated that maladaptive neuroplastic changes within the central nervous system play a crucial role in the occurrence and progression of tinnitus [29, 30]. When the brain anticipates auditory input but fails to receive actual acoustic stimulation, the affected cortical regions may generate tinnitus perception as a compensatory mechanism to maintain neural homeostasis [31]. Extensive evidence has shown that conventional acupuncture can effectively alleviate tinnitus symptoms and facilitate recovery of central nervous system function [32-34].

According to traditional Chinese medicine (TCM) theory, the Gallbladder Meridian and Triple Energizer Meridian are closely associated with auditory function. Regulation of these meridians may improve local blood circulation around the ear through promoting meridian patency and facilitating the circulation of qi and blood [35]. Several acupoints distributed along the Gallbladder Meridian, such as Ermen (TE21) and Tinghui (GB2), are closely related to ear function. Stimulation of these acupoints may enhance qi and blood circulation within the meridian, thereby increasing blood supply to the auditory region and relieving symptoms such as tinnitus and hearing impairment [36]. Meanwhile, the Triple Energizer Meridian is also considered closely associated with auditory health. Acupuncture or massage stimulation at acupoints along this meridian, including Waiguan (TE5) and Zhongzhu (TE3), may regulate visceral function and promote systemic qi-blood circulation, thereby improving microcirculation within the ear [37]. This holistic regulatory approach may not only alleviate auditory discomfort but also enhance the recovery capacity of auditory function. Clinical studies have demonstrated favorable therapeutic outcomes of treatments targeting the Gallbladder and Triple Energizer meridians in patients with ear disorders. By regulating qi and blood circulation through stimulation of these meridians, local microcirculation and blood perfusion of the ear may be

effectively improved, thereby supporting functional recovery of the auditory system [38, 39].

Low-frequency (1Hz) rTMS has been shown not only to rapidly improve tinnitus symptoms and hearing function in the short term, but also to maintain long-term therapeutic benefits, particularly when applied to the dorsolateral prefrontal cortex (DLPFC) [40, 41]. These findings suggest that low-frequency rTMS may suppress cortical hyperexcitability [42-44] and promote reorganization of functional connectivity within the auditory cortex [45], which may represent the key mechanism underlying its sustained therapeutic effects on tinnitus severity. Previous neuroimaging studies have demonstrated that the connectivity among the auditory cortex, limbic system, prefrontal cortex, and parietal cortex largely determines tinnitus severity, whereas connectivity between the parietal cortex and auditory cortex may influence auditory processing [46, 47]. Therefore, rTMS targeting these brain regions may simultaneously improve hearing loss and tinnitus symptoms [48-50]. Positron emission tomography (PET) studies have further confirmed that positioning the rTMS coil over the left temporal cortex for 1–2 weeks can significantly reduce tinnitus symptoms. Consequently, low-frequency rTMS applied to the left auditory cortex appears effective in both unilateral and bilateral tinnitus patients.

The findings of the present study demonstrated that acupuncture combined with low-frequency rTMS produced significant therapeutic effects in patients with chronic subjective tinnitus and effectively improved subjective symptoms. Specifically, scores on the Tinnitus Handicap Inventory (THI), Visual Analog Scale (VAS), Self-Rating Anxiety Scale (SAS), and Athens Insomnia Scale (AIS) all decreased to varying degrees following treatment, indicating improvements in tinnitus severity, loudness perception, anxiety, and insomnia symptoms. These results support the comprehensive therapeutic role of 1 Hz rTMS in modulating tinnitus-related dysfunction, emotional disturbances, and sleep disorders, suggesting that it may serve as an effective neuromodulatory intervention in clinical practice.

Nevertheless, several limitations should be acknowledged. First, the relatively small sample size and absence of a randomized controlled design may have reduced statistical power and limited the ability to fully exclude the influence of chance findings or potential selection bias. Second, the 12-day intensive treatment regimen employed in this study was based on previously reported effective protocols; future studies should explore whether prolonged treatment duration or maintenance therapy could further enhance therapeutic outcomes. In addition, substantial individual variability existed among patients with respect to age, disease duration, concomitant insomnia and anxiety, as well as tinnitus severity. Owing to the limited sample size, these common confounding factors were not adjusted for in the present analysis, and their influence on treatment outcomes requires further clarification in larger-scale studies. Finally, the follow-up duration was relatively short, and symptom fluctuations were observed in some patients during the later stages of follow-up, indicating that the long-term stability of therapeutic efficacy remains uncertain.

Future studies should therefore incorporate longer follow-up periods, larger sample sizes, randomized controlled trial designs, and multicenter collaboration to further validate the efficacy of this combined intervention and optimize treatment protocols. Moreover, comparative studies involving different treatment frequencies and durations, particularly short-course versus long-course interventions, are warranted to determine the optimal therapeutic regimen and provide evidence-based support for standardized treatment strategies.

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