



Neuromodulation and psychotherapy for the treatment of anxiety spectrum disorders in primary otoneurological conditions: a systematic review

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Abstract: Anxiety spectrum disorders in patients with primary otoneurological conditions have been explored for treatment using psychotherapy and non-invasive brain stimulation. However, fragmented evidence complicates the identification of effective and safe clinical protocols. **Objective:** This study aimed to summarize the evidence on the efficacy of non-invasive neuromodulation and psychotherapy in managing anxiety spectrum disorders linked to otoneurological conditions. **Material and methods:** A registered PRISMA-guided systematic review (PROSPERO: CRD420250654796) analyzed clinical studies from PubMed, LILACS, SciELO, APA, and PePsic. Studies evaluating non-invasive brain stimulation and/or psychotherapy for anxiety in otoneurological conditions were included, with no restrictions on publication year or language.

Two independent researchers searched for articles using the Ryvan tool. A third researcher participated in the final decision on the inclusion of pre-selected studies. The Cochrane Risk of Bias 2 (Rob2) tool was used to analyze the methodological quality of the included studies. Data on the study population, characteristics of the interventions, and results with the respective effect sizes were extracted from the selected studies. **Results:** Of 821 screened studies, 11 met eligibility criteria: seven randomized clinical trials, three observational studies, and one case report. Six studies supported psychotherapy, particularly cognitive behavioral therapy (CBT), while five highlighted the efficacy and safety of non-invasive brain stimulation. Of these, one tested the efficacy and safety of intermittent Theta Burst Stimulation (iTBS), one of non-invasive vagus nerve stimulation (nVNS) and three evaluated transcranial Direct Current Stimulation (tDCS). However, methodological heterogeneity, small sample sizes, and varying study designs and outcomes limited the ability to make a meta-analysis and recommend these interventions as first-line treatments. **Conclusion:** Psychotherapy and non-invasive neuromodulation show promise as complementary approaches to vestibular rehabilitation for anxiety in otoneurological conditions. However, current evidence is insufficient for widespread clinical recommendation. Further high-quality, large-scale studies are needed to establish standardized protocols and confirm efficacy and safety.

Summary Box

- To our knowledge, this is the first systematic review to synthesize clinical studies on the treatment of anxiety disorders associated with otoneurological conditions.
- The findings of this systematic review hold significant clinical relevance, offering evidence-based insights that could refine therapeutic strategies for managing anxiety disorders in patients with otoneurological conditions, ultimately improving patient outcomes and quality of life.

Keywords: Vertigo; Dizziness; Anxiety Disorders; Psychotherapy; Non-Invasive Brain Stimulation.

Introduction

Dizziness, characterized by a sense of body imbalance, instability, or altered perception of the environment, and vertigo, defined as the illusion of movement of one's own body or the surroundings, are prevalent symptoms experienced by both the general population and individuals with various neurological and/or psychiatric conditions.¹ It is estimated that approximately 20 to 30% of adults experience dizziness or vertigo at some point in their lives.² Among the most common conditions associated with these symptoms are benign paroxysmal positional vertigo (BPPV), Menière's disease, vestibular migraine, persistent postural perceptual dizziness (PPPD), vestibular neuritis, and Débarquement syndrome.³

Certain groups are at a higher risk of developing balance-related disorders, also known as otoneurological syndromes. These include the elderly, women, and individuals with comorbidities such as heart disease, diabetes, hypertension, infections, stress, anxiety, depression, panic disorders, and sleep disturbances.⁴ Notably, anxiety spectrum disorders are frequently linked to otoneurological dysfunctions.⁵ The impact of these symptoms on quality of life is significant, often leading to reduced productivity, social withdrawal, and overall functional impairment.⁶⁻⁸

Otoneurological syndromes arise from a variety of underlying mechanisms, including sensory disintegration, reduced cerebral blood flow,⁹ dysfunction in limbic networks — particularly those involving the hippocampus and amygdala — and abnormalities in the vestibulo-ocular reflex or ocular motility.¹⁰ While first-line treatments such as vestibular rehabilitation exercises, pharmacological interventions, and labyrinthine crystal repositioning maneuvers (e.g., the Epley maneuver) have shown favorable outcomes, a subset of patients experience incomplete symptom relief.¹¹ This highlights the need for complementary therapeutic approaches to address the multifaceted nature of these conditions, particularly in cases where anxiety and balance disorders coexist.

Given the complex and multidimensional nature of otoneurological dysfunctions and anxiety spectrum disorders, interdisciplinary approaches are essential. Psychotherapy and non-invasive neuromodulation techniques, grounded in applied neuroscience, offer promising avenues for alleviating symptoms and improving quality of life. These approaches can complement traditional biopsychosocial interventions, providing a more holistic treatment framework.

Non-invasive neuromodulation techniques, such as tDCS,¹² rTMS,¹³ taVNS,¹⁴ and psychotherapeutic interventions like CBT,¹⁵ have emerged as promising avenues. Several systematic reviews have evaluated these interventions in related, yet distinct, contexts. For instance, existing SRs have synthesized evidence on neuromodulation for *generalized anxiety disorder*¹⁶ or for *tinnitus*,¹⁷ and on CBT for *vertigo and dizziness* or *vestibular disorders*.¹⁸ However, these reviews have either focused on psychiatric populations without a primary otoneurological diagnosis or on otoneurological populations without a specific focus on quantifying anxiety outcomes. Crucially, no systematic review to date has specifically and concurrently evaluated the effects of both neuromodulation *and* psychotherapy *targeting anxiety symptoms* in patients with *primary otoneurological syndromes*. This represents a significant gap, as the neurophysiological and cognitive mechanisms underlying conditions like PPPD or vestibular migraine suggest that combined or comparative analysis of these brain-targeting interventions is not only logical but necessary.

Based on the PICO strategy question “What are the effects of non-invasive neuromodulation (e.g., tDCS, rTMS, taVNS) and psychotherapy (e.g., CBT) compared to control conditions (e.g., sham stimulation, standard care, other therapies) on anxiety symptoms and otoneurological outcomes in individuals with primary otoneurological syndromes (e.g., PPPD, vestibular migraine, Menière's disease)?”, the present systematic review aimed to fill this gap by synthesizing the available evidence on the effects of non-invasive neuromodulation and psychotherapy specifically for anxiety spectrum symptoms in individuals with primary otoneurological conditions. By directly comparing and consolidating findings across these two innovative therapeutic domains, we sought to clarify their relative efficacy, identify potential synergistic mechanisms, and evaluate the safety and feasibility of their application in otoneurology. This focused approach will provide clinicians with a nuanced evidence base to guide the integration of these therapies into personalized treatment strategies, addressing the intertwined vestibular and emotional components of these disabling conditions.

Methods

This systematic literature review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and is registered with PROSPERO under the registration number CRD420250654796.

Data selection process

To ensure methodological transparency and compliance with PRISMA guidelines, this review included a dedicated subsection describing the data selection process. The search was conducted across five databases: Medline - via PubMed, LILACS (Latin American and Caribbean Health Sciences Literature), SciELO (Scientific Electronic Library Online), APA PsycInfo (American Psychological Association), PePsic (Periódicos Eletrônicos em Psicologia), using combined strategies of controlled vocabulary and free-text keywords related to otoneurological conditions, anxiety spectrum disorders, and therapeutic interventions. Screening was conducted by two independent reviewers using the Rayyan platform, applying predefined inclusion and exclusion criteria. Duplicates were removed, followed by title and abstract screening and full-text assessment. A third reviewer resolved any disagreements. The PRISMA flow diagram (Figure 1) illustrates the identification, screening, eligibility, and inclusion phases of the selection process.

Inclusion criteria

The following types of clinical studies were included:

1. **Study designs:** Case reports, observational studies, case series, single-arm clinical trials, and randomized controlled trials (RCTs).
2. **Interventions:** Studies evaluating the effects of:
 - **Non-invasive neuromodulation techniques:** Transcranial electrical stimulation (tES), tDCS, TMS, taVNS, and focal ultrasound stimulation (FUS).
 - **Psychotherapy:** First-, second-, and third generation of CBT, Eye Movement Desensitization and Reprocessing (EMDR), psychoanalysis, psychodrama, and analytical therapy.
3. **Population:** Individuals with anxiety spectrum disorders (e.g., generalized anxiety disorder, panic disorder, obsessive-compulsive disorder (OCD), post-traumatic stress disorder, agoraphobia, or specific phobias) and primary otoneurological conditions, including:
 - Benign Paroxysmal Positional Vertigo (PPV)

- PPPD
 - Vestibular Migraine
 - Labyrinthitis
 - Parkinson's Disease
 - Ménière's Disease
 - Débarquement Disorder
 - Motion Sickness
 - Tinnitus
 - Vestibular Neuritis
4. **Language and publication date:** Studies published in any language and without restrictions on the year of publication were considered.
5. **Availability:** Studies must be accessible through the searched databases.

Exclusion criteria

The following studies were excluded:

- Experimental studies involving animals or cell cultures
- Mechanistic studies or studies focused solely on underlying mechanisms
- Review articles, protocol studies, or pilot studies
- Observational or interventional studies focusing on otoneurological disorders secondary to other diseases (e.g., stroke, multiple sclerosis, or brain tumors)

Search information

The following databases were consulted:

- Medline (via PubMed)
- LILACS
- SciELO
- APA PsycInfo
- PePsic

Search strategies

The search strategies were tailored to each database using a combination of controlled vocabulary (e.g., MeSH terms) and free-text keywords. The following general approach was adopted:

1. Population terms:

- Otoneurological conditions: "Benign Paroxysmal Positional Vertigo," "Persistent Postural Perceptual Dizziness," "Vestibular Migraine," "Labyrinthitis," "Parkinson's Disease," "Ménière's Disease," "Mal de Débarquement," "Motion Sickness," "Tinnitus," "Vestibular Neuritis."
- Anxiety spectrum disorders: "Generalized Anxiety Disorder," "Panic Disorder," "Obsessive-Compulsive Disorder," "Post-Traumatic Stress Disorder," "Agoraphobia," "Specific Phobias."

2. Intervention terms:

- Non-invasive neuromodulation: "Transcranial Electrical Stimulation," "Transcranial Magnetic Stimulation," "Trans auricular Vagus Nerve Stimulation," "Focal Ultrasound Stimulation."
- Psychotherapy: "Cognitive Behavioral Therapy," "EMDR," "Psychoanalysis," "Psychodrama," "Analytical Therapy."

3. Study design terms:

- "Case Report," "Observational Study," "Case Series," "Single-Arm Clinical Trial," "Randomized Controlled Trial", "Randomized Clinical Trial."

4. Combination of terms:

- Boolean operators (AND, OR) were used to combine terms related to population, interventions, and study designs. For example:

- ("Benign Paroxysmal Positional Vertigo" OR "Vestibular Migraine") AND ("Transcranial Magnetic Stimulation" OR "Cognitive Behavioral Therapy") AND ("Randomized Controlled Trial" OR "Case Series").

The complete strategies applied for the screening with respective results can be consulted in Appendix 1.

Filters:

No filters were applied for language or publication date to ensure a comprehensive search.

Results

The initial search identified 821 articles, with 15 from PubMed, 791 from LILACS, 13 from SciELO, 2 from APA, and none from PePsic. The identified studies were entered into the Rayyan platform (available at <https://new.rayyan.ai/reviews/1282038/overview>) by two independent reviewers. The reference lists of the pre-selected studies were also consulted to expand the scope of the collection. The data collection flowchart can be seen in Figure 1.

Study selection and characteristics

After applying the eligibility criteria and removing duplicate articles, eleven studies were selected for data extraction and analysis. Among these, four had declared registration in clinical trial databases. The included studies comprised seven clinical trials, three observational studies, and one case report. Geographically, the studies were distributed as follows: three conducted in Germany, two in Sweden, two in Switzerland, and one each in China, Belgium, Australia, and Brazil.

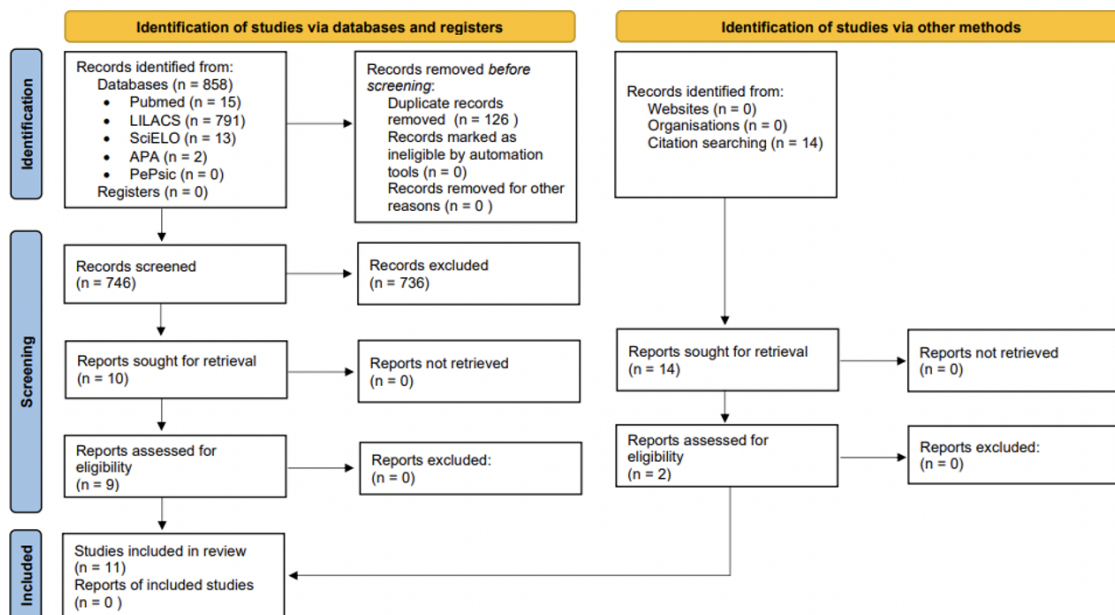


Figure 1. Flowchart of the study selection process according to the PRISMA guideline.

Note: This flowchart was adapted from the PRISMA 2020 flow diagram for new systematic reviews, licensed under CC BY 4.0. Modifications were made to the table format, text size, text box filling, and removal of editorial notes.

Otoneurological disorders and patient population

The otoneurological disorders investigated in the selected studies included: One study on Mal de Débarquement involving 20 patients, two studies on PPPD with 103 patients, three studies on general dizziness with a total of 75 patients, two studies on phobic vertigo involving 78 patients, two studies on tinnitus with 57 patients, and one case study involving 2 patients with OCD and associated dizziness symptoms. In total, this systematic review examined data from 335 patients with otoneurological disorders and anxiety symptoms.

Therapeutic approaches evaluated

The therapeutic interventions assessed in the studies included: One study evaluating Theta Burst Magnetic Stimulation, one study investigating classical repetitive magnetic stimulation, two studies examining the

effects of tDCS, one study exploring taVNS, and six studies focusing on psychotherapy, all of which utilized a CBT approach. A summary of the characteristics of the selected studies is provided in Table 1.

Table 1. Characteristics of the selected studies

Study	Country	Design	Test group	Comparative group	Otoneurological condition
Browne et al., 2024 ¹⁹	Australia	RCT	10	10	Mal de Debarquement
Yu et al., 2018 ²⁰	China	RCT	46	45	PPPD
Schaaf & Hesse, 2015 ²¹	Germany	Cohort	18	5	Chronic Dizziness
Schmid et al., 2020 ²²	Switzerland	Retrospective cohort	20	20	PPPD
Silva et al., 2016 ²³	Brazil	Case report	2	N/A	OCD
Holmberg et al., 2007 ²⁴	Germany	Follow-up study of RCT	24	N/A	PPV
Holmberg et al., 2005 ²⁵	Sweden	CT	16	15	PPV
Dale et al., 2023 ²⁶	Sweden	RCT	81	78	PPPD
Eren et al., 2018 ²⁷	Germany	RCT	12	11	PPPD
Pal et al., 2015 ²⁸	Switzerland	RCT	21	21	Tinnitus
Faber et al., 2012 ²⁹	Belgium and USA	RCT	8	7	Tinnitus

Legend: CT = Clinical Trial without control group; N/A = not applicable; USA = United States of America; OCD = obsessive compulsive disorder; PPPD = Persistent Postural-Perceptual Dizziness; PPV - Phobic Postural Vertigo; RCT = Randomized Clinical Trial.

The therapeutic protocols (Table 2) were applied from four weeks to one year of intervention. The results obtained with the approaches examined presented effect sizes that ranged from 0.54 to 4.6 in the difference between the means in the intra- and inter-group comparison (Cohen's *d* or Hedges' *g*).

Table 2. Therapeutic protocols and results obtained.

Study	PICO Strategy	Follow-up	Parameters	Effect Size	Results (+ or -)
Browne et al., 2024 ¹⁹	P = Mal de Debarquement I = tTBS + VOR vs. VOR C = Sham O = DHI, BDI, HADS-A, HADS-D, MSQ, MdDS-SQ	16 weeks	5 sessions a day 4 days 8 Coil left-DLPFC 50Hz Interval 200ms 2 trains 600 pulses/train	F (3.54) = 9.201	Both + No difference between groups
Yu et al., 2018 ²⁰	P = PPPD I = CBT + Sertraline C = Sertraline O = HARS+HDRS+DHI*	8 weeks	Sertraline daily CBT 2 sessions a week	g = 1.5	Both +, but TG > CG
Schaaf & Hesse, 2015 ²¹	P = Chronic Dizziness I = Psychotherapy C = Not Applicable O = HADS	1 year	Neurological counseling twice, CBT individual and group Health education Exercise Tai Chi Chuan Relaxation Balance training	g = 3.1	Both + No difference between groups
Schmid et al., 2014 ²²	P = Persistent dizziness I = CBT + VOR + Psychoeducation C = Not applicable O = DHI* + BSI + QoL + SoH	N/R	CBT 8 sessions	HADS g = 3.9	Intra groups analysis only
Silva et al., 2016 ²³	P = OCD resistant I = tDCS + SSRI C = Sham + SSRI O = Y-BOCS*, BAI, BDI	4 weeks by 6 months	20 daily sessions for 30 minutes (2 h) Cathode in bilateral SMA Anode on deltoid muscle	g = 0.59 one patient with significant improvement reduction of 50% in both BDI and the BAI scores; improvement of 17% in YBOCS scores and other remained symptomatic	Both +
Holmberg et al., 2007 ²⁴	P = PPV I = CBT+VR C = Not Applicable O = DHI, VSS, VHQ, HADS	1 year	10 CBT sessions (between 8 - 12); to be stand up in situations that provoke dizziness	NR	Follow-up - limited long-term effect
Holmberg et al., 2005 ²⁵	P = PPV I = CBT C = SVR + vestibular exercises O = Reduction in dizziness handicap, vertigo symptoms (VHQ and DHI), anxiety (HAS), and depression (HDS)	8-12 sessions	10 sessions of CBT Vs. Daily exercises by 15 minutes 2 times a day	VHQ = 2.79 HAS = 2.99 HDS = 2.36	Both + TG > CG
Dale et al., 2023 ²⁶	P = Patients with functional vertigo or dizziness I = Integrative Psychotherapeutic Group C = Treatment (IPGT) O = Self-Help Group (SHG) Active control VHQ	16 weeks	One time a week 90 minutes 6-10 participants 2 therapist a group	VHQ = 2.09 (physical symptoms)	Both +
Eren et al., 2018 ²⁷	P = PPPD I = nVNS + SOC C = SOC O = Improved quality of life	Part I = 4 weeks Part II = 4 weeks	Electrical sign of low tension (synodal waves of 5kHz each during 1ms Each 40ms (25Hz) 3 stimulations for 2 minutes 5 minutes of interval 2 times a day On right neck side (on vagus nerve)	Cohen's f ² = 0.853	Both + After 2 phases
Pal et al., 2015 ²⁸	P = Tinnitus I = tDCS C = Sham O = THI	5 days 1 month 3 months	5 consecutive days A on PFC 2mA 20 minutes (Test group) 1mA 90 sec (Sham group)	First month = 0.08 Third month = 0.18	Both +
Faber et al., 2011 ²⁹	P = Tinnitus I = tDCS on Left DLPFC C = Sham (n = 8) and Right DLPFC (n=7) O = HADS + VAS	2 weeks 8 weeks of washout	tDCS on left-DLPFC Cathode on right-DLPFC 1mA 20 minutes 6 sessions	Tinnitus S = - 2.06 Depression U = 8 Anxiety S = - 0.27 (p = 0.78)	Both +

Legend: BAI = Beck Anxiety Inventory; BDI = Beck Depression Inventory; CBT = Cognitive Behavioral Therapy; CG = Control Group; NR = Not reported; PICO = Patient/Population, Intervention/Exposition, Comparison, Outcomes; tDCS = transcranial Direct Current Stimulation; DHI = Dizziness Handicap Inventory; DLPFC = Dorsolateral Prefrontal Cortex; DO = Dizziness Only; HADS = Hospital Anxiety and Depression Scale; HARS = Hamilton Anxiety Rating Scale; HDRS = Hamilton Depression Rating Scale; IPGT = Integrative Psychotherapeutic Group Treatment; MdDS-SQ = Mal de Debarquement Syndrome Symptom Questionnaire; QoL = Quality of Life; rTMS = repetitive Transcranial Magnetic Stimulation; SHG = Self help group; SoH = State of Health; SMA = Supplementary Motor Area; SSRI = Selective serotonin reuptake inhibitor; SoH = State of Health; SOC = Standard of Care; SVR = Self-Administered Vestibular Rehabilitation; taVNS = trans auricular vagus nerve stimulation; THI = Tinnitus Handicap Inventory; VHQ = Vertigo Handicap Questionnaire; TG = Test Group; VR = Vestibular rehabilitation; VOR = vestibular ocular reflex; VSS = Vancouver Symptom Score; Y-BOCS = Yellow Brown Obsessive Compulsive Scale.

The RoB 2 tool detected from low to moderate risk of bias in all studies except one study²⁰ that had presented little information about the randomization process, deviation of main outcomes and outcome measures. Two studies^{19,29} were conducted without risk of bias (Figure 2).

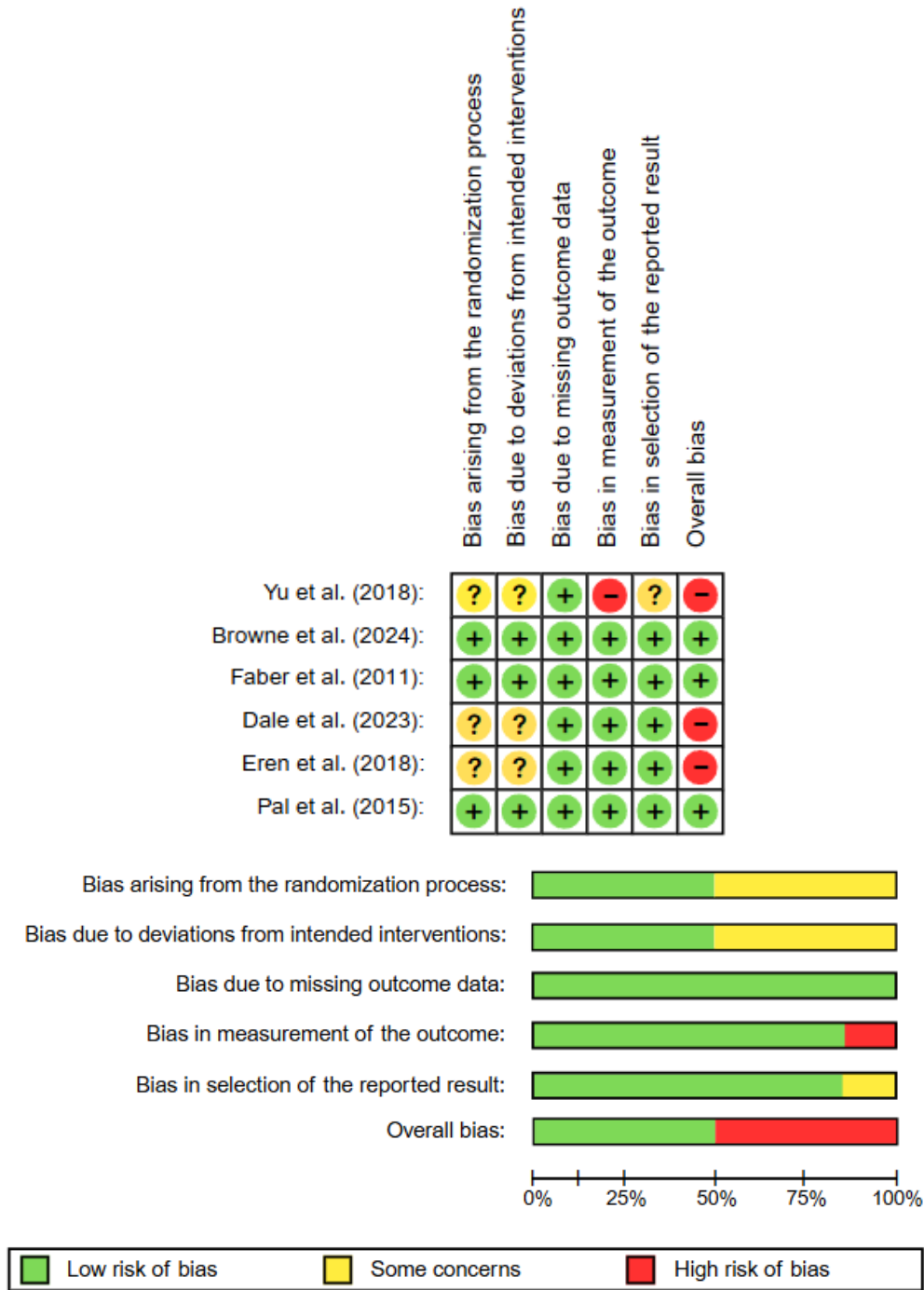


Figure 2. Risk of bias analysis according Cochrane guideline.

Discussion

This review aimed to summarize the evidence on the efficacy and safety of psychotherapy and non-invasive neuromodulation in treating otoneurological conditions associated with anxiety. However, the number of studies meeting the predefined eligibility criteria was limited. Clinical studies were identified only for populations with nonspecific dizziness, phobic vertigo, tinnitus, and Débarquement sickness. These conditions, which primarily affect balance, are characterized by symptoms such as dizziness and vertigo. Notably, no studies were found addressing the treatment of hearing loss or other otoneurological dysfunctions using these therapeutic approaches.

First-line treatments for dizziness and vertigo include pharmacological interventions,³⁰ repositioning maneuvers for labyrinthine crystals, and vestibular rehabilitation involving adaptation, habituation, substitution exercises, biofeedback, and virtual reality.³¹ In refractory cases, adjunctive therapies such as tympanic injections,³² dry needling,³³ psychotherapy,³⁴ and non-invasive neuromodulation³⁵ have been explored, albeit with limited supporting evidence. This review identified six clinical studies demonstrating consistent favorable outcomes for psychotherapy as an intervention. However, these studies lacked detailed descriptions of the techniques employed, and there is insufficient comprehensive evidence, such as meta-analyses or large-scale clinical trials, to support psychotherapy as a first-line treatment. The evidence for non-invasive neuromodulation is even more limited, with only one study on rTMS, one on continuous Theta Burst Magnetic Stimulation (cTBS), two on tDCS, and one case study on taVNS. The scarcity of evidence often leads to off-label use in clinical practice or hesitancy among professionals to prescribe these therapies.

The Brazilian Consensus on Tinnitus recommends several treatments for tinnitus management,³⁶ including sound therapy, hearing aids, medications to improve ear circulation, antidepressants or anxiolytics, CBT, relaxation techniques, biofeedback, laser therapy, and treatment of temporomandibular dysfunction. The findings of this review highlight controversial results regarding the use of tDCS for tinnitus. For instance, a study²⁸ found no significant differences between active and sham groups using bifrontal tDCS targeting the dorsolateral prefrontal cortex. In contrast, other studies²⁹ reported positive outcomes for tinnitus and depression symptoms with tDCS, though no significant effects on anxiety were observed. A recent meta-analysis involving 1,031 participants¹⁷ confirmed small to moderate advantageous effects of non-invasive neuromodulation, particularly with tDCS applied to the temporoparietal region or dorsolateral prefrontal

cortex for tinnitus treatment. These findings underscore the need for further large-scale clinical trials to resolve existing controversies and establish clearer guidelines for the use of tDCS in tinnitus management.

Neurological disorders are increasingly understood as maladaptive alterations within the multimodal neural system, particularly affecting vestibular spatial and temporal brain maps.⁸ Emerging research has identified neural correlates linking the vestibular and auditory systems with fear circuits,³⁷ underscoring the critical neuropsychological roles of the vestibular and auditory systems in cognition, movement perception, spatial memory, and body image.⁷ Furthermore, the neural network responsible for postural balance is intricately connected to cognitive, emotional, and autonomic functions.³⁷

Clinical observations reveal that patients with panic disorders, social phobia, post-traumatic stress disorder (PTSD), OCD, and substance use disorders frequently report dizziness as a prominent symptom.³⁸ Syndromes such as PPPD often respond favorably to anxiolytic treatments,⁸ although psychotropic medications can themselves induce dizziness as a side effect.³⁹ Fear of falling, exacerbated by dizziness or vertigo, can worsen symptoms by disrupting postural muscle activation, autonomic control, and balance, creating a self-perpetuating cycle of dysfunction.³⁸

This neuroscientific understanding highlights the importance of exploring psychotherapy and non-invasive neuromodulation as complementary treatment approaches. Targeted interventions in the cerebral cortex, such as electrical or magnetic stimulation, can promote neurofunctional reorganization of affected neural circuits, leading to symptom relief.¹⁹ Cognitive psychotherapy, on the other hand, facilitates the self-regulation of neurotransmitters within synaptic circuits, improving clinical outcomes. These approaches, when combined with pharmacological and physical therapeutic treatments, offer promising adjunctive or alternative options, particularly for patients who do not respond to first-line therapies.

Non-invasive neuromodulation, grounded in the principles of neuroplasticity, has gained significant clinical traction in recent decades.⁴⁰ For instance, some authors¹⁹ demonstrated that cTBS significantly alleviates symptoms of Débarquement sickness syndrome, suggesting its potential integration into vestibular rehabilitation protocols. However, tDCS has shown limited efficacy compared to rTMS in treating anxiety disorders,¹⁶ which may explain the lack of symptom improvement observed in psychological conditions with tDCS in other studies.¹⁷

Vagus nerve stimulation has emerged as a promising alternative, with demonstrated benefits in treating depression.⁴¹ Although comprehensive evidence is still lacking, this modality holds potential for addressing postural control issues associated with anxiety in patients with PPPD,²⁷ as well as other otoneurological dysfunctions. Its low risk, cost-effectiveness, and tolerability make it an attractive option for modulating the autonomic nervous system and supporting functional recovery in otoneurological conditions.⁷

The integration of psychotherapy, particularly CBT, has proven to be a critical component in managing anxiety and stress, which are often associated with otoneurological symptoms. A study²⁰ demonstrated the efficacy of CBT, whether delivered individually or in group settings, in reducing the reliance on sertraline among patients with PPPD. Similarly, other authors²⁶ conducted a clinical trial involving 159 patients and found that CBT significantly alleviated vertigo, anxiety, and depression, regardless of whether it was administered individually or in groups. Notably, a study⁴² reported that even a brief intervention of three individual CBT sessions led to measurable reductions in both physical and psychological symptoms. Furthermore, group-based CBT has shown consistent efficacy in treating refractory cases of neurotological disorders.⁴³ While CBT has demonstrated comprehensive favorable outcomes, there remains a gap in the literature regarding the effectiveness of other psychotherapeutic approaches, such as EMDR or third-generation cognitive-behavioral therapies, in this context.

Combining psychotherapy with pharmacological treatment has been shown to yield beneficial effects in managing chronic dizziness.²¹ Similarly, the integration of psychotherapy with vestibular rehabilitation has been effective in addressing dizziness, vertigo, anxiety, depression, and somatization.³⁴ However, not all studies have reported uniformly favorable results. For instance, a study²⁴ found no significant benefits of CBT in treating phobic postural vertigo, potentially due to factors such as participant age or insufficiently detailed CBT protocols. In contrast, another study²² highlighted that both CBT and vestibular rehabilitation improved clinical and functional outcomes, as well as quality of life, in patients with dizziness. These findings underscore the value of a multidimensional treatment approach, where the synergistic effects of different therapeutic modalities can enhance overall outcomes.

Patients presenting with anxiety-related dizziness, tinnitus, or vertigo require empathetic and comprehensive therapeutic reception, which should be a collaborative effort among all members of the healthcare team.⁴⁴ Psychoeducation plays a pivotal role in this process, as it helps patients understand the

interplay between psychological factors and otoneurological symptoms. This understanding facilitates endogenous modulation guided by cognitive functions.²⁶ CBT techniques, such as establishing clear and shared treatment goals, employing Socratic questioning, and assigning cognitive tasks for home practice, empower patients to autonomously manage their emotional and balance-related challenges. The evidence reviewed here underscores the critical role of CBT in treating neurotological disorders, with moderate to high effect sizes supporting its incorporation as a first-line therapeutic approach.

While non-invasive neuromodulation shows promise as adjunctive treatment for certain otoneurological conditions, the current evidence base is insufficient to support its widespread adoption as first-line therapies. Further research with comprehensive methodologies and larger sample sizes is essential to validate their efficacy and safety, thereby enhancing clinical confidence in their application.

This review is not without limitations. The heterogeneity of study samples and interventions, coupled with the lack of detailed descriptions of therapeutic protocols, precluded the possibility of conducting a meta-analysis. Furthermore, we were unable to find other systematic reviews, with or without meta-analyses, with which we could compare our findings. These limitations highlight the need for more standardized methodologies in future research.

A recent meta-analysis⁴² provides high-level evidence that additional CBT, when combined with conventional treatments such as vestibular rehabilitation or Selective Serotonin Reuptake Inhibitor, significantly improves outcomes for patients with PPPD, as reflected in reductions in Dizziness Handicap Inventory, Hamilton Anxiety Scale, Generalized Anxiety Disorder Scale-7, and Patient Health Questionnaire-9 scores. In contrast, the systematic review in the main manuscript synthesizes broader interventions for anxiety associated with otoneurological conditions, highlighting CBT as a promising adjunct but emphasizing the scarcity of robust trials and methodological heterogeneity. While both studies converge on the therapeutic relevance of CBT, this study offers quantitative confirmation of its added benefit in PPPD, whereas the main review underscores the need for standardized protocols and further large-scale research to validate these findings across diverse otoneurological disorders.

Conclusion

Psychotherapy, particularly CBT, and non-invasive neuromodulation represent promising adjuncts to vestibular rehabilitation and tinnitus treatment. However, the current evidence base is insufficient to warrant widespread clinical recommendation. Among the modalities examined, CBT – whether delivered individually or in groups – has consistently demonstrated favorable outcomes. Nevertheless, further well-designed controlled clinical trials are essential to strengthen the evidence base and refine the recommendations for these approaches. A multidimensional treatment framework, integrating psychotherapy with other therapeutic modalities, holds significant potential for improving outcomes in patients with anxiety associated with primary otoneurological dysfunctions.

Declaration of Generative Artificial Intelligence (AI) and AI-assisted Technologies in the Writing Process

The text, originally written by the authors in Portuguese and later translated into English, was reviewed with the assistance of the Deepseek AI tool for language refinement, using the prompt: “Could you help to improve this text in an elegant English” (available at <https://chat.deepseek.com/>).

Conflict of Interest

All authors declare that there are no potential conflicts of interest identified in the conduct of the research or in its reporting. No author received support, funding, goods, services or advantages for the production of this study.

Equity, Diversity, and Inclusion Statement

This review was conducted with a commitment to equity, diversity, and inclusion (EDI) at multiple levels. First, our research team represents diverse academic, geographic, and professional backgrounds, fostering inclusive perspectives in study design and analysis. Second, we prioritized a comprehensive search strategy to capture global clinical studies on anxiety and otoneurological disorders, ensuring representation across populations irrespective of gender, ethnicity, or socioeconomic status. Third, methodological rigor included scrutiny of potential biases in source studies, with explicit attention to underrepresented groups in the literature. Finally, interpretation of findings was guided by awareness of clinical applicability across

diverse settings, aiming to advance equitable mental healthcare. Limitations in available data on marginalized populations are acknowledged, highlighting the need for future research to address these gaps.

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APPENDICES**Supplementary Material**

Supplemental material associated with this article will be made available [here](#).

- Appendix 1 - Complete search strategies and screening results