Research Topics

Complementary and alternative therapies for sleep disorders: from bench to bedside

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Complementary and alternative therapies for sleep disorders: from bench to bedside

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Editorial: Complementary and alternative therapies for sleep disorders: from bench to bedside

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Editorial on the Research Topic
Complementary and alternative therapies for sleep disorders: from bench to bedside

Sleep disorders, such as insomnia, obstructive sleep apnea (OSA), and sleep initiation and maintenance disorders (SIMDs), pose a critical public health challenge worldwide, significantly affecting the physical, emotional, and cognitive wellbeing of individuals (1). Although pharmacological treatments remain a common therapeutic option, their long-term efficacy is often compromised by adverse effects and low patient adherence (2, 3). This has led to a growing interest in complementary and alternative therapies (CAT), which provide holistic, non-pharmacological approaches aimed at improving sleep quality while addressing associated comorbidities.

CAT encompasses several interventions, each of which employs distinct mechanisms to enhance sleep health. Among these, acupuncture has emerged as a prominent intervention for both primary insomnia and secondary insomnia associated with comorbidities such as hypertension and cancer. In addition to improving sleep quality, acupuncture has demonstrated benefits in regulating blood pressure, and enhancing cardiovascular health, supporting its inclusion in holistic treatment plans. Similarly, exercise-based interventions, especially when integrated with sleep education programs, offer significant benefits for individuals with OSA. Exercise alleviates the severity of OSA and enhances overall health, making it a viable non-pharmacological alternative to conventional therapies.

Beyond physical therapies, arts-based interventions—including music therapy, Tai Chi, and meditation—offer dual benefits by enhancing sleep quality and addressing mental health conditions such as anxiety and depression. These therapies align with the principles of patient-centered care, providing a comprehensive approach that addresses both psychological and physiological needs. This makes them particularly effective for individuals who are sensitive to medication-related side effects. CAT offers safer, more personalized alternatives that can fill critical gaps in conventional treatments, advancing patient care and improving long-term health outcomes.

This editorial presents nine recent studies conducted by 81 researchers from five countries that highlight the translational potential of CAT from research to clinical application. These studies encompass a spectrum of approaches, from acupuncture and exercise-based interventions to art therapies and the integration of machine learning with Traditional Chinese Medicine (TCM). Taken together, these findings demonstrate how different CAT methods can enhance sleep outcomes across different populations and clinical contexts.

For example, Li et al. employed machine learning algorithms to predict insomnia severity with high accuracy using TCM constitutional classifications. Their study illustrates the intersection of modern technology and traditional medicine, offering personalized insomnia interventions. Similarly, Rodríguez-Aragón et al. examined the impact of Global Postural Re-education on stress and sleep quality in female university lecturers. Their findings suggest that postural correction and body alignment may serve as practical, non-invasive strategies to enhance sleep and reduce stress.

Further evidence supporting exercise-based interventions comes from Fank et al., who examined the effects of combining exercise with sleep education in older adults with OSA. Their results underscore the value of structured physical activity, highlighting its potential to reduce OSA severity and promote better overall health without relying on medication. Acupuncture also plays a central role in the treatment of sleep disorders in patients with complex medical profiles. Zhang et al. conducted a systematic review and meta-analysis, confirming that acupuncture not only improves sleep quality but also reduces blood pressure, offering a dual therapeutic benefit.

Yu et al. investigated the use of weighted blankets as a non-pharmacological tool to enhance sleep. Their review found that weighted blankets, through deep pressure stimulation, were effective in improving sleep quality in individuals with insomnia, autism spectrum disorder, and attention deficit hyperactivity disorder. Huang et al. provided further insight into the global landscape of acupuncture research through a bibliometric analysis. Their findings reveal the increasing adoption of electroacupuncture for the treatment of secondary insomnia and other sleep-related disorders, such as restless legs syndrome, while emphasizing the importance of international collaboration and standardized protocols.

The role of acupuncture in the management of cancer-related insomnia (CRI) was investigated by Chen et al., who conducted a network meta-analysis comparing different acupuncture modalities. They identified auriculotherapy combined with moxibustion as the most effective non-invasive treatment for CRI, underscoring the need for further research on acupuncture as a complementary therapy in cancer care. Sleep disturbances among university students have also garnered attention, particularly in Africa, where Nakie et al. found a high prevalence of poor sleep quality linked to stress, excessive use of electronic devices at bedtime, and chronic illness. These findings call for targeted interventions to address environmental and behavioral contributors to sleep disorders.

Finally, Luo et al. explored the use of art therapies, such as music therapy, Tai Chi, and meditation, for treating SIMDs. Their review found that these therapies not only improved sleep quality but also alleviated underlying mental health issues, such as anxiety and depression, supporting their adoption as holistic treatment options in clinical practice.

The contributions within this editorial collectively highlight the expanding evidence base for CAT as a viable intervention for sleep disorders. These approaches reflect the innovative, multidisciplinary strategies being developed to address sleep disturbances in diverse populations. As research in this field continues to evolve, the integration of CAT into clinical practice offers the potential to improve patient care by providing safer, more personalized treatments for sleep disorders and promoting overall health outcomes.

Author contributions

JY: Conceptualization, Data curation, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. QZ: Formal analysis, Conceptualization, Data curation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. G-qZ: Software, Conceptualization, Data curation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. XZ: Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. HC: Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. H-TY: Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. DZ: Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. TX: Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. BG: Conceptualization, Data curation, Investigation, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. GY: Conceptualization, Data curation, Investigation, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Application of machine learning models in predicting insomnia severity: an integrative approach with constitution of traditional Chinese medicine

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Objective: This study sought to explore the utility of machine learning models in predicting insomnia severity based on Traditional Chinese Medicine (TCM) constitution classifications, with an aim to discuss the potential applications of such models in the treatment and prevention of insomnia.

Methods: We analyzed a dataset of 165 insomnia patients from the Shanghai Minhang District Integrated Traditional Chinese and Western Medicine Hospital. TCM constitution was assessed using a standardized Constitution in Chinese Medicine (CCM) scale. Sleep quality, or insomnia severity, was evaluated using the Spiegel Sleep Questionnaire (SSQ). Machine learning models, including Random Forest Classifier (RFC), Support Vector Classifier (SVC), and K-Nearest Neighbors (KNN), were utilized. These models were optimized using Grid Search algorithm and were trained and tested on stratified patient data, with the TCM constitution classifications serving as primary predictors.

Results: The RFC outperformed others, achieving a weighted average accuracy, precision, recall, and F1-score of 0.91, 0.94, 0.92, and 0.92 respectively, it also effectively classified the severity of insomnia with high area under receiver operating characteristic curve (AUC-ROC) values. Feature importance analysis demonstrated the Damp-heat constitution as the most influential predictor, followed by Yang-deficiency, Qi-depression, Qi-deficiency, and Blood-stasis constitutions.

Conclusion: The results demonstrate the potent utility of machine learning, specifically RFC, coupled with TCM constitution classifications in predicting insomnia severity. Notably, the constitution classifications such as Damp-heat and Yang-deficiency emerged as crucial determinants, emphasizing its potential in guiding targeted insomnia treatments. This approach enables the development of more personalized and efficient interventions, thereby enhancing patient outcomes.

KEYWORDS

machine learning, insomnia, constitution of traditional Chinese medicine, prediction model, random forest classifier (RFC), support vector classifier (SVC), K-nearest neighbors (KNN)

1. Introduction

Insomnia, a common sleep disorder, disrupts the ability to fall asleep, maintain sleep, or achieve restorative sleep, consequently interfering with daytime functioning (1). It is a significant public health issue, affecting approximately 10–30% of the global population and causing further health complications (2). This concern is amplified in elderly and psychiatric demographics, where its prevalence is markedly higher (3). Given the complex etiology of insomnia, which often encompasses an intricate interplay of biological, psychological, and environmental factors, crafting effective, individualized treatment strategies remains a considerable challenge for both primary care providers and sleep medicine specialists (4–6).

Traditional Chinese Medicine (TCM), with its unique health and disease perspective that emphasizes harmony among body, mind, and environment, has been suggested as a complementary approach to the conventional biomedical model for managing insomnia (7, 8). Within this framework, individual inherent traits, or "constitution," are central. These constitutions encompass physical characteristics, susceptibility to diseases, and reactions to environmental changes and are assessed using the standardized Constitution in Chinese Medicine (CCM) scale. This scale, with validated reliability, is used in various health contexts, forming a basis for understanding individual differences in health and disease from a TCM perspective (9–12). Building on this foundational concept of constitution in TCM, insomnia is interpreted as more than just a symptom; it is a manifestation of the imbalance within the body's fundamental elements such as Yin and Yang. This perspective aligns with the holistic nature of TCM, which perceives sleep disturbances as interconnected with other physiological and psychological imbalances. Historically, personalized therapeutic strategies based on individual constitution and presenting symptoms were formulated by TCM practitioners. These strategies aimed at restoring balance and harmony within the body, addressing the root causes of insomnia rather than merely alleviating the symptoms. Therefore, the ancient practices and holistic approach of TCM provide a comprehensive viewpoint to explore the underlying intricacies of insomnia and its relationship with various constitutions (13, 14).

Advancing from this holistic viewpoint and the significant role of constitution in TCM, recent empirical studies suggest the potential applicability of the CCM in managing insomnia. Specific TCM constitution types, such as Yin-deficiency and Qi-deficiency, have been recognized as more prevalent in individuals grappling with insomnia (15). Further, a study by He et al. (16) reported that acupuncture treatment based on an individual's CCM score led to notable improvements in sleep quality and a reduction in insomnia symptoms. In the face of the widespread prevalence and complex nature of insomnia, these findings indicate a promising avenue for incorporating the TCM constitution-based approach into a comprehensive, individualized management plan for this sleep disorder (14).

This study underscores the significant influence of TCM constitution on the prevention and prognosis of insomnia, suggesting that the CCM scale score could act as a crucial predictive tool for determining the severity of insomnia. The uniquely powerful role of an individual's constitution in TCM highlights its impact on overall physical and mental health, with a marked effect on susceptibility and severity of illnesses, including insomnia (17). By exploring the predictive capabilities of the CCM scale in relation to insomnia severity, we are not only poised to forge innovative links between TCM and modern sleep medicine, but also lay the foundation for the development of more comprehensive, personalized therapeutic strategies that emphasize the remarkable contributions of TCM constitution in managing and predicting insomnia, thus shaping its treatment outcomes.

Simultaneously, the advent of machine learning algorithms in healthcare presents a transformative opportunity to unearth complex relationships between variables (18). Particularly, methods like Random Forest (19), Support Vector Machine (20), and K-nearest neighbors (21) have been extensively utilized in the field of predictive medicine and have shown robust results in a variety of clinical prediction tasks (22, 23). Incorporating these algorithms to analyze the CCM scale scores might offer novel insights into the multifaceted association between TCM constitution types and insomnia severity.

While the ancient wisdom of TCM has a longstanding history in addressing insomnia, encapsulating holistic and individualized approaches, there remains a striking scarcity in modern studies with rigorous data support directly linking TCM constitution types with insomnia severity. This discernible gap in evidence-based research underscores the need for more in-depth investigations that explore the predictive role of TCM constitution in insomnia, integrating machine learning methodologies. Such exploration can deepen our understanding of insomnia through a TCM lens and contribute valuable insights towards the pathogenesis, prediction, and treatment of insomnia (24).

To this end, our study aims to examine the correlation between the CCM scale score and the severity of insomnia, utilizing machine learning algorithms for prediction. We anticipate that our findings will establish a theoretical and empirical groundwork for the application of TCM constitution in insomnia prediction and management. This, in turn, would foster a more tailored and efficacious approach to insomnia treatment, potentially improving patient outcomes and quality of life.

2. Methods

2.1. Data sources

This investigation was conducted with the explicit approval from the Ethics Committee of the Shanghai Minhang District Integrated Traditional Chinese and Western Medicine Hospital (Ethics Reference No. 2021–007) and each included patient provided a written informed consent. The data utilized in this study were meticulously collected from 165 patients diagnosed with insomnia, receiving their treatment in the Department of Preventive Medicine of the aforementioned hospital during the period of November 2021 to December 2022. The sample included 110 females with an average age of 46.92 ± 12.38 years, and 55 males with an average age of 46.05 ± 13.01 years.

2.1.1. Inclusion criteria

The inclusion criteria were established in accordance with the diagnostic criteria for primary insomnia in the 3rd Edition of the Chinese Classification and Diagnostic Criteria of Mental Disorders (CCMD-3), and the diagnostic criteria for insomnia in the "Diagnostic Criteria and Therapeutic Effect of TCM Diseases and Syndromes." The criteria were as follows: (1) Age between 18 and 75 years; (2) Sleep disorder is the primary symptom, with other symptoms secondary to insomnia. The main symptoms include difficulty in falling asleep, shallow sleep, excessive dreaming, early waking, and difficulty falling back asleep after waking. Secondary symptoms include palpitations, forgetfulness, dizziness, fatigue, a sallow complexion, among others. All of the main symptoms and at least one of the secondary symptoms should be present; (3) The sleep disorder occurs at least three times a week and lasts for more than a month; (4) Insomnia causes significant distress or some symptoms of mental disorder, leads to decreased efficiency in activities or hampers social functioning; (5) Insomnia is not due to any physical disease or mental disorder.

2.1.2. Exclusion criteria

Subjects were excluded from the study if they: (1) did not meet the aforementioned inclusion criteria; (2) were pregnant or breastfeeding women; (3) had used antipsychotics or antidepressants within a week before their consultation; (4) had serious organ dysfunction or severe diseases in other systems; (5) had serious mental disorders; (6) were patients with malignant tumors; (7) had drug dependency.

2.2. Observational indicators

2.2.1. TCM constitution evaluation

TCM constitution was assessed using the CCM scale. This scale is composed of nine TCM constitution classifications, specifically Balanced constitution, Qi-deficiency, Yang-deficiency, Yin-deficiency, Phlegm-dampness, Damp-heat, Blood-stasis, Qi-depression, and Special constitution, each comprising 6–8 items. The characteristics of these constitution classifications are listed in Table 1.

Each item provides five potential responses, ranging from "none" to "always," scored from 1 to 5, respectively. The original score is obtained by summing up the scores of each item. Subsequently, the converted score is calculated using the formula: (original score - number of items) * 100 / (number of items * 4). A converted score of ≥60, provided that the converted scores of the other eight biased constitutions are all <30, is deemed a definitive ("yes") constitution classification. A score < 40 is considered indicative ("basically yes") of a classification, while all other cases are determined as negative ("no") for the specific classification.

For this study, rather than establishing a constitution determination, we opted to employ the converted scores across all categories, given that these scores reflect the comprehensive constitutional characteristics of the patients. Hence, the converted scores of the nine classifications were input as independent variables (X) into the machine learning model for predicting insomnia severity.

2.2.2. Sleep quality evaluation

Sleep quality in this study was evaluated using the Spiegel Sleep Questionnaire (SSQ), an established and validated (Cronbach's α coefficient of SSQ is 0.868) self-reported instrument routinely employed in clinical research to assess sleep–wake patterns. This tool boasts comprehensive coverage of the sleep–wake cycle, contributing to its sensitivity and reliability in tracking sleep pattern changes over time, as well as evaluating the efficacy of sleep-related interventions. It remains particularly invaluable in the study and management of sleep disorders, including insomnia (25, 26).

TABLE 1 The characteristics of nine TCM constitution classifications.

TCM constitution classification	Characteristic
Balanced constitution	Individuals have a strong physique, stable emotions, and good adaptability. They rarely get sick and recover quickly.
Qi-deficiency	Individuals tend to have weak muscles, low energy, and poor immunity. They are easily fatigued, catch colds frequently, and sweat spontaneously.
Yang-deficiency	Individuals tend to have cold limbs, low metabolism, and slow pulse. They are sensitive to cold and dampness, and prefer warm foods and drinks.
Yin-deficiency	Individuals tend to have dry skin, hair, and mouth, hot sensations in the palms and soles, and night sweats. They are prone to heat-related diseases and insomnia.
Phlegm-dampness	Individuals tend to have overweight body, oily skin, and sticky tongue coating. They often feel heavy, sluggish, and bloated. They are susceptible to metabolic disorders and chronic diseases.
Damp-heat	Individuals tend to have yellowish complexion, red eyes, and bitter taste in the mouth. They often suffer from inflammation, infection, and skin problems. They are intolerant of hot and humid weather.
Blood-stasis	Individuals tend to have dark or purple complexion, lips, and nails, pain or numbness in certain areas, and irregular menstruation or bleeding. They often have poor blood circulation and clotting problems.
Qi-depression	Individuals tend to have emotional fluctuations, chest tightness, and sighing. They often experience stress, frustration, and depression. They are vulnerable to digestive and mental disorders.
Special constitution	Individuals have some congenital or genetic abnormalities that affect their health or appearance. They may have allergies, deformities, or rare diseases.

The SSQ explores six dimensions of sleep and wakefulness: initial and terminal insomnia, perceived quality of sleep, refreshment upon awakening, daytime alertness, and total sleep time. Each dimension is assessed on a 5-point Likert scale, with higher scores corresponding to worsened sleep disturbances. Thus, a lower cumulative score signifies improved sleep quality and decreased daytime sleepiness.

For the purposes of this investigation, insomnia severity was delineated into three classes, according to the SSQ scores of the included cases: mild (score ≥ 12), moderate (score ≥ 18), and severe (score ≥ 24). The outcomes of these three severity classifications will serve as the dependent variable (Y) in the training of our machine learning model.

2.3. Data analysis

The predictive power of TCM constitution classifications on the severity of insomnia was explored using three machine learning models: Random Forest Classifier (RFC), Support Vector Classifier (SVC), and K-Nearest Neighbors Classifier (KNN). The data set was partitioned into a training set (80% of the total data) and a test set (20% of the total data), enabling model training and subsequent performance evaluation.

2.3.1. Data preprocessing

Data preprocessing involved normalization to maintain uniformity in feature scales, imputation of missing values through domain-specific insights and statistical methods, and the handling of outliers to reduce skewness and model bias, ensuring the reliability and validity of the dataset.

2.3.2. Feature selection

The feature selection was driven by the TCM constitution assessment results acquired through the CCM scale. The converted scores derived from the nine TCM constitution classifications served as pivotal features in our models.

2.3.3. Model optimization and hyperparameter tuning

In our relentless pursuit of model optimization, a Grid Search algorithm was meticulously implemented to fine-tune the hyperparameters of each model, assessing a range of parameter values to identify the optimal combination enhancing model performance. For the RFC, the parameters under consideration included 'n_estimators' (the number of trees in the forest), which was varied among [10, 50, 100, 200, 500], 'max_depth' (the maximum depth of the tree), taking values from [None, 10, 20, 30, 50], and 'min_samples_split' (the minimum number of samples required to split an internal node), taking values from (2, 5, 10).

For the SVC, the parameters 'kernel' type, varied among ['rbf', 'linear', 'poly'], 'C' (the penalty parameter), ranging from [0.1, 1, 10, 100, 1,000], and 'gamma' (a parameter affecting the shape of the decision boundary), with values from ['scale', 'auto'] were tuned. Finally, for the KNN model, 'n_neighbors' (the number of neighbors to include in the majority of the voting process), varied among (3, 5, 10, 20), and 'weights' (the weight function used in prediction), taking values from ['uniform', 'distance'], were adjusted.

2.3.4. Model performance evaluation

Model performance was evaluated using several key indicators, including accuracy, precision, recall, f1-score and area under the receiver operating characteristic curve (AUC-ROC).

Accuracy (A) is the proportion of true results (both true positives and true negatives) among the total number of cases examined, and calculated as:

$$A = \frac{(TP + TN)}{(TP + FP + TN + FN)} \quad (1)$$

where TP is the number of true positives, FP the number of false positives, TN is the number of true negatives, and FN is the number of false negatives.

Precision (P) quantifies the number of positive class predictions that actually belong to the positive class, and is defined as:

$$P = \frac{TP}{(TP + FP)} \quad (2)$$

Recall (R) quantifies the ability of a model to find all the relevant cases within a dataset, and is defined as:

$$R = \frac{TP}{(TP + FN)} \quad (3)$$

The F1-score (F1) is the harmonic mean of precision and recall, calculated as:

$$F1 = \frac{2PR}{(P + R)} \quad (4)$$

AUC-ROC is a performance measurement for the classification problems at various threshold settings, representing the degree or measure of separability and indicating how well the model can distinguish between classes. In this work, AUC-ROC was used in evaluating the predictive accuracy of machine learning models in distinguishing between different severity levels of insomnia. Each model's performance was evaluated on the test set to ensure the evaluation is unbiased and reflects the model's ability to generalize to unseen data.

In addition to building the predictive models, correlation analyses were performed to assess the relevance of the nine TCM constitution classifications to insomnia severity. Those constitutions demonstrating a higher correlation were considered as key features, enriching the predictive models and enhancing their practical applicability in insomnia management. The whole research workflow is shown in Figure 1.

3. Results

The Basic information, TCM constitution converted scores and SSQ scores of insomnia patients were listed in Table 2. Three machine learning models – RFC, SVC, and KNN - were utilized to discern patterns in TCM constitution converted scores, with the aim to predict insomnia severity.

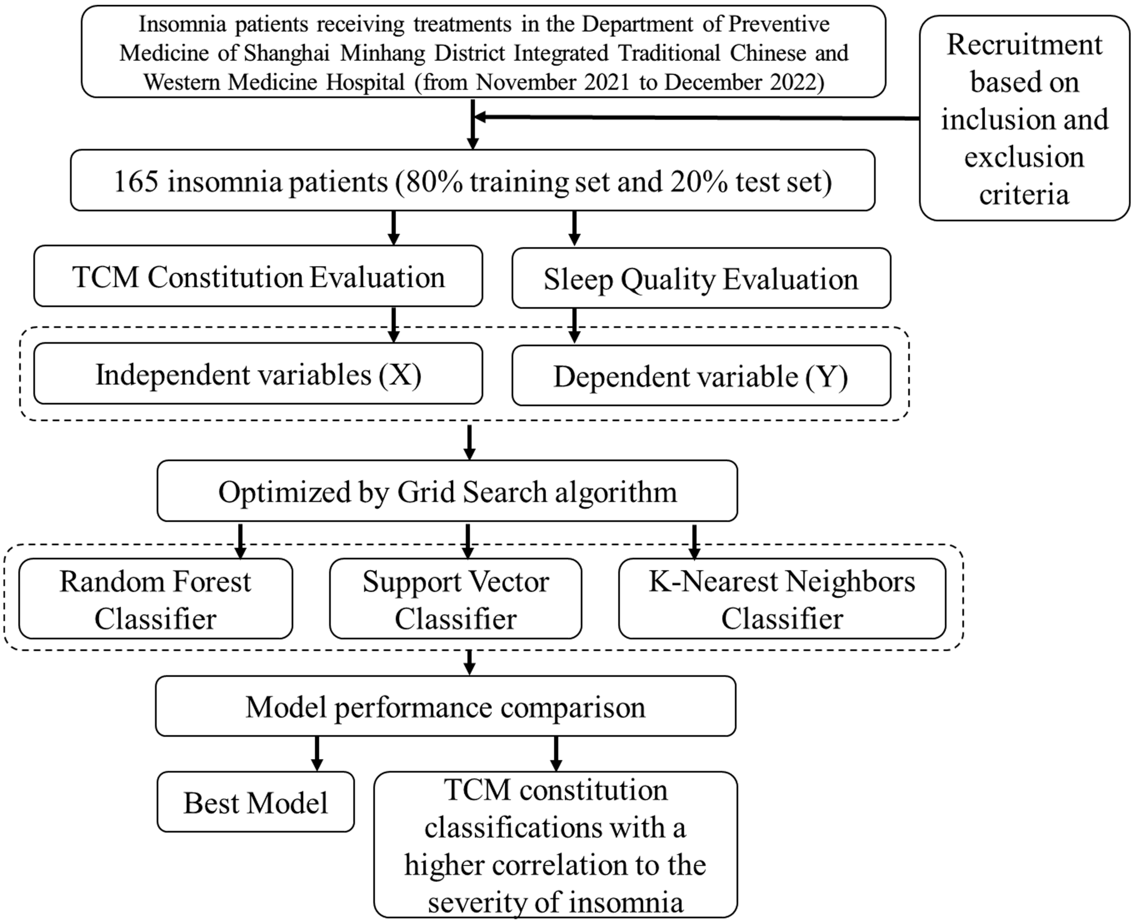

FIGURE 1
Overview of the data acquisition, modeling, and model performance evaluation.

The comparative performance of various classifiers is presented in Figure 2. Among all the models evaluated in this study, the RFC outperformed others, yielding an accuracy score of 0.916. The superior performance of RFC was achieved with hyperparameters set at a maximum depth of None, a minimum sample split of 5, and 100 estimators. This accentuates the promising utility of RFC for classifying the severity of insomnia grounded on Traditional Chinese Medicine (TCM) constitution scores. In contrast, the SVC and KNN classifiers, despite being fine-tuned based on their optimal parameters, rendered relatively lower accuracies of 0.75 and 0.66, respectively.

Upon further evaluation, the RFC displayed superior weighted averages across precision, recall, and F1-score, suggesting its robust performance across all categories of insomnia severity. The SVC and KNN classifiers also demonstrated commendable performance, as indicated by their weighted averages; however, they were marginally outperformed by the RFC. More specifically, RFC presented a weighted average precision of 0.94, a recall of 0.92, and a F1-score of 0.92, underpinning its high predictability and low false positive rate. Furthermore, the predictive performance of the models was also evaluated using AUC-ROC. For differentiating mild insomnia from other classes, all three models demonstrated exemplary performance, with RFC and SVC achieving a perfect AUC of 1, and KNN closely following with an AUC of 0.95 (Figure 3A). When distinguishing moderate insomnia from the other severities, RFC still performed significantly well with an AUC of 0.93, whereas SVC and KNN yielded lower AUCs of 0.67 and 0.7, respectively (Figure 3B). In the classification of severe insomnia against the other classes, RFC achieved an AUC of 1, showcasing its superior predictive capability, while SVC and KNN showed commendable performance with AUCs of 0.89 and 0.86, respectively (Figure 3C). This denotes that, in this context, RFC tends to provide a more accurate and reliable classification prediction of insomnia severity.

The RFC model's insightful exploration delineated a hierarchy of TCM constitution classifications based on their predictive potency and correlation with insomnia severity. Emphasizing this, the Damp-heat constitution manifested the highest feature importance, registering at 0.1514. This was closely followed by Yang-deficiency, Qi-depression, Qi-deficiency, and Blood-stasis constitutions, with importance values of 0.1374, 0.1346, 0.1249, and 0.1082 respectively, all surpassing the benchmark of 0.10. The substantial feature importance of these TCM constitution classifications, therefore, underscores their significant predictive role and potent correlation with insomnia severity (Figure 4).

TABLE 2 Basic information and evaluation results of TCM constitution and sleep quality of insomnia patients.

Indicators	Female	Male
Number	110	55
Age (Year)	46.92 ± 12.38	46.05 ± 13.01
Course of disease (Year)	2.5 ± 1.72	2.37 ± 1.64
Balanced constitution converted score	32.57 ± 9.12	35.71 ± 12.64
Qi-deficiency converted score	37.29 ± 10.91	32.81 ± 13.8
Yang-deficiency converted score	29.57 ± 14.36	20.67 ± 16.79
Yin-deficiency converted score	32.58 ± 13.09	31.82 ± 11.08
Phlegm-dampness converted score	21.37 ± 10.38	18.42 ± 10.05
Damp-heat converted score	18.14 ± 11.14	16.16 ± 10.09
Blood-stasis converted score	35 ± 10.61	29.41 ± 11.77
Qi-depression converted score	31.8 ± 13.35	26.5 ± 13.1
Special constitution converted score	10.42 ± 13.18	5.26 ± 6.98
SSQ score	22.16 ± 6.05	22.09 ± 6.3
Number of patients with mild insomnia	33	15
Number of patients with moderate insomnia	37	18
Number of patients with severe insomnia	40	22

4. Discussion

The use of machine learning models in the field of medical research and particularly in the realm of TCM represents a significant advance in contemporary medicine (27). In the current study, we used three established machine learning models: Random Forest, Support Vector Machine, and K-Nearest Neighbors, to predict the severity of insomnia based on TCM constitution scores. Among these, RFC emerged as the most predictive model, demonstrating superior accuracy compared to SVC and KNN. Random forest, a powerful ensemble machine learning model, has been widely used in various medical fields, including in the diagnosis and prognosis of diseases like cancer (28), cardiovascular disease (29), and diabetes (30). Its high performance can be attributed to its ability to handle high-dimensional data, capture non-linear relationships, and accommodate potential interactions among features (31). These attributes are particularly important when dealing with complex medical data, where a multitude of factors interplay to determine health outcomes (32). Additionally, random forest has the added advantage of providing feature importance, offering insight into which predictors most significantly impact the predicted outcome (33). Thus, random forest presents a potent tool for predicting insomnia severity in the context of TCM constitutions.

The importance of TCM constitution classifications in predicting insomnia severity cannot be understated. Our results showed that certain TCM constitution classifications such as 'Qi-deficiency', 'Yang-deficiency', 'Damp-heat', 'Blood-stasis', and 'Qi-depression' exhibited significant feature importance, each greater than 0.10. This suggests that these specific TCM classifications might play a key role in contributing to the severity of insomnia.

Interestingly, modern medical research supports this observation. For instance, a study published in 2015 established a link between Qi-deficiency, which relates to energy levels and fatigue in TCM, and increased severity of insomnia (34). Similarly, 'Yang-deficiency' which in TCM is associated with cold sensations and poor circulation, has been shown to affect sleep quality, particularly in the elderly population (35). 'Damp-heat', another TCM constitution classification, refers to a state of imbalance in the body often associated with inflammation (36). This imbalance has been linked to sleep disturbances in a study published in 2021 (37). Blood-stasis, representing a stagnation or slowing down of circulation in TCM, has been associated with sleep apnea in a recent study (38), which could lead to disrupted sleep and increased insomnia severity. Lastly, 'Qi-depression', a state of emotional stagnation in TCM, has been associated with psychiatric conditions such as depression and anxiety, which are well-known contributors to insomnia (39, 40).

The application of this prediction model, particularly in clinical treatment and prevention of insomnia, could be wide-reaching. As we have demonstrated, the model can effectively predict insomnia severity based on TCM constitution classifications. These insights could guide clinicians in tailoring individual treatment strategies for patients suffering from insomnia, taking into consideration the identified important TCM constitution classifications. Moreover, it could assist in patient stratification, helping healthcare professionals to identify individuals at higher risk of severe insomnia and therefore needing more immediate or intensive interventions (41). For example, for patients showing signs of 'Qi-deficiency' and 'Yang-deficiency', treatment strategies could focus on addressing the corresponding imbalances, using modalities such as herbal remedies, acupuncture, or lifestyle adjustments known to help correct these specific deficiencies. Similarly, for those showing 'Damp-heat', 'Blood-stasis', and 'Qi-depression' classifications, targeted therapies could be implemented to address these conditions, which in turn, could ameliorate the severity of insomnia (42).

Importantly, the use of such a model can also guide preventative measures (43, 44). By identifying the at-risk population, preventive interventions can be implemented early, before the onset of severe insomnia. Such proactive management could potentially reduce the burden of insomnia on both the individual and healthcare system.

Furthermore, while our model has been applied to insomnia in the context of TCM, the same methodology can be applied to other health conditions where TCM constitution classifications play a role. This opens the door to a range of potential applications, further enhancing the utility of TCM constitution classifications in modern healthcare.

Nevertheless, further validation of the model in different populations and clinical settings is necessary to ascertain its generalizability. As we continue to integrate traditional and modern medical knowledge, models such as the one presented in this study

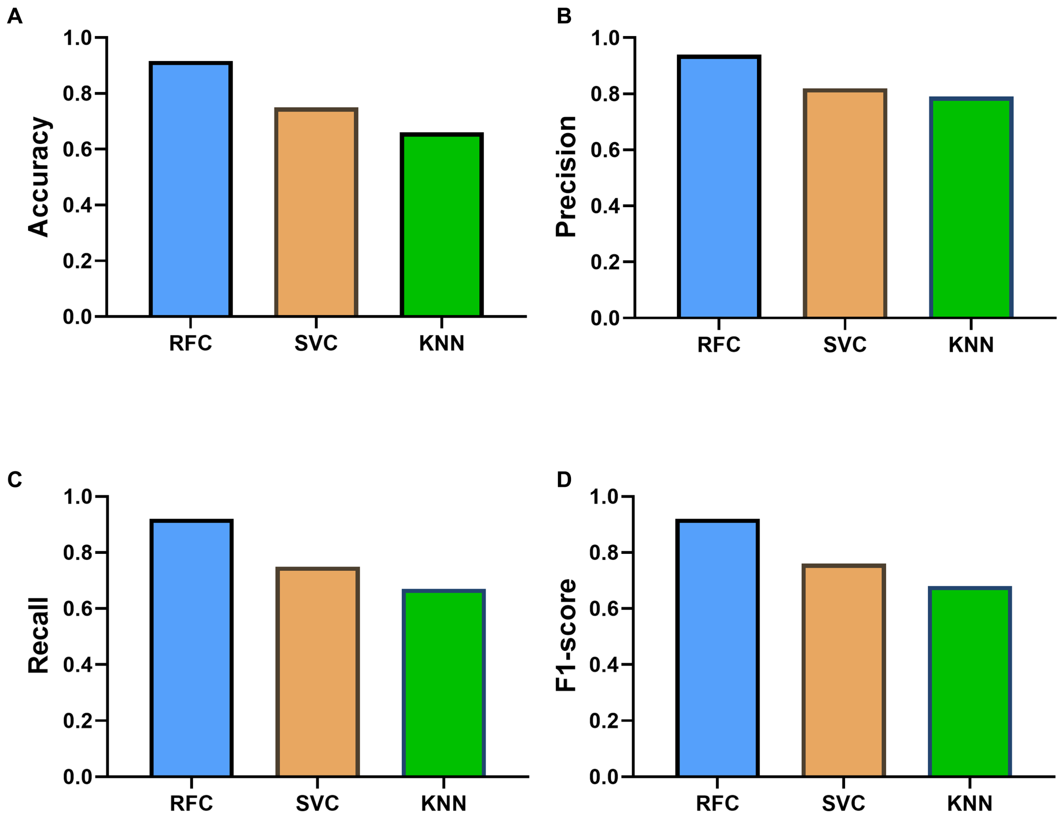

FIGURE 2
Performance Comparison of Different Machine Learning Models—Random Forest Classifier (RFC), Support Vector Classifier (SVC), and K-Nearest Neighbors (KNN)—in Predicting Insomnia Severity Levels based on the Constitution in Chinese Medicine (CCM) Scale Score. Panel **(A–D)** showed the results of accuracy, precision, recall and F1-score, respectively.

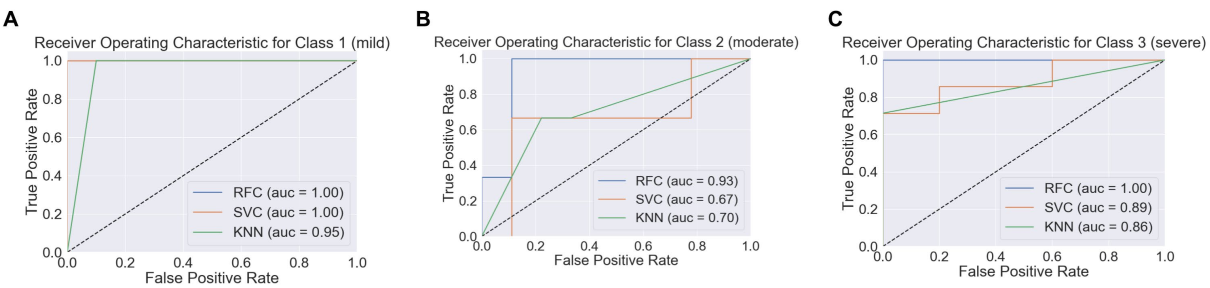

FIGURE 3
Receiver operating characteristic curves (ROC) for three machine learning models. Panel **(A–C)** represented the insomnia severity classification of class 1 (Mild Insomnia), class 2 (Moderate Insomnia), and Class 3 (Severe Insomnia) against other classes, with AUC values indicating the models' discriminatory power, respectively.

will be instrumental in enabling a more nuanced understanding of health and disease, ultimately benefiting patient care.

5. Conclusion

In conclusion, this study illuminates the potential of employing machine learning models, particularly the Random Forest, alongside TCM constitution classifications to enhance the management of insomnia. The substantial predictive capacity of TCM constitution types such as Damp-heat and Yang-deficiency suggests a pathway towards more personalized, and therefore potentially more effective, treatment approaches. These predictive models could serve as valuable tools in both the clinical decision-making process and the formulation of targeted preventative measures. While the results are encouraging, further validation in diverse patient populations remains essential to ensure their robust applicability.

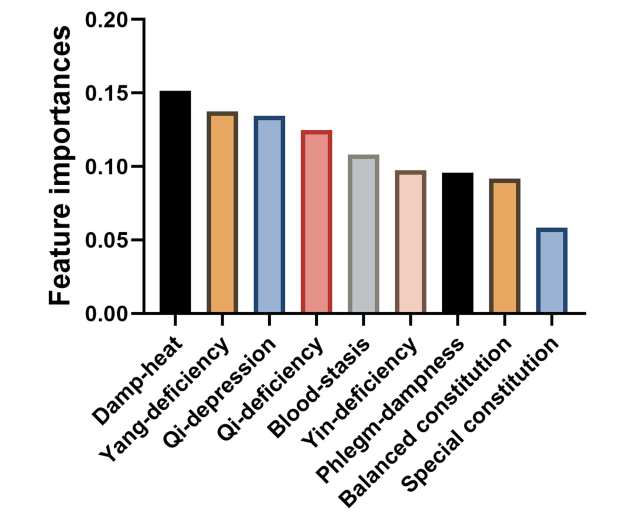

FIGURE 4
Feature importance values of traditional Chinese medicine (TCM) constitution classifications in random forest classifier (RFC).

Author contributions

SL: Data curation, Funding acquisition, Investigation, Writing – original draft. PZ: Data curation, Investigation, Writing – review & editing. GC: Data curation, Investigation, Writing – review & editing. JL: Data curation, Investigation, Writing – review & editing. TH: Conceptualization, Writing – review & editing. WT: Conceptualization, Writing – review & editing.

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Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Shanghai Minhang District Integrated Traditional Chinese and Western Medicine Hospital (Ethics Reference No. 2021-007). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The effects of global postural re-education on sleep quality and stress in university women lecturers: a randomized controlled trial

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Objective: The present study aimed to evaluate the effect of global postural re-education (GPR) on sleep quality and stress in female health science lecturers.

Methods: A total of 24 female university lecturers were allocated in this randomized controlled trial into intervention ($n = 12$) and control ($n = 12$) groups. The intervention group underwent familiarization and training on the therapy to execute an 8-week treatment with GPR. Data collected on sleep quality were analyzed using 24-h accelerometry (Actigraphy GT3X+) in addition to the Pittsburgh Sleep Quality Index (PSQI) questionnaire score as well as the State-Trait Anxiety Inventory (STAI) anxiety questionnaire. Data on stress were collected by measuring salivary cortisol.

Results: After comparing the GPR of the groups, there was a main effect of the group ($F = 5.278$, $p = 0.044$) for PSQI. The *post-hoc* analysis revealed that both groups decreased scores between pre- and post-treatment. Additionally, post-treatment, there were differences between groups. For sleep latency, there were main effects of group ($F = 6.118$, $p = 0.031$) and score × group ($F = 9.343$, $p = 0.011$) interactions. The *post-hoc* analysis revealed that treatment groups decreased scores between pre- and post-treatment, and there were differences between groups (all $p < 0.050$).

Conclusion: The self-administered GPR improves sleep quality in female university lecturers, providing a valuable self-regulation tool for enhanced sleep quality and enhanced academic performance. Further study may help to develop this as a potential tool to help university lecturers' job performance.

KEYWORDS
sleep quality, Pittsburg questionnaire, stress, cortisol, high education, self-treatment

1 Introduction

Human beings need adequate control to regulate the stimuli received during his life and sufficient rest to be able to obtain a biological, physical, and emotional balance. In this sense, stress and sleep quality are influential determinants of health status (1). University lecturers are exposed to certain degrees of pressure related to personal management with students, other lecturers, administrative staff, and people in senior or management positions (2). The professional development of the university lecturer requires, in many cases, in addition to teaching, an added labor toward research, management, participation in talks and/or committees, extra training, work groups, supervision of students, maintenance with the profession of base, and pressure for coordination with different people from the university environment (3). The sum of these charges is a predisposing factor that damages the health of a person (4, 5). Similarly, due to the pandemic declared in 2020, consequences have been described for the mental and physical health of people, including stress and sleep quality (6). Adaptation to the pandemic situation has been associated with a decrease in the physical and mental wellbeing of lecturers (7).

Sleep is a physiological process defined as a behavior and state of the brain that appears daily. The circadian phases were adjusted to night and day (8) and were regulated in the suprachiasmatic nucleus of the hypothalamus (9). During this reversible state, awareness and response to the environment are diminished. Sleep problems affect a person's performance and health. Total or partial sleep deprivation can generate physiological and psychological changes such as attention deficits, irritability, motivation, and stress, among others (10).

Stress is an adaptive and necessary reaction that prepares the body to react to different situations. From the point of view of neuroscience, considered a type of emotional activation, stress is defined as a physiological reaction that affects the properties of brain cells and can affect the nervous system and other systems, as well as behavioral processes and cognitive processes (11). It has positive connotations since it is necessary to keep the individual alert, motivated, and strong. On the other hand, if stress occurs in excess and adaptation is not achieved, it paralyzes, generates anger, sadness, and fear, and can have negative repercussions on health (1, 12). In situations of stress, among other glucocorticoids, the adrenal glands secrete cortisol upon receiving adrenocorticotropin (ACTH) from the bloodstream. ACTH is produced after the activation of the hypothalamic-pituitary-adrenal axis and is driven into the pituitary by corticotropin produced in the hypothalamus (13).

Physiological processing in the face of mechanical and psychological stimuli is different in men and women. The prevalence of mental and physical pathologies has marked patterns according to gender. It is of special interest to study the differences between genders since gender is considered an important and influential biological factor in vulnerability to psychosocial stress (14). Women perceive potentially stressful circumstances as more intense than men, such as their job occupation or the social role they have acquired (15), showing a higher incidence of mood problems and anxiety states in women compared to men (16).

Global postural re-education (GPR) is a physiotherapy proposal that attempts to coordinate the tension of the muscular chains using the powerful components of concentration, flexibility, proprioception, and strength using guided breathing (17). It is a therapy of wide clinical use, and its effects have been studied in cervical pain (18), low back pain (19), and temporomandibular disorders (20). Similarly, it has been studied for other types of pathologies such as urinary incontinence (21, 22), ankylosing spondylitis (23), and even in Alzheimer's and Parkinson's diseases (24). Although GPR has been widely employed in clinical practice, demonstrating its utility in treating various pathologies (18–24), further research is needed to determine its effectiveness in other areas due to the variability of physiological implications triggered during its execution. GPR stands out as a fundamental pillar, particularly for its focus on slow and controlled respiratory mechanics. Laborde et al. (25) point out that the slow and voluntary breathing characteristic of GPR leads to an increase in parasympathetic nervous system control mediated by the vague nerve. This type of breathing, specifically abdominal or diaphragmatic, has been shown to improve sleep quality given its crucial role in the body. Similarly, abdominal breathing used in GPR is characterized by deep inhalations and prolonged exhalations, facilitating oxygen intake and carbon dioxide elimination and inducing bodily relaxation and a decrease in stress and anxiety levels (26). This effect promotes an improvement in sleep onset as well as in quality and restfulness during sleep (25).

In this context, there is a need for gaining knowledge of tools that reduce costs in national healthcare systems, enhance patient autonomy, and aim to support the reduction of inappropriate self-administration of medications focused on improving sleep and anxiety. Furthermore, these tools should be aimed at improving patient safety under the guidance and education of healthcare professionals, requiring minimal time for implementation, allowing flexibility, and adapting to the patient's lifestyle to facilitate adherence.

Therefore, the present study aimed to evaluate whether the application of a self-treatment program with GPR has effects on sleep quality and stress in higher education lecturers. We hypothesized that effective sleep quality in female university lecturers' conditions is good for academic performance and that self-treatment with GPR helps to improve sleep quality and stress in this cohort of female lecturers.

2 Materials and methods

2.1 Study design

A single-center, randomized, controlled study (National Clinical Trial identifier NTC05488015) was assessed.

2.2 Participants

A total of 24 female university lecturers from the Universidad Francisco de Vitoria, Madrid, Spain were included in this study. The inclusion criteria were (a) female university lecturers and (b) age between 32 and 61 years. The exclusion criteria were as follows: (a) pregnant university lecturers, who due to hormonal fluctuations, such as increased progesterone levels, can experience daytime sleepiness, frequent nighttime awakenings, and difficulties falling asleep, contributing to decreased sleep quality. Additionally, physical changes such as weight gain and physical discomfort can interfere with comfort during rest, thereby increasing stress levels; (b) those who use of drugs [non-steroidal anti-inflammatory drugs (NSAIDs), anticonvulsants, beta-blockers, and antidepressants]: These drugs can influence sleep quality and stress levels in various ways. For instance, antidepressants and beta-blockers may alter neurotransmitter regulation in the brain, affecting sleep patterns. In addition, anticonvulsants might induce daytime drowsiness or disrupt sleep cycles, negatively impacting rest quality; (c) those with musculoskeletal or neurological pathologies associated with sleep disorders such as chronic pain, discomfort, or involuntary movements during sleep, disrupting both sleep quality and quantity. Chronic pain can wake individuals up during the night and hinder their falling back asleep, contributing to the onset of sleep disorders; (d) those affected by sleep disorders such as sleep apnea disrupt breathing during sleep, leading to micro-awakenings and poor sleep quality. Circadian rhythm disorders affect the body's internal clock, making it challenging to regulate the sleep-wake cycle, causing insomnia or other sleep issues that may elevate stress levels; (e) those with acute or subacute back pain or pathology can cause significant discomfort at night, frequent awakenings, and difficulty finding a comfortable sleeping position, thereby disrupting sleep and increasing stress levels; and (f) those with tumors and rheumatological, adrenal, or pituitary diseases. These conditions can directly impact sleep quality and stress levels due to physical symptoms such as pain, fatigue, or hormonal changes that affect the ability to rest adequately and manage stress effectively.

All participants signed a written informed consent before participating in the study. The study protocol was approved by the Research Ethics Committee of the Universidad Francisco de Vitoria (UFV 18/2021), following the Declaration of Helsinki of 1964 (last actualization: 2013).

2.3 Sample size

The sample size was calculated using G*Power 3.4 software (27). An *a priori* sample size calculation indicated that female students of health sciences were needed to obtain statistically significant differences between the intervention and control groups. This *a priori* sample size was calculated to obtain an effect size of 25.7% of reduction in stress by using the GPR method (statistical power of 80% with type I error set at 5%) based on a previous investigation that obtained these results when they studied the effect of the intervention regarding the control group in the intervention group (28). A target sample size of 24 participants was determined.

2.4 Randomization method

Participants were randomly allocated after baseline data collection in a parallel group (1:1 ratio) to either an intervention group or a control group. Participants were randomized on an Excel-generated randomization schedule. The research coordinators regularly performed data quality control, management, and protocol compliance verification. Due to the nature of the intervention, blinding of participants, care providers, and outcome assessors was not possible.

2.5 Procedure

The experimental group was provided with different materials to become familiar with the intervention. These materials were as follows: (1) an informative triptych with the GPR intervention process and with the positions to be carried out explained in writing and images; (2) two explanatory videos on the execution and evolution of the postures; (3) an audio that allows to follow the evolution of the postures step by step during their execution, with the necessary corrections to avoid making mistakes; (4) an exam that allowed us to evaluate and establish the knowledge about the learning obtained; and (5) the participants had the continuous support of the researchers during the intervention time.

2.5.1 Intervention

The GPR postures were done before going to sleep for 4–5 days a week for 8 weeks. The two chosen postures were performed on the ground, looking for a hard and stable surface and unloading gravity to facilitate self-management. The first position was a coxofemoral opening with closed arms. The position begins with the participant lying supine on the floor, with the arms open at 90° and the palms of the hands facing the ceiling. The lower limbs begin with hip and knee flexion, with the soles of the feet together, the heels near the gluteal region, and a hip abduction opening between 30° and 45°. The physiological curves of the spine must be maintained, and good support and alignment between the occiput and the sacrum are sought. From that starting position, the posture progressively evolves, seeking to close the arms along the body and extend the hips and knees in the direction of an anatomical position. The second position to perform was coxofemoral closure with closed arms. This position begins with the participant lying supine, with arms open at 90° and palms facing the ceiling. The lower limbs are found with the hips and knees flexed and the soles of the feet together and leaning against a wall. The physiological curves must be maintained, and good support and alignment of the occipital and sacral regions are sought. The posture evolves by progressively closing the arms toward the patient's body and raising the legs up the wall, generating tension in the posterior myofascial chain. During the execution of both postures, the participants had to maintain a specific GPR breath as the fundamental basis of the method. Each posture was held for 15 min, with a total of 30 min per session.

2.6 Outcomes and measurements

The participants received personal instructions to collect the different samples and fill out the different questionnaires and outcomes as follows:

2.6.1 Primary outcomes

2.6.1.1 Actigraphy

Actigraphy GT3X+ [*ActiGraph, (Pensacola, FL, EEUU)*] activity bracelets were used to take measurements of the quality of sleep. Accelerometry data were collected using a 90-Hz sampling rate and integrated into 60-s steps (24, 29). The participants wore the bracelet during the week before the intervention to collect baseline measurements and the week after the intervention for comparison. The bracelets were maintained for a full week at each shot (30). It was indicated that the bracelet should be worn on the non-dominant hand (31). The data provided by the bracelets were as follows: In Bed (time to go to bed), Out Bed (time to get up), Latency (time spent from going to bed to falling asleep in minutes), Efficiency (the efficiency of sleep itself, according to the hours spent sleeping and being in bed), total time in bed (TTB), total sleep time (TST—total sleep time expressed in minutes), wake after sleep onset (WASO—time of awakenings while asleep), Number of awakenings at night, and Average Awakening (average time of each awakening at night). The results obtained were extracted from a computer using the Actylife version 6.9 software.

2.6.1.2 Pittsburgh self-administered Sleep Quality Index questionnaire

Actigraphy data were supported by the self-administered Pittsburgh self-administered Sleep Quality Index (PSQI) Questionnaire (32). The PSQI is a validated questionnaire, and it has been shown to report reliable measures (33). The PSQI consists of 19 questions that assess sleep factors such as sleep duration, frequency, or latency. These questions are grouped into seven proficiency scores and are rated from 0 (no difficulty) to 3 (great difficulty). These seven scores report on other components of subjective sleep quality, such as subjective quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of hypnotic medication, and daytime dysfunction. For the final score, seven scores are added, with the highest scores being those with the worst sleep quality (32).

2.6.1.3 Sleep diary

Self-reported sleep quality with a sleep diary was used. This diary was filled out every day of the study, including the weeks in which the baseline measurements were taken before and after the intervention. Participants were informed and reminded in the mornings that they had to fill in the diary about the night before (34, 35). The diary includes questions related to the quality of sleep, answered using a Likert scale, a question to verify the performance of the posture during the week, and a section for observations. The diary allows the calculation of certain parameters: TST, sleep onset latency at the beginning of the night (SOL), WASO, sleep efficiency (SE), and perceived sleep quality or satisfaction using the Likert scale established from 0 (very poor) to 4 (very good) (35, 36).

2.6.2 Secondary outcomes

2.6.2.1. Salivary cortisol level

To collect the amount of cortisol in saliva as an indicator of stress levels, the participants were instructed about explanatory videos on the collection process. The Salivette® kit (Sardtedt AG & Co. KG, Nümbrecht, Germany) was used. The saliva samples were analyzed by chemiluminescence after centrifuging for 2 min, following the manufacturer's instructions for the kit (Cortisol Saliva ELISA SA E-6000) from LDN®, which is developed and approved for the measurement of cortisol levels in saliva in humans.

The participants collected saliva for a full day to assess the circadian changes in cortisol levels, obtaining four samples: (1) upon waking up, (2) at 11:00 a.m., (3) at 3:00 p.m., and (4) at bedtime (37). The samples were stored at 4°C for no more than 2 days by the participants, and once they were delivered to the researchers, they were stored at −80°C until analysis.

2.6.2.2 State-Trait Anxiety Inventory questionnaire

Anxiety is one of the emotional reactions to stress. The State-Trait Anxiety Inventory (STAI) questionnaire has been validated and is accepted by the scientific community to measure anxiety and relate it to stress levels. The questionnaire evaluates two independent concepts of anxiety: (a) state anxiety (STAI S-A), which is an individual's emotional and transitory anxiety condition, and (b) trait anxiety (STAI T-A), which is the individual's stable propensity for anxiety, which may be a trait of his or her personality (38). Each of these concepts include 20 items in the questionnaire. Each of the items is evaluated on a 4-point scale (0, not at all; 1, somewhat; 2, quite a bit; and 3, a lot), which is rated as inverse (if they decrease anxiety) or direct (if they increase anxiety) (38).

2.6.3 Statistical analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 25.0 (IBM Corp., Armonk, United States). Continuous data were presented as the mean and standard deviation (SD) and 95% confidence intervals (95% CIs) of the mean. Continuous data were given as counts and percentages. The Shapiro-Wilk test was used to check the normality of all variables. Since all variables were normally distributed, parametric tests were applied to examine differences among conditions. Differences in continuous data between groups were assessed with the *t*-test. The time courses of continuous variables were evaluated using a two-way analysis of variance (ANOVA) with a repeated measurements design, providing readings of a continuous quantity (dependent variable) at two levels of a within-subject factor and a dichotomous characteristic (e.g., group assignment) as an independent, between-subjects factor. Interactions between the results of a biomarker decline between pre-intervention and post-intervention examinations in the treated group and the control group were analyzed (e.g., results of a biomarker decline between pre- and post-intervention examinations in the treated group, whereas they stagnated or even rose in the control group). Finally, repeated measurement of variance analysis was conducted to identify potential interaction effects between time and sessions in the study outcomes as follows. To determine whether participants' anxiety significantly changed and to uncover potential differences between groups at pre- and post-assessment, the STAI questionnaire was subjected to statistical analysis. Responses to the State and Trait Anxiety Inventory were scored separately to reveal an STAI S-A and STAI T-A, PSQI, TST, WASO, SE, and SOL. Each one was subjected to two-factor mixed repeated measures ANOVA (2 groups × 2 evaluation times). When a significant F value was obtained for any main effect or interaction, a least significant difference (LSD) *post-hoc* analysis was performed to determine pairwise differences for the values obtained pre- and post-treatment within each group. The significance level was set at a *p*-value of < 0.05.

3 Results

From September to October 2022, 31 women filled out the registration questionnaire to participate. A total of 24 participants meeting the inclusion criteria were contacted and recruited and randomized in the intervention and control groups. The sample was finally composed of 24 women lectures, 12 in the control group and 12 in the intervention group, who completed pre- and post-intervention assessments. Microsoft Excel software was used to randomize the participants and divide them into two groups, namely, the control group ($n = 12$) and the experimental group ($n = 12$; Figure 1).

Detailed baseline data for participants are shown in Table 1. As intended, both groups did not significantly differ regarding age, body mass index (BMI), biomarkers, and outcome scores.

For PSQI, there was a main effect of group ($F = 5.28$, $p = 0.044$) with no main effects of the score ($F = 0.67$, $p = 0.433$) and score × group ($F = 0.00$, $p = 0.952$) interaction (Table 2). The *post-hoc* analysis revealed that both groups decreased scores between pre- and post-treatment. Additionally, post-treatment, there were differences between groups (all $p < 0.050$; Figure 2).

For sleep latency, there was a main effect of group ($F = 6.12$, $p = 0.031$) and score × group ($F = 9.34$, $p = 0.011$) interaction, with no main effect of the score ($F = 0.53$, $p = 0.482$; Table 2). The *post-hoc* analysis revealed that the treatment group decreased scores between pre- and post-treatment. Additionally, post-treatment, there were differences between groups (all $p < 0.050$; Figure 3).

4 Discussion

This study evaluates the application of a self-treatment program with GPR effects on sleep quality and stress among university lecturers, showing the first outcomes during 8 weeks of intervention on sleep quality and stress in female university lecturers. The results obtained from the GPR through the PSQI questionnaire and actigraphy suggest that the intervention had a positive effect on the sleep quality of this cohort of women lecturers.

Previous studies have shown that light to moderate physical activity, done in the morning or in the evening, has had a positive impact on sleep quality even in interventions of shorter duration than the present study (39, 40). Along the same lines, there are studies that apply other physical activities, such as yoga, which requires concentration, posture maintenance, and guided breathing. These studies have also demonstrated their effectiveness in improving sleep quality in older adults (41–43).

It is also possible that the positive effects of GPR on sleep quality are due to the reduction of muscular tensions and the improvement of body posture that this therapy has already demonstrated from a musculoskeletal point of view through the performance of specific exercises that seek muscular balance and the release of muscular tensions (18, 19). Several studies have linked the improvement of posture and the reduction of muscular tensions with a relaxing effect on the body and, therefore, may favor a better quality of sleep (44, 45).

It is interesting to note that both the sleep diary and actigraphy measure some similar variables, allowing the results between the two tests to be compared from subjective and objective points of view. Overall, this study found a good correlation between the data collected by the two tests, although there were also some notable differences. For example, actigraphy revealed that some participants slept less than their sleep diary indicated, which could indicate an overestimation in the diary. This could be due to a greater awareness of their sleep and a more critical subjective assessment of sleep quality, whereas actigraphy only measures objective aspects such as sleep duration and amount of movement. These discrepancies between objective and subjective sleep assessment have already been exposed in other studies (46, 47). It was also suggested that actigraphy might not be sensitive enough to detect subtle improvements in sleep quality (48).

On the other hand, the positive effects on sleep quality in this study may have been positively influenced by the time of the intervention. Studies such as those by Tsai et al. (49) not only perform the intervention before sleep but also focus on guided breathing that helps to decrease vagal activity. In other words, one could attribute to GPR a relaxing and meditative nature that reduces the physiological and mental activity necessary to improve sleep quality. In any case, it is important to keep in mind that the effects of GPR on sleep quality may depend on several factors, such as the duration and frequency of the intervention, as well as the individual characteristics of the participants, such as their age, gender, and stress level. In this sense, from a methodological point of view, this study is aligned with the recommendations of intervention with GPR used in different studies such as Amorim et al. (50), Brooks et al. (51), and Kloek et al. (52). However, we can contrast the results with other studies focused on older people, children, or special populations and using interventions of different durations ranging from 6 weeks (53) to 12 weeks (54). Therefore, it would be interesting to expand GPR studies focusing on physiological and cognitive variables such as sleep quality and stress to determine the best protocols. It is important to note that the sample used in this study is composed exclusively of female university lecturers, which limits the generalizability of the results to other populations. However, these findings provide relevant information for understanding sleep quality in this specific group and may be useful for the implementation of intervention programs aimed at improving sleep quality in women university lecturers.

The relationship between sleep quality and stress has been previously evaluated in female university lecturers in studies such as that of Vela-Bueno et al. (55), where they found that poor sleep quality associated with the professionals evaluated was associated with a greater presence of job stress and lower job satisfaction, which is highly prevalent in university lecturers (56). In view of this relationship, stress was also assessed in this study using the biomarker cortisol and the STAI anxiety questionnaire. For these variables, the proposed intervention does not seem to have had different effects if we compare the results of the control group with those of the intervention group. Although there are studies such as the one by Sugano and Nomura (57) that claim that stretching can have a positive effect on cortisol control, there are different factors that may influence why this study did not obtain the same results. It is possible that the 8-week intervention was not sufficient to generate significant changes in cortisol levels in female university lecturers. Some studies have found that stress reduction through therapies such as meditation and yoga can take longer than 8 weeks

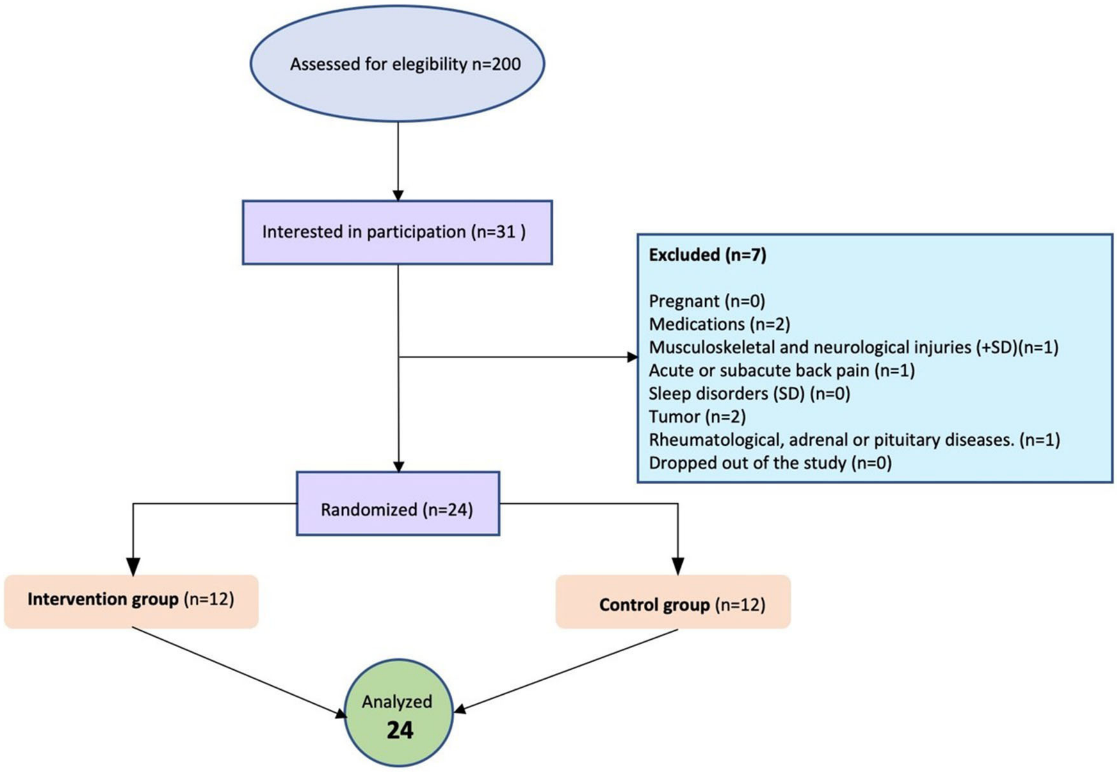

FIGURE 1
Flow diagram.

TABLE 1 Baseline characteristics of both the intervention and control groups were presented by mean (standard deviation).

	Intervention group	Control group	Effect size	*p*-value
Age (years)	38.08 (3.80)	42.42 (6.62)	0.542	0.105
Weight (kg)	58.83 (9.04)	63.37 (14.02)	0.385	0.365
Height (m)	1.65 (0.06)	1.65 (0.06)	0.016	0.973
BMI (kg/m^2)	21.46 (2.74)	23.18 (5.48)	0.398	0.339
Biomarker				
Saliva cortisol (ng/dl)	19.81 (7.82)	20.53 (7.26)	0.094	0.827
Outcomes				
Sleep latency	4.09 (3.28)	2.12 (2.32)	−0.693	0.085
TST (min)	393.92 (45.04)	383.93 (43.36)	−0.225	0.587
WASO (min)	41.48 (31.59)	46.48 (25.62)	0.173	0.675
Awakenings	13.99 (4.58)	14.768 (6.611)	0.137	0.74
Average awakenings	2.90 (1.77)	3.20 (1.37)	0.187	0.649
TIB (min)	440.21 (51.47)	431.94 (35.72)	−0.186	0.652
STAI (T-A)	33.08 (25.03)	32.75 (29.08)	−0.012	0.976
STAI (S-A)	40.83 (25.88)	39.17 (28.39)	−0.061	0.882
PSQI	5.00 (3.07)	5.58 (2.91)	0.194	0.638

BMI, body mass index; STAI (T-A), State-Trait Anxiety Inventory Trait Anxiety; STAI (S-A), State-Trait Anxiety Inventory State Anxiety; PSQI, Pittsburgh; WASO, wakefulness after the onset of sleep; SE, sleep efficiency; TST, total sleep time; SOL, sleep onset latency at the beginning of night sleep.

TABLE 2 Data on repeated measurement design and differences in outcome scores between the intervention and control groups.

	Main effect score	Main effect group	Interaction group × score
Sleep latency	$F = 0.53$	$F = 6.12$	$F = 9.34$
	$df_1 = 1; df_2 = 11$	$df_1 = 1; df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.046$	Partial $\eta^2 = 0.357$	Partial $\eta^2 = 0.459$
	$p = 0.482$	$p = 0.031^*$	$p = 0.011^*$
TST (min)	$F = 2.59$	$F = 1.33$	$F = 0.89$
	$df_1 = 1; df_2 = 11$	$df_1 = 1; df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.206$	Partial $\eta^2 = 0.117$	Partial $\eta^2 = 0.082$
	$p = 0.138$	$p = 0.276$	$p = 0.367$
WASO (min)	$F = 0.42$	$F = 0.00$	$F = 0.00$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.037$	Partial $\eta^2 = 0.000$	Partial $\eta^2 = 0.000$
	$p = 0.531$	$p = 0.944$	$p = 0.969$
Awakenings	$F = 0.03$	$F = 0.85$	$F = 0.30$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.003$	Partial $\eta^2 = 0.072$	Partial $\eta^2 = 0.005$
	$p = 0.866$	$p = 0.376$	$p = 0.823$
Average awakenings	$F = 0.27$	$F = 0.29$	$F = 0.03$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.024$	Partial $\eta^2 = 0.026$	Partial $\eta^2 = 0.003$
	$p = 0.614$	$p = 0.602$	$p = 0.871$
TIB (min)	$F = 2.31$	$F = 0.900$	$F = 1.24$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.177$	Partial $\eta^2 = 0.075$	Partial $\eta^2 = 0.101$
	$p = 0.153$	$p = 0.364$	$p = 0.289$
STAI (T-A)	$F = 0.42$	$F = 2.62$	$F = 1.33$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.037$	Partial $\eta^2 = 0.192$	Partial $\eta^2 = 0.108$
	$p = 0.523$	$p = 0.134$	$p = 0.273$
STAI (S-A)	$F = 0.37$	$F = 2.99$	$F = 4.46$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.416$	Partial $\eta^2 = 0.214$	Partial $\eta^2 = 0.298$
	$p = 0.554$	$p = 0.112$	$p = 0.058$
PSQI	$F = 0.67$	$F = 5.28$	$F = 0.00$
	$df_1 = 1; df_2 = 11$	$df_1 = 1$ $df_2 = 11$	$df_1 = 1; df_2 = 11$
	Partial $\eta^2 = 0.063$	Partial $\eta^2 = 0.345$	Partial $\eta^2 = 0.000$
	$p = 0.433$	$p = 0.044^*$	$p = 0.952$

df, degrees of freedom; TST, total sleep time; WASO, wake after sleep onset; STAI (T-A), Trait Anxiety Inventory; STAI (S-A), State Anxiety Inventory; PSQI, Pittsburgh. Effect sizes are given as partial η^2. Statistically significant $^*p < 0.05$.

to be evident in salivary cortisol levels (58, 59). On the other hand, the heterogeneity of risk factors that play a role in stress among university lecturers may have limited the effectiveness of the stress intervention (60). Given the close relationship between students and lecturers and their mutual influence throughout the academic year, conducting a study involving students to compare stress levels, sleep patterns, and the effects of such interventions between both populations would be highly valuable. Exploring these aspects in students could provide a comprehensive understanding of the broader educational environment and potentially yield insights

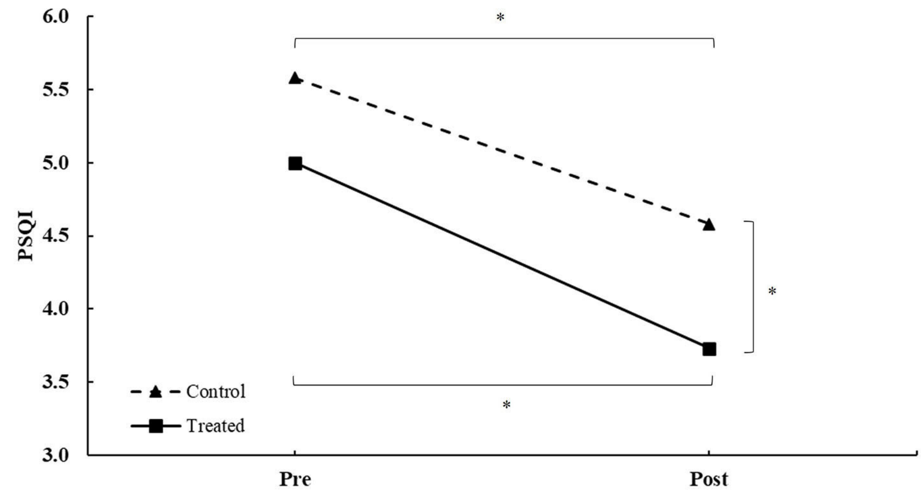

FIGURE 2
PSQI score during intervention in patients between the treated and control groups during intervention. *Differences at a p-value of < 0.050.

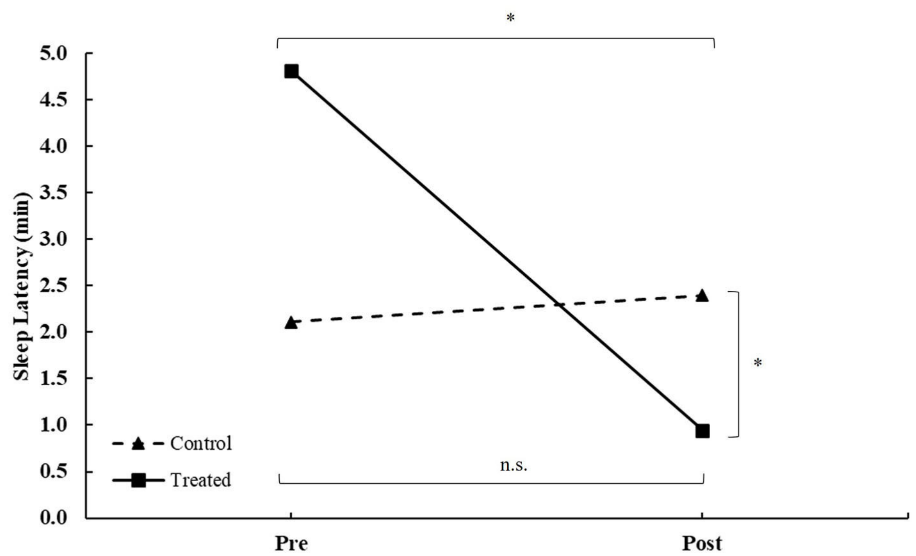

FIGURE 3
Sleep latency during intervention in patients between the treated and control groups during intervention. *Differences at a p-value of < 0.050, n.s., non-significant.

into strategies for enhancing overall wellbeing and academic performance across the entire educational community.

The overarching goals of the World Health Organization's (WHO) health-promoting universities program emphasize a comprehensive approach to health encompassing physical, mental, and social wellbeing within academic settings (61). Universities are increasingly aware of the significance of faculty wellbeing and the strategies needed to achieve it. This study aligns with these strategies, focusing on university professors but potentially transferable to the wider university community. GPR not only targets physical aspects such as posture or pain reduction but also addresses fundamental psychological aspects such as stress management and sleep improvement. It signifies an enhancement of both physical and mental health, contributing to cultivating a healthier academic environment. Furthermore, the methodology employed provides self-care tools, promoting health and a balance between work and personal life among university lecturers.

This investigation exhibits certain strengths that merit emphasis. It can be asserted that the measurement and comparison of variables using objective markers and subjective assessments through questionnaires have allowed us to highlight the therapeutic intention focused on patient perception and preferences. Moreover, interventions that can be appropriately guided may empower patients with significant autonomy and contribute to cost savings for National Healthcare Systems. However, this study presents potential limitations. We can enumerate the following: (a) the small sample size in this study raises caution when making definitive conclusions due to the small sample size; (b) the aspect of self-management by patients, which could potentially benefit from therapist-assisted manual treatment amplification; and (c) the absence of in-person familiarization sessions. Incorporating in-person sessions with therapist-guided management during the familiarization process would be beneficial or, following classroom-based training/treatment, live lessons in between self-management would be beneficial. Given these limitations, the findings of this investigation should be extrapolated to subjects following a similar familiarization and treatment methodology.

5 Conclusion

This randomized controlled study shows for the first time that GPR self-treatment helps to improve sleep quality in female university lecturers and will serve as a support in periods of need so that this autonomy can serve as a catalyst that will result in improved sleep quality and, consequently, better psychological conditions to enhance work performance.

Based on these findings, it seems worthwhile to encourage and promote research among other populations, particularly those related to educational settings, who may also experience sleep quality problems and stress, such as university students (62). Exploration of these aspects by students could provide an overall understanding of the broader educational environment and potentially yield insights into strategies for improving general wellbeing and academic performance across the educational community.

Similarly, it will be interesting to apply these results in future studies to people suffering from diseases that are highly correlated with sleep quality problems, such as patients with arterial hypertension (63).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study protocol was approved by the Research Ethics Committee of the Universidad Francisco de Vitoria (UFV 18/2021), following the Declaration of Helsinki of 1964 (last actualization: 2013). All participants signed a written informed consent before participating in the study.

Author contributions

MR-A: Conceptualization, Funding acquisition, Investigation, Methodology, Visualization, Writing – review & editing. DB-R: Data curation, Methodology, Writing – review & editing. MM-M: Data curation, Methodology, Writing – review & editing. SS-J: Data curation, Methodology, Writing – review & editing. DV-D: Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. NV-B: Conceptualization, Investigation, Methodology, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Efficacy of acupuncture therapy on cancer-related insomnia: a systematic review and network meta-analysis

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Objectives: Cancer-related insomnia (CRI) takes a toll on many cancer survivors, causing distressing symptoms and deteriorating the quality of life. Acupuncture therapy has been used for CRI already. However, it is still uncertain which acupuncture regime is best for CRI. The primary objective of this review is to conduct a comparative evaluation and ranking of the effectiveness of different acupuncture therapies for CRI.

Methods: Randomized controlled trials (RCTs) that were published up to July 31, 2023, from 8 databases (PubMed, Embase, Cochrane library, Web of Science, China National Knowledge Infrastructure, Wanfang Database, VIP Database, and China Biology Medicine disc) were integrated in this study. Trials that met the inclusion criteria were evaluated the risk of bias. Pittsburgh sleep quality index (PSQI) was used to assess the efficacy of different acupuncture therapies as the primary outcome. Then, STATA 15, R, and OpenBUGS were applied to perform the network meta-analysis. PRISMA statements were followed in this network meta-analysis.

Results: A total of 37 studies were included in this review, involving 16 interventions with 3,246 CRI participants. Auriculotherapy + moxibustion [surface under the cumulative ranking curve (SUCRA) 98.98%] and auriculotherapy (SUCRA 77.47%) came out top of the ranking, which were more effective than control, medicine, usual care and sham acupuncture.

Conclusion: Auriculotherapy + moxibustion and auriculotherapy + acupuncture emerged as the top two acupuncture regimes for CRI and future studies should pay more attention to CRI.

Clinical trial registration: https://clinicaltrials.gov/, identifier INPLASY202210095.

KEYWORDS

network meta-analysis, cancer-related insomnia, the complication of cancer, acupuncture therapy, non-pharmacological therapy

1 Introduction

Cancer-related insomnia (CRI) is a substantial complication of cancer, tormenting many cancer survivors. It is manifested as sleep initiation disorder, frequent night awakenings, early awakenings, or dreamy in the process of the diagnosis and treatment of cancer (1–3). These annoying symptoms also cause a sequence of adverse effects on cancer survivors, such as impairment in daytime function and quality of life, anxiety and depression (4, 5). As is reported, 30–50% (up to 95%) of cancer survivors suffer from CRI, and the incidence is exceptionally high in lung cancer and breast cancer (1, 6, 7). Since CRI threatens the quality of life and prognosis of cancer survivors, attention should be paid to the treatment of CRI.

Regarding the treatment of CRI, both pharmacotherapy and non-pharmacological therapies can be applied to relieve CRI symptoms. The medications used to manage CRI are mainly sedatives and melatonin. Although these medications do alleviate sleep disturbances in many cancer survivors with CRI, they may produce many side effects such as withdrawal, cognitive impairment, headache and so on, which leads to poor tolerance and low adherence of medication (3, 8). Cognitive behavioral therapy (CBT), as a non-pharmacological therapy recommended in guidelines for various types of insomnia (9, 10), has been confirmed to have a definite curative effect on CRI (11, 12). But the popularizing rate of CBT was not so desirable due to its time-consuming, complicated, and more effort and self-discipline required than normal therapy (13). Acupuncture therapy is effective, low risky, and easy to implement for the treatment of CRI, so increasing cancer survivors are turning to the assistance of acupuncture therapy (14–16). Acupuncture therapy encompasses but is not limited to acupuncture, electroacupuncture, auriculotherapy, moxibustion and acupoint application. A brief introduction of conventional acupuncture was shown in Supplementary Figures S1–S6.

A considerable number of relative randomized controlled trials have been executed to authenticate the efficacy of acupuncture therapy in treating CRI. Acupuncture therapy could improve habitual sleep efficiency, prolong sleep duration, reduce the frequency of sleep awakenings (17, 18). In recent years, meta-analyses have also corroborated the effectiveness of acupuncture therapies in treating CRI. Studies (19, 20) have demonstrated that acupuncture therapy could effectively ameliorate sleep disorders, augment the sleep duration and reduce the reliance on sleep medication in CRI patients. However, above meta-analyses only compared acupuncture therapy in pairs. Ou et al. (21) compared the efficacy of different acupuncture therapies on CRI, but we noticed that several studies included in the network meta-analysis were related to surgery. Consequently, it was impossible to define whether insomnia was cancer-related or surgery-related in these studies. Moreover, several studies within the network meta-analysis incorporated other non-pharmacological interventions in the experimental group, which may impact the ranking of acupuncture therapies. Therefore, which acupuncture regime has the first-class curative effect is still in the mist and the development of acupuncture therapy for CRI is a need in the field. Thus, the dominating purpose of this review is to compare the difference of the curative effect among acupuncture regimens for CRI and rank the efficacy of acupuncture therapies for CRI.

2 Methods

2.1 Study design

This network meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines published in 2020 and procedures shown in the Cochrane Handbook. The protocol for this network meta-analysis has been published (22). Informed consent was not required as the data used in this review derived from pre-existing articles.

2.2 Eligible criteria

2.2.1 Patients

Cancer survivors with CRI.

2.2.2 Intervention

Acupuncture therapies include but not limited to acupuncture, moxibustion, electroacupuncture, acupressure, auriculotherapy and acupoint application. Pharmacotherapy and usual care could be combined with the above-mentioned acupuncture therapies.

2.2.3 Comparator

Medications, usual care and sham acupuncture interventions.

2.2.4 Outcome

In this study, Pittsburgh sleep quality index (PSQI) was used to assess the efficacy of different acupuncture therapies as the primary outcome, with the secondary outcomes being the subitems of the PSQI.

2.2.5 Study design

Only peer-reviewed randomized controlled trials with available and detailed data were included.

2.3 Exclusion criteria

(1) Reviews, animal experiments, case reports, protocols, systematic reviews, conference papers, comments, etc. (2) Primary insomnia or other secondary insomnia. (3) Non-randomized controlled trials such as inappropriate random method, retrospective study, etc. (4) Other complementary or alternative therapies were included in experimental group and/or control group, which are not limited to psychological intervention, behavioral therapy, herbal therapy, etc. (5) Identical acupuncture therapy with varying treatment time or materials. (6) Duplicate published literature or literature without full text or specific data.

2.4 Search strategy

A full-scale electronic literature search was conducted across 8 databases (PubMed, Embase, Cochrane library, Web of Science, China National Knowledge Infrastructure, Wanfang Database, VIP Database, and China Biology Medicine disc) to retrieve English and Chinese literature from setup until 31st July 2023. Based on the retrieval needs of each database, we personalized the search strategy, and the detailed search strategies were displayed in Supplementary Tables S1–S8.

2.5 Data extraction

Two reviewers screened titles and abstracts severally to assess eligible RCTs using EndNote X9 software. Subsequently, a comprehensive review was performed with the full-text of included articles for further evaluation and data extraction. The data to be extracted were studies' characteristics (author, year of publication, country), participants' characteristics (sample size, types of acupuncture therapies, and comparisons), and results. Any discrepancies or disagreements between two reviewers were adjudicated by a third reviewer.

2.6 Risk of bias

The risk of bias of included studies was performed based on Cochrane risk-of-bias tool (ROB 2.0) (23) and was classified into "low risk," "high risk," or "some concern." In the event of any discrepancies, a third investigator was consulted for adjudication.

Bias was evaluated by reviewers in the following five domains: (1) bias generating during randomization, (2) bias due to deviations from expected interventions, (3) bias from missing outcome data, (4) bias in outcome measures, (5) bias in the selection of the reported outcomes.

2.7 Data synthesis and statistical methods

Network meta-analyses were carried out by OpenBUGS, STATA 15, and R. Global consistency was performed by residual deviance and local consistency by node spilt analysis. Then, OpenBUGS analyzed MD and CI for each outcome with followed parameters: number of chain = 3, tuning iterations = 25,001, thinning interval = 1, stimulation iterations = 100,000. In addition, MD and CI were transformed into the surface under the cumulative ranking curves (SUCRA) and league figures by STATA 15 to visualize the comparisons. Funnel plots were applied to evaluate potential publication bias. Moreover, subgroup and sensitivity analysis would be carried out if required.

3 Results

3.1 Study identification and selection

A comprehensive search of eight electronic databases yielded a total of 4,365 relevant studies. After eliminating duplicate studies, 2,335 studies were discarded through examination of titles and abstracts, and 374 articles proceeded to the full-text review stage. Subsequently, 337 studies were ruled out following a thorough assessment of their full text. Ultimately, 37 studies satisfied the inclusion criteria. Then, R was applied to perform node spilt analysis for each outcome and all outcomes met the requirement of consistency (Supplementary Figures S7–S13). Consequently, 37 studies were eventually incorporated into this network meta-analysis. Figure 1 showed the selection process for this review.

3.2 Description of included studies

The 37 studies included 35 two-arm trials and two multi-arm trials, involving of 3,246 participants and 16 interventions which contain 10 single interventions and six combined interventions. Among the included studies, 28 studies have been published within the past 5 years, indicating that acupuncture therapy on CRI is garnering increasing attention. The characteristics of eligible studies were presented in Table 1. The usage statistics of acupoints in included studies was displayed in Supplementary Table S9. And the most commonly employed acupoints on CRI were Xin (heart, CO15) and Shenmen (TF4).

3.3 The risk of bias

As for the risk of bias, three studies were found to have a lower risk of bias while two studies had a higher risk of bias. The selection of the reported result constituted the primary source of bias. Figure 2 illustrated the risk of bias.

3.4 Network meta-analysis

3.4.1 Primary outcome: PSQI

Figure 3 exhibited the network map of eligible comparisons on PSQI. The network map indicated that majority of acupuncture therapies were compared with control or medications, yet a scarcity of comparisons existed between distinct acupuncture therapies.

League figure is derived from pairwise comparison of the various interventions. If both MD and the 95%CI are greater than or less than 0, the difference between the two interventions is deemed statistically significant. The league figure was presented in Figure 4. The SUCRA was calculated after comparing all interventions to rank their effectiveness of each intervention and determine the optimal one. The findings revealed that auriculotherapy + moxibustion exhibits the most significant impact on reducing the PSQI score in CRI patients. The SUCRA of PSQI was showed in Figure 5.

3.4.2 Secondary outcome

The secondary outcome consisted of the subitems of PSQI, which contain subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, daytime dysfunction and the use of sleep medications. Intervention of some studies included sleep medications, so the use of sleep medications was not statistically analyzed in this review.

Supplementary Figures S14A–F were the network map of each subitem of PSQI, with each subitem encompassing the same interventions. The results of subitems of PSQI were presented in Supplementary Figures S15A–F and Supplementary Figures S16A–F (Supplementary Figures S15A–F were league figure and Supplementary Figures S16A–F were SUCRA).

We found that the efficacy of auriculotherapy + acupuncture ranked highest in sleep latency, sleep duration, habitual sleep efficiency and daytime dysfunction, while the efficacy of auriculotherapy + moxibustion demonstrated the highest ranking in subjective sleep quality and sleep disturbances. The detailed rankings could be observed in Supplementary Figures S16A–F.

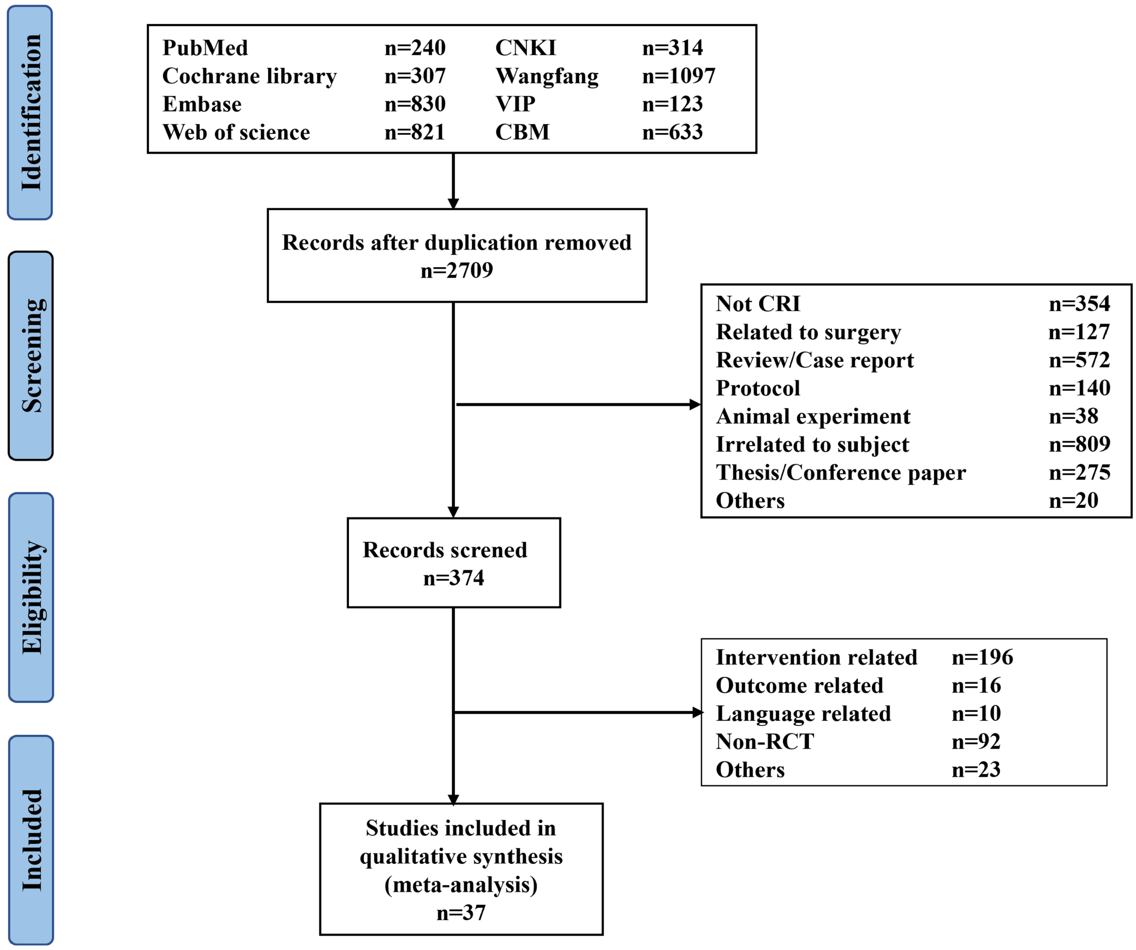

FIGURE 1
PRISMA flow diagram of the study selection process. CNKI, China National Knowledge Infrastructure; VIP, China Science and Technology Journal Database.

3.5 Network funnel plot of included studies

The adjusted funnel plot for PSQI was plotted and presented in Figure 6, revealing a general symmetry. However, some nodes were found to be outside the funnel, indicating the presence of heterogeneity or publication bias in those trials.

4 Discussion

In the wake of the high prevalence and the detrimental effect of CRI, there is a growing desire to find all prospective acupuncture therapies. In this review, we meticulously examined 37 randomized controlled trials involving acupuncture therapy for CRI and observed that auriculotherapy + moxibustion and auriculotherapy + acupuncture might be the optimal regimes for CRI.

Compared with previous meta-analyses (19, 20, 24–26), this study carried out a more comprehensive retrieval, including more recently published trials, successfully updating the evidence. The previous meta-analysis encompassed some studies in which participants were not diagnosed with CRI, PSQI served merely as a secondary outcome, and the experimental groups included other non-pharmaceutical interventions. In this review, however, the participants were confined to cancer survivors diagnosed with CRI, PSQI was the primary outcome, and we excluded studies that incorporated other non-pharmaceutical interventions. Furthermore, we came to different conclusions in comparison with previous network meta-analysis (21). The results of previous network meta-analysis displayed that transcutaneous electrical acupoint stimulation was the best acupuncture therapy for CRI. Several factors might account for the discrepancy: (1) Some of the included studies in the previous network meta-analysis pertained to tumor surgery, but this part of studies was excluded from this network meta-analysis, as it was challenging to differentiate between insomnia related to cancer or surgery, leading to a discrepancy in the included interventions. (2) The intervention in some of the included studies of previous network meta-analysis encompassed other non-pharmaceutical therapies, rendering the efficacy ranking of intervention was non-specific to acupuncture therapy. Consequently, these studies were also omitted in this review. Thus, the results of this review are more reliable to some extent.

Auriculotherapy + moxibustion was found to be the optimal acupuncture regime for reducing PSQI score, while auriculotherapy + acupuncture and auriculotherapy + moxibustion were the best acupuncture regimes for reducing the score of PSQI subitems.

TABLE 1 Characteristics of included studies.

Id	Study	Year	Region/Language	n	Intervention (control group—experimental group)
1	Feng, Y	2011	China/English	80	Medicine – acupuncture
2	Hyeon GY	2019	Korea/English	41	Sham – auriculotherapy
3	Lee B	2022	Korea/English	22	Usual care – sham – electroacupuncture
4	Wang Y	2022	China/English	68	Control – auriculotherapy
5	Zhang J	2023	China/English	117	Sham – acupuncture
6	Zhang J	2021	China/Chinese	28	Control – auriculotherapy + electroacupuncture
7	Cao M	2020	China/Chinese	80	Sham-acupoint application
8	Chen SY	2021	China/Chinese	64	Medicine – auriculotherapy +acupuncture
9	Chen YL	2022	China/Chinese	78	Usual care – auriculotherapy
10	Fa XY	2021	China/Chinese	80	Control – auriculotherapy + acupoint application
11	Fan GH	2020	China/Chinese	97	Medicine – auriculotherapy + acupuncture
12	Guo X	2019	China/Chinese	116	Control – auriculotherapy – moxibustion – auriculotherapy + moxibustion
13	He SY	2021	China/Chinese	80	Control – acupoint application
14	He J	2017	China/Chinese	64	Control – moxibustion
15	Huang YY	2020	China/Chinese	88	Control – auriculotherapy + acupoint application
16	Li HW	2019	China/Chinese	59	Control – acupoint application
17	Li WJ	2020	China/Chinese	80	Control – auriculotherapy
18	Lin J	2018	China/Chinese	60	Control – auriculotherapy
19	Liu GL	2016	China/Chinese	40	Medicine – auriculotherapy + acupuncture
20	Ma JH	2021	China/Chinese	70	Medicine – acupoint application
21	Peng XH	2016	China/Chinese	190	Medicine – acupuncture
22	Shen LF	2016	China/Chinese	100	Control – electroacupuncture
23	Shi Y	2020	China/Chinese	80	Medicine – acupuncture
24	Song JR	2015	China/Chinese	120	Medicine – acupuncture + moxibustion
25	Song YP	2014	China/Chinese	100	Control – auriculotherapy
26	Wang BN	2019	China/Chinese	80	Sham – acupuncture
27	Wei XL	2019	China/Chinese	148	Control – auriculotherapy
28	Wu H	2019	China/Chinese	80	Control – acupoint application
29	Xie JJ	2021	China/Chinese	84	Control – acupuncture
30	Yu XX	2018	China/Chinese	102	Control – acupoint application
31	Zhang LF	2022	China/Chinese	90	Control – auriculotherapy + acupuncture + acupressure
32	Zhang M	2022	China/Chinese	60	Auriculotherapy – auriculotherapy + moxibustion
33	Zhang XJ	2019	China/Chinese	248	Control – auriculotherapy + moxibustion
34	Zhang ZY	2021	China/Chinese	102	Control – auriculotherapy
35	Zhong QL	2021	China/Chinese	80	Control – auriculotherapy + acupoint application
36	Zhong QL	2022	China/Chinese	100	Control – auriculotherapy + acupoint application
37	Zong TT	2023	China/Chinese	70	Medicine – moxibustion

We conjectured that the auriculotherapy assumed a primary role, as its ranking surpassed that of acupuncture and moxibustion in the majority of outcomes.

The occurrence of insomnia is intimately linked to the hyperexcitation of the sympathetic and the hypo-excitability of the parasympathetic (27–29). Auriculotherapy is an intervention that involves stimulating auricular points with the acupuncture needle, thumb-tack needles, finger pressure, or beads for the therapeutic aim. Abundant nerve branches are distributed across the surface of the auricle (30). The concha auriculae area is primarily innervated by the

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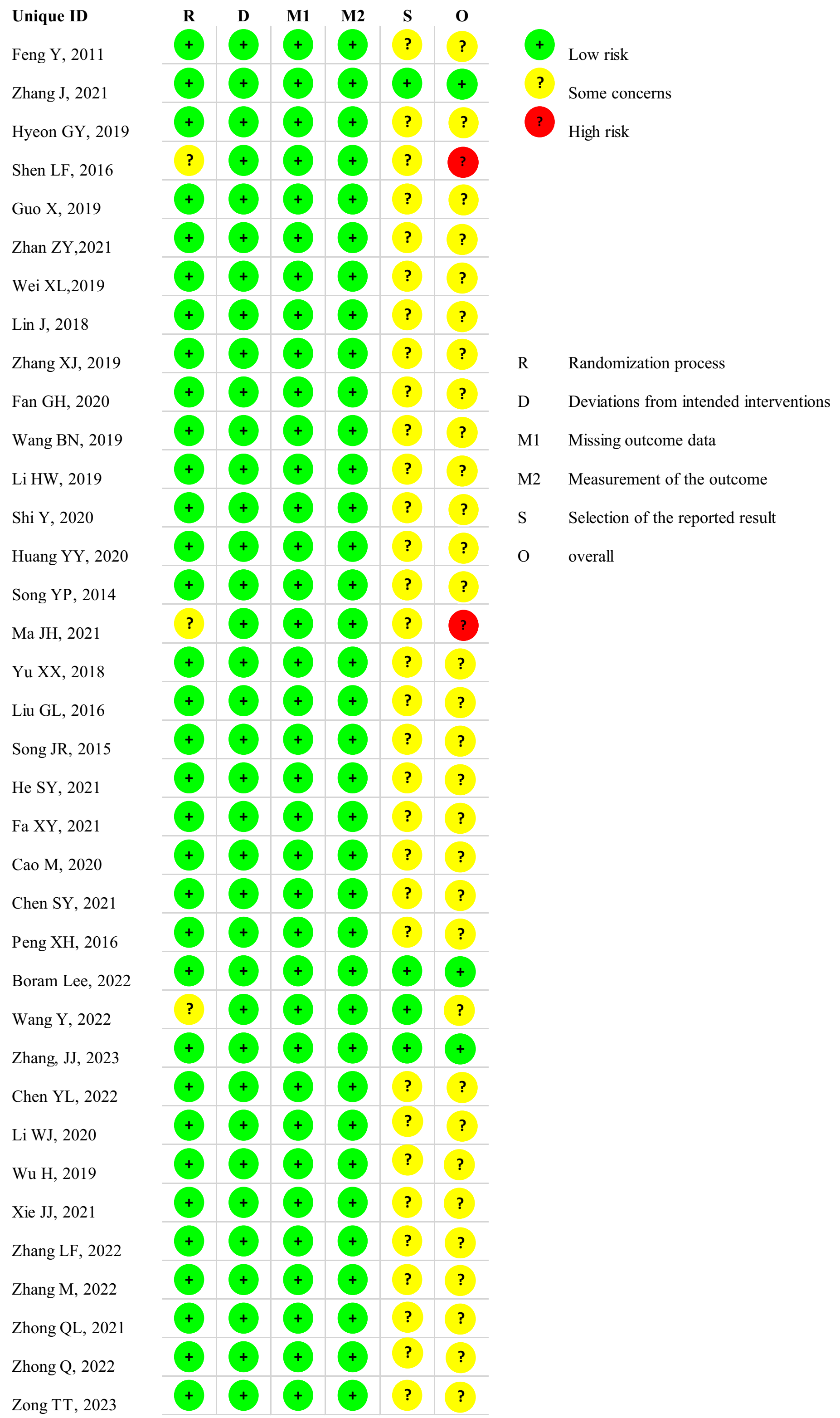

FIGURE 2
The risk of bias of included studies. The selection of the reported result constituted the primary source of bias.

auricular branch of the vagus nerve, while the triangular fossa area is innervated by the spinal nerve, vagus nerve and other nerves. According to Supplementary Table S9, the most commonly employed auricular points on CRI were Xin (heart, CO15) and Shenmen (TF4), locating in concha auriculae and triangular fossa respectively, which are both the distribution of the vagus nerve. As a vital component of the parasympathetic nervous system, the vagus nerve is instrumental in restoring balance between the sympathetic and parasympathetic nervous systems. Stimulation of the vagus nerve results in a reduced heart rate and blood pressure, contributing to a relaxed state,

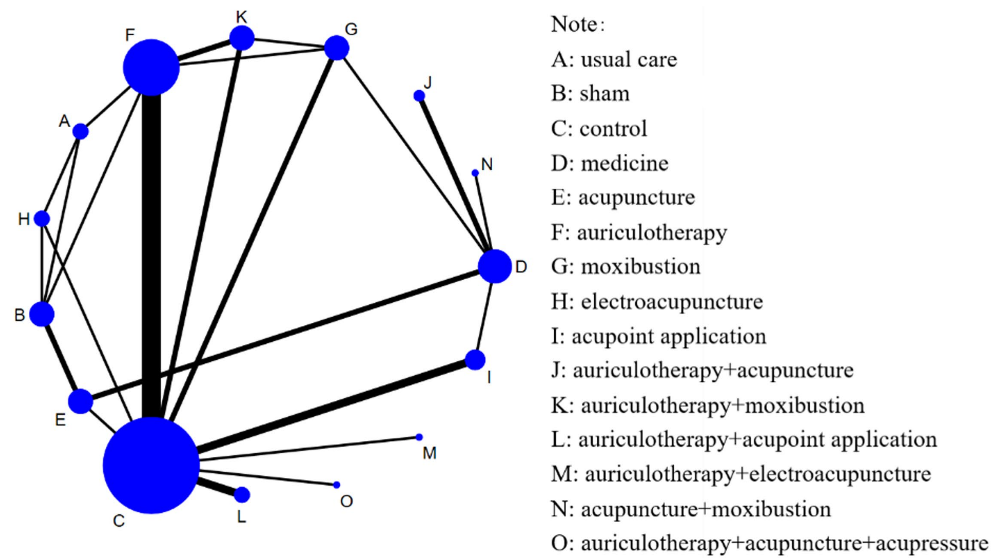

FIGURE 3
The network map of included studies. The size of each node was proportional to the number of participants receiving the respective intervention, while the boldness of the connecting lines corresponded to the number of comparative studies between the interventions. A total of 32 studies with 2,752 participants accepted one of 15 interventions, respectively, reporting the reduction of PSQI. The included studies generated 15 nodes, contributing to 23 pairs of comparisons.

auriculotherapy +moxibustion														
-2.44 (-3.94,-0.94)	**auriculotherapy**													
-2.31 (-5.29,0.67)	0.13 (-2.62,2.88)	**auriculotherapy +acupuncture +acupressure**												
-2.49 (-4.57,-0.41)	-0.05 (-1.79,1.69)	-0.18 (-3.16,2.79)	**auriculotherapy +acupoint application**											
-2.41 (-5.41,0.59)	0.03 (-2.69,2.75)	-0.10 (-3.83,3.62)	0.08 (-2.97,3.13)	**electroacupuncture**										
-2.84 (-4.85,-0.83)	-0.40 (-2.06,1.25)	-0.53 (-3.48,2.42)	-0.35 (-2.39,1.69)	-0.43 (-3.42,2.56)	**acupoint application**									
-3.36 (-5.48,-1.23)	-0.92 (-2.66,0.82)	-1.05 (-4.12,2.02)	-0.87 (-3.06,1.33)	-0.95 (-3.89,2.00)	-0.52 (-2.45,1.42)	**acupuncture**								
-4.00 (-6.01,-1.99)	-1.56 (-3.33,0.21)	-1.69 (-4.77,1.39)	-1.50 (-3.73,0.72)	-1.59 (-4.69,1.51)	-1.16 (-3.22,0.91)	-0.64 (-2.74,1.46)	**moxibustion**							
-4.76 (-7.80,-1.72)	-2.32 (-5.13,0.48)	-2.45 (-6.22,1.32)	-2.27 (-5.37,0.83)	-2.35 (-6.08,1.38)	-1.92 (-4.70,0.86)	-1.40 (-4.03,1.23)	-0.76 (-3.66,2.13)	**auriculotherapy +acupuncture**						
-4.76 (-7.03,-2.48)	-2.32 (-4.19,-0.46)	-2.45 (-5.65,0.75)	-2.27 (-4.64,0.10)	-2.35 (-5.23,0.54)	-1.92 (-4.12,0.29)	-1.40 (-3.05,0.24)	-0.76 (-3.09,1.57)	0.00 (-2.97,2.98)	**sham**					
-5.38 (-9.18,-1.57)	-2.94 (-6.58,0.70)	-3.07 (-7.44,1.30)	-2.88 (-6.70,0.93)	-2.96 (-7.37,1.44)	-2.54 (-6.31,1.24)	-2.02 (-5.89,1.85)	-1.38 (-5.28,2.52)	-0.62 (-5.07,3.83)	-0.62 (-4.59,3.35)	**auriculotherapy+ electroaupuncture**				
-5.52 (-8.11,-2.94)	-3.08 (-5.25,-0.92)	-3.21 (-6.65,0.22)	-3.03 (-5.74,-0.32)	-3.11 (-6.07,-0.15)	-2.68 (-5.30,-0.06)	-2.17 (-4.74,0.41)	-1.52 (-4.25,1.20)	-0.76 (-4.21,2.69)	-0.76 (-3.29,1.76)	-0.15 (-4.32,4.03)	**usual care**			
-5.72 (-9.17,-2.28)	-3.29 (-6.53,-0.04)	-3.42 (-7.52,0.68)	-3.23 (-6.73,0.26)	-3.31 (-7.37,0.75)	-2.88 (-6.11,0.34)	-2.37 (-5.45,0.72)	-1.73 (-5.04,1.58)	-0.96 (-4.37,2.44)	-0.97 (-4.36,2.43)	-0.35 (-5.10,4.41)	-0.20 (-4.01,3.60)	**acupuncture +moxibustion**		
-5.48 (-6.96,-4.00)	-3.04 (-3.97,-2.11)	-3.17 (-5.77,-0.57)	-2.99 (-4.46,-1.52)	-3.07 (-5.74,-0.40)	-2.64 (-4.04,-1.23)	-2.12 (-3.76,-0.49)	-1.48 (-3.16,0.19)	-0.72 (-3.45,2.01)	-0.72 (-2.58,1.14)	-0.10 (-3.62,3.41)	0.04 (-2.22,2.31)	0.24 (-2.93,3.42)	**control**	
-6.46 (-8.64,-4.28)	-4.02 (-5.89,-2.16)	-4.15 (-7.27,-1.04)	-3.97 (-6.24,-1.70)	-4.05 (-7.12,-0.98)	-3.62 (-5.44,-1.80)	-3.10 (-4.66,-1.54)	-2.46 (-4.43,-0.49)	-1.70 (-3.81,0.41)	-1.70 (-3.80,0.39)	-1.08 (-5.01,2.84)	-0.94 (-3.66,1.78)	-0.74 (-3.40,1.93)	-0.98 (-2.71,0.75)	**medcine**

FIGURE 4
The league figure of included studies. Data with light green background meant significant difference between the comparisons. And compared with medicine, 8 interventions demonstrated significant results.

diminishing stress and anxiety, and thus alleviating insomnia symptoms, facilitating both the initiation and maintenance of sleep (31).

In a three-arm randomized trial involving 14 healthy males, researcher (32) performed acupuncture, electroacupuncture, and other stimuli on the auricular acupoints, corroborating the capability of auriculotherapy to stimulate the vagal activity.

At present, various imaging modalities, such as functional magnetic resonance imaging (fMRI), are employed to scrutinize the effect of auricular points. Study (33) reveals that transcutaneous auricular vagus nerve stimulation (taVNS) can regulate the activation state of the precuneus, a key encephalic region involved in episodic memory, emotional regulation, and introspection. The precuneus plays a role in regulating emotional, cognitive, and behavioral processes by suppressing excessive cortical activation, thereby aiding in the treatment of CRI. The etiology of CRI exhibits similarities with that of primary insomnia, all of which are predisposing factors, precipitating factors and perpetuating factors (34). Consequently, we postulated that auriculotherapy could be efficacious through a mechanism analogous to the aforementioned.

Employing PSQI subitems results, we discerned that various acupuncture modalities exhibit distinct curative effects on diverse CRI manifestations. Auriculotherapy + moxibustion demonstrated its merits in the improvement of subjective sleep quality and alleviating sleep disturbances (easy to wake up, difficulty in breathing, dreaminess, etc.), while auriculotherapy + acupuncture represented the optimal choice for ameliorating habitual sleep efficiency, abbreviating sleep latency, extending sleep duration and

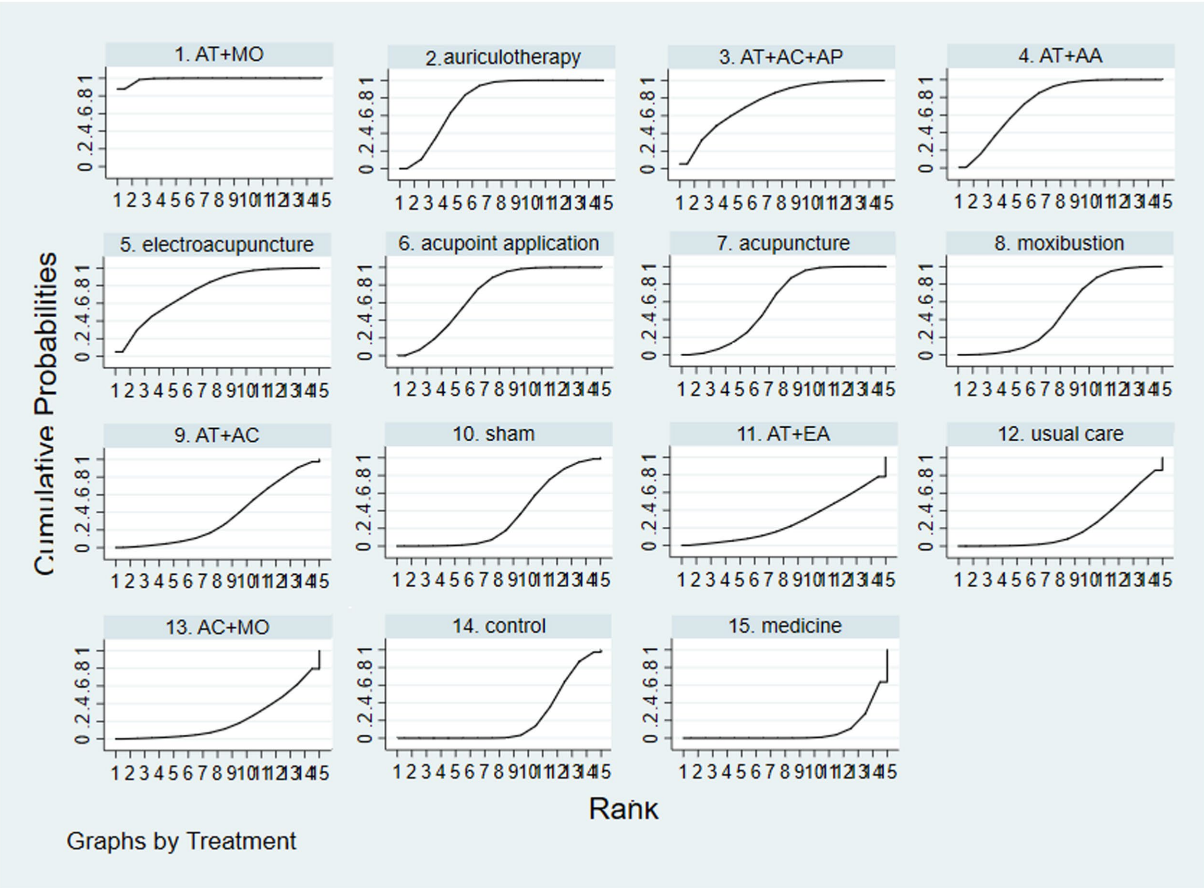

FIGURE 5
The SUCRA of included studies. Bigger SUCRA means higher rank, representing better efficacy of the intervention. The rank (SUCRA value) of each intervention in PSQI: auriculotherapy + moxibustion (98.98%) > auriculotherapy (77.47%) > auriculotherapy + acupuncture + acupressure (75.79%) > auriculotherapy + acupoint application (75.27%) > electroacupuncture (74.38%) > acupoint application (69.4%) > acupuncture (60.18%) > moxibustion (47.84%) > auriculotherapy + acupuncture (35.62%) > sham (34.31%) > auriculotherapy + electroacupuncture (27.65%) > usual care (22.35%) > acupuncture + moxibustion (21.57%) > control (21.52%) > medicine (7.67%). And auriculotherapy + moxibustion was the optimal acupuncture regime in reducing the score of PSQI according to SUCRA. AT, auriculotherapy; AC, acupuncture; MO, moxibustion; AP, acupressure; AA, acupoint application; EA, electroacupuncture.

alleviating daytime dysfunction. Consequently, an appropriate acupuncture regimen can be tailored based on the findings of this review and the individual survivor's symptoms. For instance, auriculotherapy + acupuncture could be selected for those experiencing difficulty in falling asleep, while auriculotherapy + moxibustion could be opted for those experiencing dreaminess or easy awakening. In addition, we found that the curative efficacy ranking of acupuncture therapy differed in the PSQI and its subitems. For example, auriculotherapy + acupuncture demonstrated a higher ranking in subitems but a lower ranking in the PSQI, which might be related to some studies listing only the total score or only some subitems of PSQI, which influenced the ranking of auriculotherapy + acupuncture.

4.1 Limitations

The results of this review provided more evidential recommendations for steering clinical practice. However, this review also encountered certain limitations. Studies other than those published in English and Chinese were excluded in this review, which could generate language bias. Furthermore, the insufficient quantity of

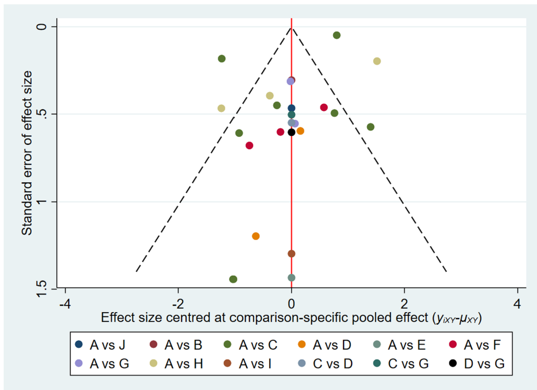

FIGURE 6
The adjusted funnel plot of included studies of PSQI. Though the distribution was nearly symmetric, some nodes were out of the funnel which showed some heterogeneity or publication bias in those studies. A, control; B, acupuncture; C, auriculotherapy; D, moxibustion; E, electroacupuncture; F, acupoint application; G, auriculotherapy + moxibustion; H, auriculotherapy + acupoint application; I, auriculotherapy + electroacupuncture; J, auriculotherapy + acupuncture + acupressure.

studies, particularly in English, undermined the scope of the review. Methodologically, we assessed the risk of bias based on the Cochrane tool, and the risk of bias of most trials included was deemed uncertain. In addition, the morbidity of CRI varies across different cancers, while the cancer types were not explicitly stated in most studies, precluding the conduct of subgroup analysis. A majority of studies were conducted in China, with two in Korea. Acupuncture therapy's deep historical and cultural roots in China, coupled with numerous practitioners and dedicated resources, likely contribute to the region's higher volume of studies. Furthermore, trials from Europe and the United States that used non-pharmaceutical therapies like CBT as control group were excluded in this study. Consequently, the concentration of studies in China, as explained, may introduce a degree of publication bias.

5 Conclusion

We carried out an elaborate comparison and ultimately discovered that auriculotherapy + moxibustion constitutes the most efficacious acupuncture regimen for CRI patients with more substantial reductions in the score of PSQI, subjective sleep quality and sleep disturbances. In the meantime, auriculotherapy + acupuncture was found to be the most beneficial acupuncture regimen for CRI patients with more notable diminution in the score of sleep latency, sleep duration, habitual sleep efficiency and daytime dysfunction. Our results can assist healthcare professionals in choosing the optimal acupuncture regime for CRI.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

LC: Data curation, Formal analysis, Methodology, Project administration, Software, Writing – original draft. JL: Data curation, Formal analysis, Resources, Software, Writing – original draft. SX: Formal analysis, Investigation, Methodology, Writing – original draft. ZL: Investigation, Software, Writing – original draft. YJ: Project administration, Supervision, Writing – review & editing. ZZ: Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fneur.2024.1342383/full#supplementary-material

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Effects of combined exercise training with sleep education in older adults with obstructive sleep apnea: protocol for a randomized clinical trial

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Background: Obstructive sleep apnea (OSA) is a common disorder that affects approximately 1 billion people worldwide. Advanced age is a significant risk factor. Various treatment options have been explored to reduce the severity of OSA symptoms and physical exercise has emerged as a potential alternative therapy. Therefore, this study aims to investigate the effects of a combined exercise program with sleep education on sleep quality and on the severity of OSA in older adults.

Methods: This is a randomized clinical trial with two parallel groups that will involve individuals of both genders aged between 60 and 79 years who have an apnea-hypopnea index (AHI) of more than 15 events per hour and who have not received or are currently undergoing treatment for OSA. Older adults who have engaged in regular exercise in the last six months and individuals with contraindications to exercise will be excluded. The study will assess outcomes related to OSA, including AHI, oxygen desaturation index, minimum and mean oxyhemoglobin saturation, sleep efficiency, sleep latency, and the type of respiratory events. Additionally, sleep quality-related outcomes, daytime sleepiness, physical activity, physical fitness, aerobic capacity, cognitive status, anthropometric measures, and health-related quality of life will be analyzed. Participants will be randomized to two groups: a combined exercise group (involving both resistance and aerobic training) with sleep education, and a control group that will receive only educational recommendations for managing OSA. The intervention will last 12 weeks and will consist of three sessions per week, totaling 36 exercise sessions. Sample size calculation indicates a minimum number of 36 participants.

Discussion: If the hypothesis is confirmed, this clinical trial will indicate an effective non-pharmacological intervention for treating OSA in older adults. This intervention could be used as an adjunct to existing approaches designed to improve OSA management.

Clinical trail registration: Brazil Clinical Trials Registry (ReBEC), identifier RBR-9hk6pgz.

KEYWORDS

obstructive sleep apnea, combined training, aerobic exercise, sleep hygiene, strength training, older adults

1 Introduction

Obstructive sleep apnea (OSA) is a highly prevalent breathing disorder that affects approximately 1 billion people worldwide (Benjafield et al., 2019). The prevalence of moderate to severe OSA ranges from 6 to 17% among adults and can reach up to 49% in older age groups (Senaratna et al., 2017). The main risk factors associated with OSA are obesity, male gender, craniofacial abnormalities, genetic predisposition, ethnic differences, and advanced age (Young et al., 2004; Jordan et al., 2014; Lee and Sundar, 2021).

Positive airway pressure therapy is the primary treatment for individuals with symptomatic OSA of any severity and continuous positive airway pressure (CPAP) is the gold standard among its modalities (Epstein et al., 2009; Gottlieb and Punjabi, 2020; Lee and Sundar, 2021). However, although CPAP is effective in many patients, it is not always well tolerated, a fact that can reduce patient adherence to treatment (Rotenberg et al., 2016). Additionally, CPAP can have some adverse effects (Sawyer et al., 2011), such as skin breakdown, conjunctivitis, nasal congestion, airway dryness, and gastrointestinal obstruction (Zandieh and Katz, 2010; Virk and Kotecha, 2016).

Recently, alternative treatments for OSA have been investigated and physical exercise has received notable attention from the scientific community (Peng et al., 2022). In addition to reducing the severity of the disorder by decreasing the apnea-hypopnea index (AHI) and the oxygen desaturation index (ODI), meta-analyses have highlighted the ability of exercise to improve several OSA-related outcomes, which include sleepiness, sleep quality, and sleep efficiency, as well as parameters like maximal oxygen consumption (VO_2max), body mass index (BMI), and overall quality of life (Iftikhar et al., 2014; Aiello et al., 2016; Lins-Filho et al., 2020; Fank et al., 2022; Peng et al., 2022).

Despite these advances, the exact mechanisms underpinning the beneficial effects of exercise on symptom alleviation and OSA severity remain only partially understood (Torres-Castro et al., 2021). It is plausible that a single mechanism may not solely account for these effects; instead, a complex interplay of contributing factors could be responsible (Iftikhar et al., 2014). Notably, aerobic exercise interventions can potentially be used to manage obesity, a pivotal risk factor for developing OSA (Aiello et al., 2016). Additionally, resistance training interventions have shown the capacity to mitigate fluid accumulation in the legs, which might help prevent nocturnal fluid displacement toward the neck during sleep, thereby reducing the likelihood of upper airway collapse – an event implicated in OSA (Yumino et al., 2010; Mirrakhimov, 2013). Consequently, the combined implementation of these exercise modalities may not only promote synergistic benefits in OSA but also aligns with the health recommendations of the World Health Organization (Bull et al., 2020).

Although numerous studies have examined the impacts of exercise on OSA, adult populations have been the primary focus (Aiello et al., 2016; Lins-Filho et al., 2020; Peng et al., 2022). Thus, it is important to expand the scope of investigation by including older individuals who not only have a higher prevalence of OSA but are also more vulnerable to developing the disease (Edwards et al., 2010). It will therefore be possible to determine whether the beneficial effects of exercise observed in adults also apply to older adults.

The use of exercise as a tool for treating OSA may contribute to reducing healthcare costs. Exercise offers a low-cost option in terms of both implementation and monitoring and its cost-effectiveness has been demonstrated across different contexts (Roine et al., 2009; Garrett et al., 2011; Abu-Omar et al., 2017). Within the context of global healthcare spending, sleep disorders, including OSA, are the primary contributors (Mohit and Wickwire, 2020) and their prevalence continues to rise annually (Ensrud et al., 2020). Moreover, sleep-disordered breathing, which includes OSA, has substantial health, societal, and economic repercussions, thereby inflating healthcare expenses for both patients and society (Jennum and Kjellberg, 2011). These implications include vehicle and occupational accidents and different associated comorbidities (Knauert et al., 2015). It is therefore crucial to reduce the direct and indirect costs related to OSA, mainly through more cost-effective and noninvasive therapies (Wickwire et al., 2020).

Therefore, this study aims to investigate the effects of a combined exercise program with sleep education on sleep quality and on the severity of OSA in older adults. The results obtained will enable healthcare professionals to build their daily practice on evidence-based science, incorporating another non-pharmacological treatment option for older adults with OSA. The hypothesis is that the combination of resistance and aerobic exercises, coupled with sleep education, will be capable of reducing both the severity and symptoms of OSA in older adults when compared to the control group, which will exclusively receive educational recommendations for managing OSA.

2 Methods

2.1 Study design

This study is designed as a two-arm parallel group, randomized controlled trial that assesses the effects of a combined exercise program with sleep education on sleep quality and on the severity of OSA in older adults. Participants will be recruited from the waiting list for polysomnography in a city in southern Brazil. After initial screening, older people at high risk for OSA will undergo polysomnography. Older adults who meet the inclusion criteria will be randomized to the intervention or control group. The intervention will last 12 weeks, three times a week, and will be conducted at the Center for Health and Sports Sciences, State University of Santa Catarina, Brazil. The study was designed following the SPIRIT recommendations (Chan et al., 2013) and the schedule of enrolment, interventions, and assessments is shown in Figure 1.

	STUDY PERIOD				
	Enrolment	**Allocation**	**Post-allocation**		
TIMEPOINT	$-t_1$	0	t_1 *Baseline*	t_2 *Intervention*	t_3 *Follow-up*
ENROLMENT:					
Eligibility screen	X				
Informed consent	X				
Allocation		X			
INTERVENTIONS:					
Combined exercise				X	
Control				X	
ASSESSMENTS:					
STOP-BANG	X				
Home Polysomnography	X				X
Clinical restrictions	X				
Prior or current exercise	X				
Pittsburgh Sleep Quality Index			X		X
Epworth Sleepiness Scale			X		X
International Physical Activity Questionnaire			X		X
Senior Fitness Test			X		X
Aerobic capacity (VO2 max)			X		X
Mini-Mental State Examination			X		X
Body composition			X		X
Quebec Sleep Questionnaire			X		X
Treatment satisfaction					X

FIGURE 1
SPIRIT schedule of enrolment, interventions, and assessments.

2.2 Participants

The following inclusion criteria will be applied to select the participants in this randomized clinical trial (Figure 2): age between 60 and 79 years; both genders; moderate to severe OSA with an AHI > 15 events per hour, and no history of previous or ongoing treatment for OSA. Older adults who have engaged in regular exercise in the last six months and those with contraindications (cardiovascular, respiratory, musculoskeletal, or neurological) to exercise will be excluded. Participants who do not adhere to the interventions at a rate ≥ 85% will also be excluded from the study.

The sample will be selected by non-probabilistic sampling. Participants will be recruited through partnerships with public and private institutions in Grande Florianopolis, Santa Catarina, Brazil. Additionally, the study will be promoted through healthcare services, elderly community groups, local media (radio and newspapers) and, if necessary, leafleting in neighborhoods near the university and during technical-scientific events.

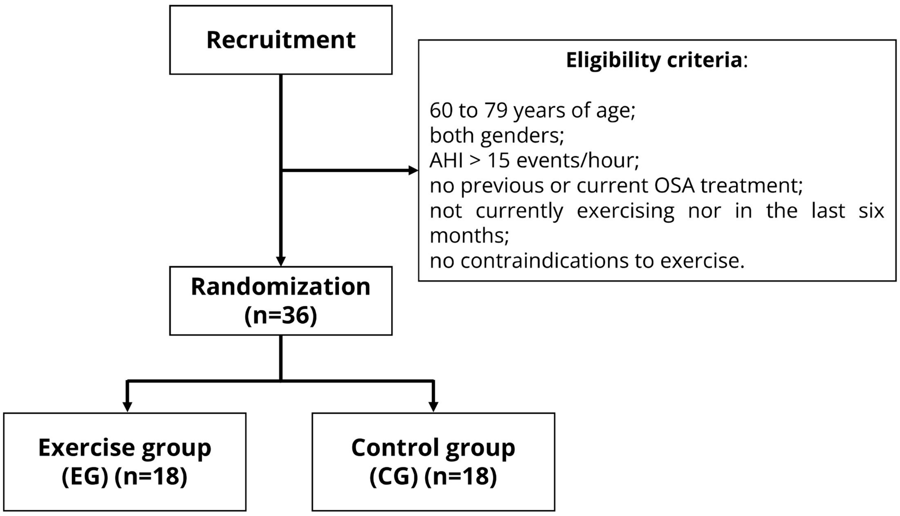

FIGURE 2
Recruitment and randomization of the clinical trial. AHI, apnea-hypopnea index; OSA, obstructive sleep apnea.

2.3 Sample size

To determine the minimum number of participants required for the interventions, the sample size was calculated using the GPower 3.1 software. Using repeated measures ANOVA (within-subjects and between-subjects interaction) and assuming a significance level (α) of 0.05, power (β) of 0.95, and effect size of 0.35 (da Silva et al., 2022), the minimum sample size is 30 individuals. This number will be increased by 20% to account for potential sample losses, resulting in a minimum sample size of 36 participants divided into two groups: – the exercise group (EG) and the control group (CG), each consisting of 18 subjects. Losses after randomization will be included in the intention-to-treat analysis but not in the analysis of the protocol.

2.4 Eligibility outcomes

2.4.1 Obstructive sleep apnea

To assess the risk of OSA in older adults, the STOP-BANG questionnaire (Chung et al., 2012) will be administered, which is designed to identify individuals at a higher risk of developing apnea. This screening instrument consists of eight questions that evaluate risk factors for OSA, with the responses being categorized as "yes" or "no." The score ranges from 0 to 8 and scores ≥3 have shown high sensitivity in detecting moderate to severe OSA (Chung et al., 2012).

After the first assessment, participants classified as being at higher risk for OSA will undergo type III home polysomnography (HPSG) (Philips Respironics Alice NightOne). HPSG consists of the concurrent monitoring of sleep and respiration using thoracic and abdominal belts, an oximeter (to capture oxygen saturation and heart rate), and a nasal cannula (to monitor airflow and snoring), as well as the recording of body position during sleep (Jordan et al., 2014; Lee and Sundar, 2021). The following data will be obtained: AHI, ODI, minimum and mean oxyhemoglobin saturation (SaO2), sleep efficiency, sleep latency, and the type of respiratory event. Only individuals exhibiting an AHI ≥15 events per hour will be eligible for participation in the study.

2.4.2 Clinical restrictions and prior or current regular exercise

Participants will be asked questions regarding their history of cardiovascular, respiratory, musculoskeletal, and neurological conditions to determine any clinical restrictions for participation in exercise. These questions developed by the research team are aimed at identifying potential health issues that may restrict the participant from participating in this clinical trial. The following two questions will be used to determine whether the participant currently exercises or has engaged in regular exercise in the last six months, which will also be used as inclusion criteria: (a) "Do you currently exercise?" and (b) "Have you regular exercise in the last six months?"

2.5 Primary outcomes

2.5.1 Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) will be used to evaluate sleep quality. The PSQI has been validated for use in Brazil (Bertolazi et al., 2011), showing high internal consistency (Cronbach's $\alpha = 0.82$). The questionnaire consists of 19 items that assess various sleep-related issues over the past month. The questions are divided into seven components and a score ranging from 0 to 3 is assigned to each component. These components include sleep quality, sleep duration, sleep latency, habitual sleep efficiency, sleep disturbances, medication use, and daytime dysfunction. The sum of scores for each component provides a global score ranging from 0 to 21, with higher scores reflecting poorer sleep quality. A score above 5 indicates poor quality (Buysse et al., 1989).

2.5.2 Daytime sleepiness

Daytime sleepiness will be assessed with the Epworth Sleepiness Scale (ESS) (Johns, 1991). The instrument has been validated for use in Brazil, with a reliability coefficient of 0.83 (Bertolazi et al., 2009). The ESS is aimed at evaluating the likelihood of dozing off in eight situations known to induce sleepiness. Respondents are required to indicate the probability of falling asleep in each situation, which ranges from "would never doze" (0) to "high chance of dozing" (3). The overall score ranges from 0 to 24 and a score above 10 suggests a diagnosis of excessive daytime sleepiness (Johns, 1991).

2.6 Secondary outcomes

2.6.1 Physical activity and sedentary behavior

The International Physical Activity Questionnaire (IPAQ) adapted for older adults will be used to investigate physical activity. This instrument has been validated for use in Brazilian older adults (Mazo and Benedetti, 2010), showing good reproducibility (Benedetti et al., 2004). The IPAQ estimates the weekly energy expenditure from physical activity across various domains. These domains include physical activity at work, physical activity during transportation, household physical activity, recreational, sports and exercise-related physical activity, and sedentary behavior.

The adapted version consists of 15 questions that evaluate moderate to vigorous physical activity; these activities should be performed for at least 10 consecutive minutes to be considered. In the current study, only sections four (recreational, sports and exercise-related physical activity) and five (sitting time) of the IPAQ (Mazo and Benedetti, 2010) will be administered and the time in minutes/week of moderate and/or vigorous physical activity will be calculated to classify the sample as active (≥150 min/week) or insufficiently active (<150 min/week).

2.6.2 Physical fitness

The physical fitness of the participants will be assessed using the Senior Fitness Test battery (Rikli and Jones, 1999), which evaluates the physiological capacity of older adults to perform habitual activities of daily living. The battery consists of the following tests: chair stand to estimate lower limb strength; arm curl to assess upper limb strength; chair sit-and-reach to measure lower limb flexibility; back scratch to test upper limb flexibility; 8-foot up-and-go to analyze coordination, dynamic balance, and agility, and 6-min walk to evaluate aerobic endurance.

This battery will be used because of its specificity and validation in the elderly population (Rikli and Jones, 1999), its ease of application, and operational cost-effectiveness. In addition, this instrument has been used across different countries, including Brazil (Silva et al., 2019; Gonçalves et al., 2021). The results will be analyzed based on the difference (Δ) between the values obtained by the participants in the tests before and after the interventions.

2.6.3 Aerobic capacity

Aerobic capacity will be assessed based on maximal oxygen consumption (VO_2max). VO_2max will be measured directly by an external researcher using a treadmill exercise test according to the modified Bruce protocol (Lerman et al., 1976). The test will be conducted using ergospirometry equipment capable of collecting direct measurements of O_2 and CO_2 concentrations, respiratory exchange ratio, heart rate, and ambient temperature and pressure in real-time. Pre-test instructions will be provided to the participants in accordance with the guidelines of the American Heart Association (Fletcher et al., 2013). For safety reasons, all tests will be supervised by a cardiology professional. Exhaustion will be defined when at least one of the following criteria is met: Borg rating of perceived exertion ≥18 out of 20 associated with a respiratory exchange ratio exceeding 1.10, and/or reaching a peak heart rate ≥ 85% of the predicted maximum heart rate, and/or achieving a point of stabilization in oxygen uptake (Vecchiato et al., 2022).

2.6.4 Cognitive status

The Mini-Mental State Examination (MMSE) will be used to evaluate the cognitive status of the participants. The MMSE was developed by Folstein et al. (1975) and was validated for use in Brazil (Bertolucci et al., 1994). The instrument generates a maximum final score of 30 points, corresponding to high cognitive capacity. The cutoff values to determine preserved cognitive status take into account the educational level (Brucki et al., 2003).

2.6.5 Body composition

Anthropometric and body composition measurements will be carried out to examine various outcomes. These measurements will be used to determine possible correlations with changes in the primary outcomes of OSA after the intervention. Body weight will be measured with a G-Life® Millenium digital scale (silver model CA6000). Height will be measured with a Cardiomed® stadiometer (height limit of 2.16 m) from the feet to the highest point of the head. The body mass index (BMI) will be calculated from the body weight and height using the formula: BMI (kg/m^2) = body weight (kg)/height^2 (m). Neck circumference (NC) will be measured with a Cescorf® measuring tape immediately above the thyroid cartilage.

Body composition will also be evaluated by whole-body dual-energy X-ray absorptiometry (DXA) using a Hologic system (Discovery Wi Fan-Beam, Bedford, Massachusetts, United States). The equipment will be calibrated daily and weekly according to the manufacturer's recommendations. The same lab technician will position the participant for each scan, perform the scans, and analyze the data according to the operator's manual using the standard analysis protocol. DXA provides data on bone mineral content (g), bone mineral density (g/cm^2), lean mass (kg), and fat mass (kg).

2.6.6 Quality of life

Quality of life will be analyzed using the Quebec Sleep Questionnaire (Lacasse et al., 2004), an instrument specifically designed to assess the quality of life of individuals with OSA. The questionnaire has been translated and adapted for use in Brazil (de Melo et al., 2017) and comprises 32 questions that evaluate the impact of apnea across five distinct domains: daytime sleepiness, daytime symptoms, nighttime symptoms, emotions, and social interactions. Each domain consists of four to 10 items, each scored on a Likert scale ranging from 1 to 7. The results will be presented individually for each domain considering the mean score obtained for each domain (Lacasse et al., 2004).

2.6.7 Treatment satisfaction

To evaluate satisfaction with the treatments, participants will complete a brief questionnaire based on the study by Kline et al. (2011), which assesses the expected changes in the severity of OSA, sleep quality, daytime sleepiness, mood, and overall health. Responses will be rated on a Likert scale, where 1 = much worse and 5 = much better. Additionally, participants will be asked about their overall treatment satisfaction using a Likert scale, where 1 = very dissatisfied and 2 = very satisfied.

2.7 Data collection

Before the recruitment process, participants will receive an explanation of the objectives and assessment procedures of the study. Upon agreeing to participate, the older adults will read and sign the informed consent form. Participants will then respond to the questionnaires and undergo HPSG to determine their eligibility for the study. After confirmation of their eligibility, older adults will complete the remaining questionnaires and undergo the remaining tests. Assessments regarding HPSG will be conducted by an assessor blind to treatment allocation. Because of the inherent characteristics of the intervention, it is not possible to maintain blinding for either the participants or the researcher regarding allocation. However, both are strongly advised against revealing the allocation status of participants during follow-up assessments.

Next, participants will be randomized to two groups: the exercise group (EG) and the control group (CG). To ensure similarity in participant characteristics within the groups, stratified randomization will be conducted to control the covariates sex (2 levels: male and female) and OSA severity (2 levels: moderate and severe). For this purpose, an external researcher will generate a computerized sequence of random numbers to determine the 1:1 allocation to either EG or CG based on the order of participant recruitment. The specific schedules for instrument administration and the data collection procedure are outlined in Figure 3.

2.8 Experimental design

As previously mentioned, participants will be allocated to either EG or CG. Participants randomized to EG will undergo a 12-week intervention, three times per week, totaling 36 sessions. Each training session will last approximately 60 min and will be organized as follows: warm-up (5 min), training (50–60 min), and cool-down (5 min). Training intensities will be progressively adjusted throughout the weeks according to the principle of overload.

The intervention will consist of a training program that combines aerobic and resistance exercises within the same session. This approach is based on other studies that have applied similar training programs to adults with OSA (Kline et al., 2011; Desplan et al., 2014; Bughin et al., 2020). The combined exercise approach is also in line with the physical activity recommendations for Brazilian older adults, which suggest the prescription of both types of exercise (de Coelho-Ravagnani et al., 2021). Each training session will start with a warm-up (5 min), followed by aerobic exercise (20 min) and resistance exercises (30 to 40 min), and concluding with a cool-down (5 min).

The aerobic training protocol will be conducted on a treadmill or stationary bicycle, with intensity corresponding to the anaerobic threshold determined based on the ventilatory thresholds established in the stress test. Pre-test instructions will be provided to participants

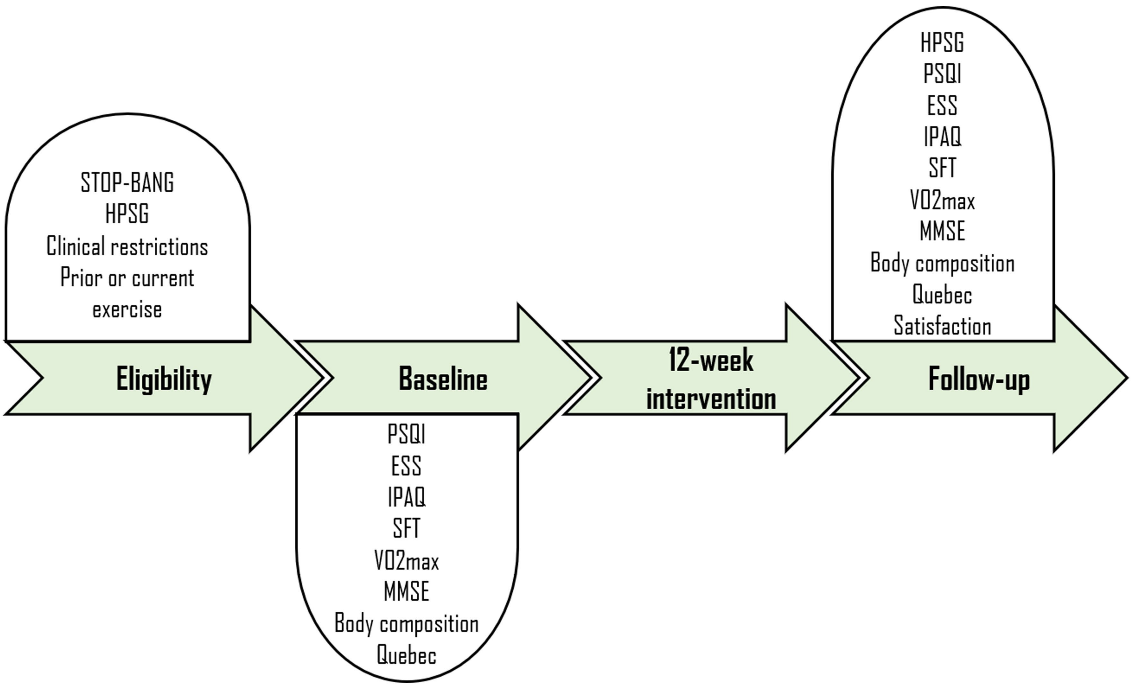

FIGURE 3
Clinical trial design. HPSG, Home Polysomnography; PSQI, Pittsburgh Sleep Quality Index; ESS, Epworth Sleepiness Scale; IPAQ, International Physical Activity Questionnaire; SFT, Senior Fitness Test; MMSE, Mini-Mental State Examination.

in accordance with the recommendations of the American Heart Association (Fletcher et al., 2013). Heart rate will be monitored during the sessions using a Polar heart rate monitor.

The resistance exercise protocol will consist of exercises for the legs, arms, chest, back, and abdomen. All exercises will comprise three sets, with a rest interval of 90 s. Additionally, the intervention will be divided into three phases: familiarization, load determination, and training. The familiarization phase will involve learning the proper range of motion, breathing, and rhythm for each exercise. Participants will be instructed to inhale during the eccentric phase and to exhale during the concentric phase of the exercise, performing repetitions at a tempo of two seconds for each phase of the movement.

Loads will be determined using the maximum repetition (RM) test to define loads within the training target zone, which will be set at 10 RM in this study. This load determination is based on various studies (Jambassi Filho et al., 2011; Gurjão et al., 2012; Virtuoso et al., 2019). Participants will be instructed to perform as many repetitions as possible with a load subjectively chosen by the researcher (trial and error). During this determination process, a maximum of two attempts will be made for load definition, with a recovery interval of 3 to 5 min. If a participant completes more than 12 repetitions, 1 kg will be added for every two additional repetitions. If the number of repetitions falls below 8 RM, the load will be adjusted through trial and error. To ensure accuracy in load definition and to assess reproducibility, the tests will be repeated after a minimum interval of 48 h. Following the load determination, participants will start the resistance exercises as part of the intervention.

In addition to the exercise, participants in EG will also receive sleep education, which will include information on sleep hygiene and on the pathophysiology, risk factors, and treatments of OSA. Sleep education will also be administered to participants randomized to CG so that they would adhere to the recommendations of the American Academy of Sleep Medicine (AASM) (Epstein et al., 2009). A booklet containing information about sleep hygiene will be provided to CG participants before the start of the intervention. Furthermore, recorded videos on the pathophysiology, risk factors, and treatments for OSA will be sent remotely to the participants. These materials will be systematically distributed over the 12-week period. The participants will also be asked to maintain their normal activities and not to perform exercise. After the research period, CG participants will be referred for appropriate treatment according to medical recommendation.

2.9 Ethical standards

The ethical principles of the Declaration of Helsinki will be followed. The research proposal was formally submitted to the Ethics Committee for Research Involving Humans of the State University of Santa Catarina and received approval under number 5.729.066 (CAAE: 60046022.5.0000.0118). Additionally, the clinical trial was submitted and approved (RBR-9hk6pgz) by the Brazilian Registry of Clinical Trials (ReBEC). Prospective subjects who meet the eligibility criteria will be invited to participate in the study. Upon agreement, participants will start the interventions only after they had thoroughly read and signed the informed consent form.

2.10 Data analysis

The data will be organized using Microsoft Excel and subjected to statistical analysis using the IBM SPSS 20.0 software. Descriptive statistics will be employed to assess all variables and will include absolute frequency, relative frequency, mean, and standard deviation. Data distribution normality will be tested by the Shapiro–Wilk test. Baseline characteristics will be examined based on the nature of the variables (numerical or categorical). Differences between groups at baseline will be evaluated using one-way analysis of variance (ANOVA) or the Kruskal-Wallis test for numerical variables and Pearson's chi-square or Fisher's exact test for categorical variables.

Repeated-measures ANOVA will be applied to assess post-intervention group-by-time interactions. Multiple comparisons will be performed using Tukey's post-hoc test. Furthermore, potential associations between deltas (Δ) – mean changes before and after the intervention – of OSA-related outcomes (AHI and ODI) and possible explanatory variables (VO_2, BMI, and NC) will be explored using Pearson's or Spearman's correlation test, depending on data normality. A 95% confidence interval will be employed in all analyses, corresponding to a significance level of 0.05 (5%). As highlighted previously, losses after randomization will be included in the intention-to-treat analysis but not in the analysis of the protocol. (Supplementary Table S1) shows the summary of the outcomes along with their respective measurement tool.

3 Discussion

This study aims to investigate the impact of a combined exercise program and sleep education on the severity and symptoms associated with OSA among older adults. The hypothesis posits that the combination of resistance and aerobic exercises, along with sleep education, will effectively reduce both the severity and the symptoms of OSA in older adults compared to the control group. This protocol is based on previous research demonstrating the potential of combined physical exercise to mitigate OSA severity in middle-aged adults (Kline et al., 2011; Desplan et al., 2014; Bughin et al., 2020).

The strengths of this study include the direct assessment of OSA using HPSG and the analysis of various symptoms associated with the disorder such as sleep quality and efficiency, as well as the measurement of anthropometric variables. The use of validated instruments increases the validity and reliability of the results. Participant recruitment will be broad but specific, with the inclusion criteria being based on previous studies and considering the specificity of OSA. Furthermore, the ecological validity of the study is considered, especially in relation to the exercise intervention, enabling its application in clinical practice. These strengths provide a solid framework and will thus increase the internal validity and clinical relevance of the study, which will contribute to scientific knowledge and improve the quality of life of older people with OSA.

The present study is of great importance for the scientific advancement in this field since it aims to investigate whether the positive effects of combined exercise on OSA are also observed in older people. If the study results demonstrate significant improvements in sleep parameters and OSA severity after the combined exercise program, this may indicate an effective non-pharmacological intervention for treating these conditions in older adults. This discovery would be of great clinical relevance by adding a non-pharmacological therapeutic option to the treatment of OSA in this population, which could be used as an adjunct to existing approaches. Moreover, effective intervention for managing sleep apnea in older adults may result in substantial savings in public health costs by preventing complications caused by OSA and reducing the need for expensive medical treatments.

Furthermore, the potential results may equip healthcare professionals with empirical data for their daily practice, enabling the incorporation of evidence-based strategies in the non-pharmacological treatment modalities for OSA. This approach has the potential to improve the quality of life of older people with OSA; in addition, it provides a safer and more affordable alternative to pharmacological interventions. This study also has the potential to boost initiatives that promote physical exercise among older adults as an essential part of geriatric care. Therefore, the findings of this study may have important impacts both in the field of sleep research and in clinical practice, providing an additional scientifically supported option for the treatment of OSA in older adults.

Ethics statement

The studies involving humans were approved by the Ethics Committee for Research Involving Humans of the State University of Santa Catarina. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

FF: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. RA: Methodology, Writing – review & editing. MS: Methodology, Writing – review & editing. AE: Methodology, Writing – review & editing. DM: Methodology, Supervision, Writing – review & editing. GM: Conceptualization, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2024.1322545/full#supplementary-material

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Acupuncture for insomnia symptoms in hypertensive patients: a systematic review and meta-analysis

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Purpose: In the realm of pain management, traditional Chinese medicine, specifically acupuncture, has garnered increasing attention. This meta-analysis pioneers the evaluation of acupuncture's effectiveness in treating insomnia among hypertensive patients.

Methods: We conducted a comprehensive search across several databases—PubMed, Web of Science, Cochrane Library, WANFANG, China National Knowledge Infrastructure (CNKI), Sinomed, and the Chinese Journal of Science and Technology (VIP). Additionally, forward and backward articles of studies published from the inception of these databases until 10 September 2023, were reviewed. This systematic review and meta-analysis included all randomized controlled trials (RCTs) focusing on acupuncture for insomnia in hypertensive patients, without imposing language or date restrictions. We rigorously assessed all outcome measures reported in these trials. The evidence was synthesized by calculating the difference between mean differences (MD) in symptom change. The quality of the evidence was determined using the Cochrane Risk of Bias tool. This study is registered with PROSPERO under number CRD42023461760.

Results: Our analysis included 16 RCTs, comprising 1,309 patients. The findings revealed that acupuncture was significantly more effective than the control group in reducing insomnia symptoms, as indicated by a greater decrease in the PSQI score (MD = –3.1, 95% CI [–3.77 to –2.62], $p < 0.00001$). Additionally, improvements in both systolic and diastolic blood pressure were more pronounced in the acupuncture group compared to the control group (SBP: MD = –10.31, 95% CI [–16.98 to –3.64], $p = 0.002$; DBP: MD = –5.71, 95% CI [–8.19 to –3.23], $p < 0.00001$). These results suggest that acupuncture not only improves sleep quality but also lowers blood pressure in patients suffering from hypertension and insomnia. Further research is warranted to elucidate optimal acupuncture points and the duration of treatment for maximized therapeutic effect.

Systematic review registration: https://www.crd.york.ac.uk/prospero, CRD42023461760.

KEYWORDS

acupuncture, insomnia, hypertension, complementary and alternative therapies, sleep disorders

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Background

Insomnia, a common sleep disorder characterized by difficulties in both falling asleep and staying asleep, accompanied by daytime dysfunction (1), affects approximately 30% of the global population, with at least one symptom of insomnia being experienced (2). This condition exerts a detrimental impact on both physical and mental health (3). Studies have demonstrated a direct link between shortened sleep duration, chronic insomnia disorders, and an increased risk of conditions such as obesity, high blood pressure, and all-cause mortality (4). Furthermore, persistent sleep problems have been associated with an increased risk of recurrent depression, and insomnia is considered a significant contributing factor to the risk of suicide (5, 6). Hypertension is recognized as a major contributor to the global burden of disease and mortality. The number of individuals with hypertension and its prevalence worldwide is expected to continue to rise over the next decade (7). Notably, symptoms of insomnia are frequently reported by patients with hypertension. Studies indicate that these patients have a relatively high risk of developing insomnia, with risk ratios (RR) ranging from 1.5 to 3.18 (8).

The conventional approach to treating patients with both hypertension and insomnia often involves the combined use of antihypertensive medications and sleep aids (9). However, due to concerns about dependence and other potential side effects, patients often show reluctance toward conventional sleeping medications, limiting their long-term clinical use. Among alternative therapies, acupuncture stands out as a popular and safe treatment option (10). Acupuncture, recognized for its effectiveness in treating a range of clinical disorders, particularly those related to neuroendocrine imbalances such as menopause, depression, and insomnia, operates by stimulating specific body points to regulate heart and brain functions (11). Acupuncture operates by stimulating specific points on the body to regulate the functions of the heart and brain.

Numerous clinical studies, notably randomized controlled trials (RCTs), have explored acupuncture's potential as an intervention for insomnia. These studies have consistently reported positive outcomes associated with the use of acupuncture in treating this sleep disorder. Research findings suggest that acupuncture treatments are effective in reducing sleep latency, and they also contribute to an increase in sleep duration and improvement in sleep efficiency (12). This body of evidence underscores the therapeutic value of acupuncture in addressing insomnia, providing a compelling case for its inclusion in treatment plans for individuals struggling with sleep disturbances.

Despite the growing body of clinical evidence, no meta-analytic studies have yet focused on the effectiveness of acupuncture in treating insomnia specifically in hypertensive patients. This gap highlights the need for more targeted meta-analyses, especially as clinical trials evolve. Our proposed meta-analysis aims to fill this void by assessing the effectiveness of acupuncture for insomnia symptoms in hypertensive patients, using clearly defined outcome measures. By covering all clinical studies to date on this subject, our meta-analysis will provide valuable insights and inform future clinical treatment strategies. This will be particularly beneficial for physicians seeking effective methods to control insomnia in patients with hypertension.

Methods

Search strategy

For our systematic review and meta-analysis, we extensively searched numerous literature databases including PubMed, Web of Science, Cochrane Library, WANFANG, China National Knowledge Infrastructure (CNKI), Sinomed, and Chinese Journal of Science and Technology (VIP). Our search aimed to identify randomized controlled trials (RCTs) examining the effects of acupuncture on insomnia, spanning from the inception of each database to 10 September 2023. The search strategy was specific, utilizing terms related to "acupuncture," "hypertension," and "insomnia." For interventions, we included keywords such as 'acupuncture OR electro-acupuncture OR electrosurgical needle OR fire needle OR Fire needles'. The disease-related keywords comprised 'Hypertension OR Blood Pressure, High OR Blood Pressures, High OR High Blood Pressure OR High Blood Pressures' and 'Disorders of Initiating and Maintaining Sleep OR DIMS (Disorders of Initiating and Maintaining Sleep) OR Early Awakening OR Nonorganic Insomnia OR Primary Insomnia OR Transient Insomnia OR Rebound Insomnia OR Secondary Insomnia OR Sleep Initiation Dysfunction OR Dysfunctions, Sleep Initiation OR Sleeplessness OR Insomnia Disorder OR Insomnia OR Chronic Insomnia OR Psychophysiological Insomnia'. Initially, the search utilized intervention keywords to gather relevant studies, followed by a second step employing hypertension and insomnia-related terms. The results from these two steps were then combined. All identified articles from various databases were consolidated into article management software (EndNote, version 20) for further analysis. We did not impose any specific restrictions on article types. Additionally, a thorough review of all relevant previously published meta-analyses and their reference lists was conducted. To our knowledge, there have been no recent updates on this topic, which substantiates our claim regarding the absence of recent reports in this field. The detailed search strategies employed in this study are documented in Supplementary File 1.

Literature selection

We applied the following set of inclusion criteria during the report selection process (13, 14): (1) Patients were diagnosed with "Hypertension and Insomnia" based on explicit diagnostic (inclusion) criteria. The diagnostic criteria for hypertension are as referred to in China's Guidelines for Prevention and Treatment of Hypertension (2018 Revision) And the following criteria are referenced in the diagnosis of insomnia: American diagnostic and statistical manual of mental disorders, fifth edition (DSM-V), classification and diagnostic criteria for Chinese mental disorders (CCDM), the diagnostic and therapeutic criteria for traditional Chinese medicine syndromes (DTCTCMS), guidelines for traditional Chinese medicine (new drug) clinical research (GTCMCR), and other commonly used diagnostic criteria. This criterion was irrespective of age, gender, duration, or source of cases, and patients did not have any other concurrent diseases. (2) These reports are randomized controlled trials that investigated the use of acupuncture (including needling, pointers, etc.) as a therapeutic intervention. Research implementation of acupuncture is not restricted in terms of manipulation and specific acupuncture points. (3) Control: this refers to any type of control group, including conventional Western medicine, routine nursing, or blank control. (4) Outcomes: at least one of the following scales was required to be included in the evaluation of sleep quality: Pittsburgh Sleep Quality Index (PSQI), the efficiency of the diagnostic and therapeutic criteria for TCM syndromes, the efficiency of guidelines for TCM (new drug) clinical research, sleep status self-assessment scale, or other inferable data mentioning insomnia and acupressure for carrying out meta-analysis; and systolic and diastolic blood pressure were used to evaluate blood pressure. Exclusion criteria encompassed (13): (1) Studies involving animal experiments, (2) Repetitive experiments, (3) Studies with incomplete data (e.g., missing sections like conference abstracts), (4) Studies published before the year 2000, as these often do not meet current standards of research quality and methodology.

Data collection

First, two researchers independently reviewed titles and abstracts based on predetermined inclusion and exclusion criteria, and then read the full text after excluding obviously irrelevant literature. The final included literature was identified after further screening, after which the two researchers extracted data without knowledge of each other's reviews. Finally, the results were cross-checked. These discrepancies were resolved through consensus with the third researcher.

Data extraction included the following: (1) general information: first author, year of publication, subject of literature, etc.; (2) study characteristics: baseline comparability, sample size, sex ratio, intervention, etc.; (3) outcome metrics; and (4) factors associated with assessing risk of bias.

Quality assessment

The risk of bias in the included randomized controlled trials was assessed using the revised Cochrane Risk of Bias Tool (RoB-2). This evaluation addressed several key aspects: random sequence generation and allocation concealment (both related to selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other potential biases. Each aspect was categorized based on the level of bias risk: low, unclear (indicating some concerns), or high. For instance, in assessing random sequence generation, a high risk of bias was attributed to methods prone to error, such as sorting by date of birth or outpatient number, whereas a low risk was associated with more reliable methods like random number tables, computer-generated random sequences, or coin flips (13–17). The findings from this comprehensive bias assessment were then visually represented using Revman 5.4 software, offering a clear graphical depiction of the potential biases within these trials.

Statistical analysis

The outcomes, including the significantly efficient rate, efficacy rate, and adverse reactions, alongside the sample sizes of the investigated studies, were input into the Revman software for conducting meta-analysis. The results were then visualized through forest plots. The level of heterogeneity was evaluated using the I^2 index, where values up to 30% indicated mild heterogeneity, 31%–50% suggested moderate heterogeneity, and values exceeding 50% indicated substantial heterogeneity. In cases where effects displayed heterogeneity ($I^2 > 50\%$), a random effects model was employed for the analysis. Conversely, a fixed effects model was utilized when the data appeared to be homogeneous. The calculated outcome measures and their corresponding 95% confidence intervals (CI) were illustrated in the forest plot. To determine statistical significance, a value of p less than 0.05 was considered indicative. Sensitivity analysis of the study using a case-by-case culling approach. Publication bias was estimated with a funnel plot (13, 14, 16, 17).

Results

Search results

At the outset, our search using the designated terms yielded a total of 585 potential research articles. Among these, 131 duplicate studies were eliminated through EndNote 20. Upon reviewing the titles and abstracts, 314 studies were identified as irrelevant and subsequently excluded. Furthermore, 90 articles were discarded due to their nature as reviews or conference materials. Subsequently, a thorough examination of the full text was conducted for 50 articles. Among these, 23 were excluded for reasons such as involving excessive time since publication, being retrospective studies, or not being pertinent to hypertension and insomnia. An additional 11 studies were excluded due to insufficient data. Ultimately, after careful scrutiny, a total of 16 clinical studies met the criteria and were deemed suitable for inclusion in the meta-analysis Figure 1.

Characteristics of the included studies

The 16 included trials contained a total of 1,309 patients, 673 in the acupuncture group and 636 in the control group (18–33). Among the 16 acupuncture studies, one study performed direct acupressure instead of acupuncture for acupoint stimulation (21), three studies used other traditional Chinese medical treatments based on acupuncture (22, 24, 30). One study used Qiju dihuang pills in conjunction with acupuncture (22), and two other studies used acupoint compresses in conjunction with acupuncture (24, 31). In four studies the control group used other treatments based on conventional drugs. Primarily, the control group was treated with herbal medicine (19, 20, 25, 33). For the diagnosis of hypertension, the Chinese Guidelines for the Prevention and Treatment of Hypertension (18–24, 26, 30–33) were used in 12 studies. The diagnostic criteria for hypertension were as follows: systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg. Hypertension was diagnosed if this criterion was met in multiple measurements. For the diagnosis of insomnia, six studies used the Chinese Guidelines for the Diagnosis and Treatment of Insomnia in Adults (19, 22, 23, 27, 31, 33), with the following diagnostic criteria: (1) Subjective description: patients subjectively felt sleep problems, including difficulty in falling asleep, difficulty in maintaining sleep,

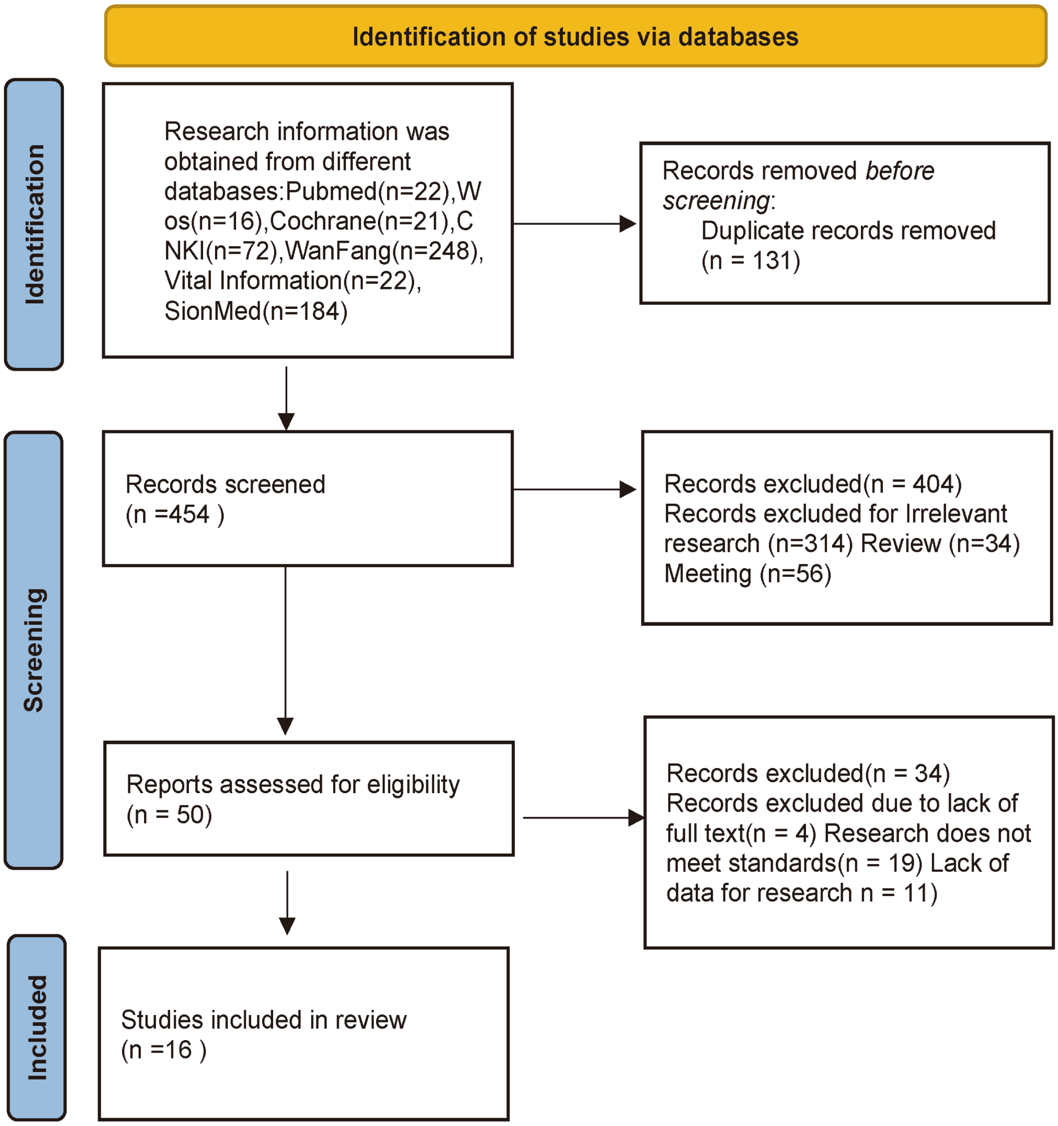

FIGURE 1
Flow diagram showing the screening and selection process of reports to be included in the meta-analysis.

early awakening, or poor quality of sleep. (2) Duration: these sleep problems should have persisted for at least 3 months. (3) frequency: insomnia problems should occur at least 3 times a week. (4) impact on daily life: insomnia problems affect the patient's daily life, social activities, studies or ability to work. (5) exclusion of other causes: insomnia is not caused by other medical or psychiatric disorders, e.g., depression, anxiety disorders, substance abuse, etc. Table 1 shows the main characteristics of the included studies: sample size of the treatment and control groups, age of the patients in the treatment and control groups, treatment chosen in the treatment group, treatment used in the control group, and duration of insomnia and hypertension. For the efficacy criteria of the included studies, 13 studies (18, 19, 21–30, 32) assessed SBP vs. DBP, and 12 studies (19–21, 23, 25–29, 31–33) assessed PSQI scores.7 studies (18, 19, 22–24, 31, 33) evaluated the efficacy of the treatment of insomnia using the therapeutic criteria of the TCM syndrome. Table 2 shows the included outcome metrics for the included studies.

Quality assessment

The results of the methodological assessment are shown in Figure 2. Ten of the 16 studies that mentioned random allocation methods were assessed as low risk due to the use of a random number table (19, 20, 22, 23, 26, 27, 30–33), and the remaining 6 studies were categorized as having an unclear risk of bias because of insufficient information provided. None of the 16 studies described the process of allocation concealment in sufficient detail and were judged to be at unclear risk of bias. Blinding of subjects or administrators could not be used in any of the 16 studies because of significant differences in the use of acupuncture treatment between treatment and control groups (18–33). The completeness of all study outcome data was judged to be at low risk of bias. Fourteen studies were categorized as having a low risk of bias for selective reporting because all prespecified endpoints were reported and were rated as having a low risk of bias for selective reporting. Two studies (18, 33) were rated at high risk of

TABLE 1 Characteristics of included studies.

Author	Total number of persons included (males/females)	Age (years)	Research design	Treatment group	Control group	Duration of hypertension (years)	Duration of insomnia (years)	Acupuncture point
Chen et al. 2020	T:40(15/25) C:40(14/26)	T:59.13 ± 8.10 C:57.65 ± 7.2	RCT	Control group + acupuncture	Using conventional interventions, including antihypertensive medication, dietary guidance, and health education	10.24 ± 6.7	6.31 ± 0.7	Shenmen (HT7), Taixi (KI3)
Ding et al. 2022	T:46(15/31) C:44(16/28)	T:65 0.64 ± 2.39 C:65 0.42 ± 2.45	RCT	Control group + acupuncture	Conventional drugs and Chinese herbal soup	T:6.48 ± 0.43 C:6.51 ± 0.47	T:14.26 ± 3.0 C:14.38 ± 3.15	Sanyinjiao (SP6), Neiguan (PC6), Shenmen (HT7), Baihui (DU20), Yintang (DU29), Shenting (DU24)
Guo et al. 2016	T:50(28/22) C:50(27/23)	T:70.61 ± 4.22 C:70.99 ± 4.17	RCT	Control group + acupuncture	Amlodipine tablets and ozone therapy	T:8.89 ± 6.35 C:9.12 ± 6.64	NA	Fengchi (GB20)
Han 2018	T:30(17/13) C:30(16/14)	T:64.112 ± 10.54 C:63.25 ± 11.42	RCT	Control group + acupoint stimulation	Benzodiazepine	T:13.12 ± 3.36 C:12.24 ± 3.41	NA	Shenmen (HT7), Shenting (DU24), Peaceful Sleep, Zhongwan (RN12), Xiawan (RN10), Zusanli (ST36)
Huanget a l. 2023	T:30(9/21) C:30(10/20)	T:70.83 ± 9.35 C:68.23 ± 4.98	RCT	Control group + acupuncture and Lycium Chrysanthemum Di Huang Pills	Alprazolam tablets	NA	NA	Baihui (DU20), Four Alert Spirit Points, Neiguan (PC6), Shenmen (HT7), Sanyinjiao (SP6), Taixi (KI3)
Kong 2015	T:45(24/21) C:45(23/22)	T:55.82 ± 4.17 C:56.07 ± 5.25	RCT	control group + acupuncture	Zopiclone Capsules	T:17.21 ± 6.83\ u00B0C:16.90 ± 6.33	NA	Renying (ST9), Hegu (LI4), Taichong (LR3), Quchi (LI11), Zusanli (ST36), Four Alert Spirit Points
Lin et al. 2019	T:60 C:60	NA	RCT	Control group + acupuncture and acupoint stimulation	Amlodipine benzenesulfonate, eszopiclone tablets	NA	NA	Shenmen (HT7)
Lin et al. 2021	T:30(16/14) C:30(14/16)	T:72.98 ± 3.21 C:71.99 ± 2.09	RCT	Control group + acupuncture	conventional drugs and Six-flavored Dihuang Pill	T:8.98 ± 2.90 C:9.45 ± 3.10	NA	Sanyinjiao (SP6), Shenmen (HT7), Shenting (DU24), Hegu (LI4), Neiguan (PC6), Zutonggu (BL66), Taichong (LR3)

(Continued)

TABLE 1 (Continued)

Author	Total number of persons included (males/females)	Age (years)	Research design	Treatment group	Control group	Duration of hypertension (years)	Duration of insomnia (years)	Acupuncture point
Ma 2021	T:31(18/13) C:33(17/16)	T:47.40 ± 5.22 C:48.53 ± 5.73	RCT	Control group + acupuncture	Amlodipine benzenesulfonate, eszopiclone tablets	T:3.09 ± 0.4 C:3.04 ± 0.42	NA	Shenmen (HT7), Shenting (DU24), Peaceful Sleep, Zhongwan (RN12), Xiawan (RN10)
Wang et al. 2023	T:30(18/12) C:30(20/10)	T:52.33 ± 12.91 C:49.33 ± 9.93	RCT	Control group + acupuncture	Amlodipine benzenesulfonate	T:5.90 ± 2.89 C:5.70 ± 2.95	T:1.23 ± 0.58 C:1.14 ± 0.43	Baihui (DU20), Yintang (DU29), Taichong (LR3), Hegu (LI4)
Xu 2020	T:45(25/20) C:45(26/19)	T:46.93 ± 5.39 C:48.34 ± 5.62	RCT	Control group + acupuncture	Nifedipine extended-release tablets, alprazolam tablets	NA	NA	Lingtai (DU10), Fengchi (GB20)
Ye et al. 2019	T:25(14/11) C:25(15/10)	T:44 ± 6.5 C:43.8 ± 6.6	RCT	Control group + acupuncture	conventional drugs	T:4.81 ± 0.82 C:4.78 ± 0.84	NA	Lingtai (DU10), Fengchi (GB20)
Zhang et al. 2022	T:50(28/22) C:50(27/23)	T:55.13 ± 4.75 C:55.21 ± 4.31	RCT	Control group + acupuncture	Conventional treatment and nursing interventions	T:7.14 ± 2.32 C:7.25 ± 2.21	NA	Shenmen (HT7)
Zhao 2021	T:51 (30/21) C:51 (22/29)	T:59.67 ± 9.78 C:58.35 ± 9.77	RCT	Control group + acupuncture and acupoint stimulation	Nifedipine, Enalapril Maleate Tablets	NA	T:7.87 ± 5.67 C:7.9 ± 5.68	Neiguan (PC6), Shenmen (HT7), Shenting (DU24), Baihui (DU20)
Zheng et al. 2014	T:38(14/24) C:37(12/25)	T:59.84 ± 7.2 C:58.95 ± 8.29	RCT	Control group + acupuncture	conventional drugs	T:9.16 ± 5.3 C:8.43 ± 4.43	NA	Shenmen (HT7)
Zhou et al. 2019	T:72(29/43) C:36(14/22)	T:64.61 ± 8.37 C:62.73 ± 9.85	RCT	Control group + acupuncture	conventional drugs and Chinese herbal soup	T:7.87 ± 6.67 C:6.12 ± 4.5	NA	Neiguan (PC6), Shenmen (HT7), Shenting (DU24), Baihui (DU20)

bias for selective reporting because of imperfect reporting of endpoints. In 16 studies, there were insufficient data required to judge other risks of bias (18–33).

Results of individual studies

Main outcome indicators

Systolic blood pressure

A total of 13 articles assessed systolic blood pressure, involving a total of 999 patients (18, 19, 21–30, 33). It is noteworthy that the values of Systolic blood pressure (SBP) were lower in cases where acupuncture treatment was performed. Given the large heterogeneity between these studies ($I^2 = 98\%$, $p < 0.00001$), a random-effects model was used. The pooled results showed (Figure 3) that the difference in SBP was statistically significant (MD = −10.31, 95% [−16.98,−3.64], $p = 0.002$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study, indicating the robustness of the results (Table 3). This result suggests that the treatment group that used acupuncture had a better effect on the improvement of blood pressure systolic compared to the control group.

Diastolic blood pressure

As with systolic blood pressure, a total of 13 articles evaluated systolic blood pressure, involving a total of 999 patients (18, 19, 21–30, 32). Given the large heterogeneity among these studies ($I^2 = 95\%$, $p < 0.00001$), a random-effects model was used. Pooled results showed (Figure 4) that the difference in Diastolic blood pressure (DBP) was statistically significant (MD = −5.71, 95% [−8.19,−3.23], $p < 0.00001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after

TABLE 2 Data on outcome indicators included in the study.

Author	SBP	DBP	PSQI scores for sleep quality	PSQI scores for sleep time	PSQI scores for time to sleep	PSQI scores
Chen et al. 2020	A:126.24 ± 8.80 B:132.76 ± 9.35	A:73.34 ± 7.09 B:76.28 ± 6.54	NA	NA	NA	NA
Ding et al. 2022	A:131 0.47 ± 4.5 B:142.73 ± 5 0.39	A:83.45 ± 1 0.91 B:89.92 ± 2.1	A:1.54 ± 0.25 B:1.88 ± 0.27	A:1.64 ± 0.19 B:1.92 ± 0.25	A:1.40 ± 0.17 B:1.79 ± 0.22	NA
Guo et al. 2016	NA	NA	A:1.33 ± 0.31 B:1.94 ± 0.27	A:1.31 ± 0.24 B:2.16 ± 0.33	A:1.73 ± 0.28 B:2.03 ± 0.31	A:8.49 ± 1.34 B:12.31 ± 1.56
Han 2018	A:128.22 ± 6.84 B:135.32 ± 5.44	A:85.35 ± 6.64 B:94.11 ± 5.66	NA	NA	NA	A:5.42 ± 0.61 B:9.13 ± 1.66
Huang et al. 2023	A:138.83 ± 11.30 B:140.93 ± 11.50	A:83.27 ± 13.07 B:84.60 ± 7.20	NA	NA	NA	NA
Kong 2015	A:134.43 ± 12.37 B:142.35 ± 14.53	A:85.48 ± 8.92 B:87.85 ± 9.02	A:1.54 ± 0.63 B:2.01 ± 0.72	A:1.19 ± 0.20 B:1.86 ± 0.41	A:1.47 ± 0.23 B:1.92 ± 0.27	A:6.93 ± 1.87 B:10.33 ± 2.75
Lin et al. 2019	A:124.2 ± 7.9 B:135.4 ± 8.4	A:82.7 ± 4.6 B:88.8 ± 3. 2	NA	NA	NA	NA
Lin et al. 2021	A:125 ± 10 B:131 ± 9	A:85 ± 6 B:89 ± 8	NA	NA	NA	A:7.29 ± 3.80 B:9.80 ± 4.07
Ma 2021	A:121.10 ± 7.68 B:126.26 ± 12.15	A:74.56 ± 9.17 B:75.66 ± 8.80	A:0.8 ± 0.5 B:1.6 ± 0.6	A:0.7 ± 0.7 B:1.5 ± 0.8	A:1.4 ± 0.6 B:2.1 ± 0.5	A:6.8 ± 2.7 B:11.1 ± 2.7
Wang et al. 2023	A:131.57 ± 8.23 B:142.47 ± 9.38	A:82.30 ± 4.58 B:87.63 ± 7.67	A:1.80 ± 0.55 B:2.10 ± 0.66	A:1.50 ± 0.73 B:1.90 ± 0.76	A:1.57 ± 0.63 B:2.00 ± 0.83	A:7.77 ± 2.87 B:10.23 ± 4.17
Xu 2020	A:110.29 ± 3.08 B:141.57 ± 3.19	A:74.32 ± 2.62 B:88.49 ± 2.17	A:1.49 ± 0.08 B:1.96 ± 0.15	NA	NA	NA
Ye et al. 2019	A:135.87 ± 3.82 B:140.02 ± 4.11	A:85.86 ± 1.87 B:89.95 ± 2.13	A:1.56 ± 0.23 B:1.89 ± 0.25	A:1.65 ± 0.20 B:1.91 ± 0.23	A:1.45 ± 0.15 B:1.78 ± 0.20	NA
Zhang et al. 2022	A:119.16 ± 7.12 B:134.62 ± 7.43	A:78.41 ± 7.53 B:89.93 ± 7.68	NA	NA	NA	NA
Zhao 2021	NA	NA	A:1.56 ± 0.23 B:1.89 ± 0.25	A:0.83 ± 0.12 B:1.55 ± 0.13	A:1.03 ± 0.21 B:1.42 ± 0.21	A:6.86 ± 1.35 B:8.82 ± 2.11
Zheng et al. 2014	A:118.61 ± 6.66 B:132.73 ± 12.22	A:73.47 ± 7.17 B:76.92 ± 8.45	NA	NA	NA	A:7.37 ± 3.98 B:9.81 ± 3.76
Zhou et al. 2019	NA	NA	NA	NA	NA	A:7.13 ± 1.96 B:10.46 ± 2.77

arbitrarily excluding one study, indicating the robustness of the results (Table 3). This result suggests that the treatment group that used acupuncture had a better effect on the improvement of blood pressure diastolic blood pressure compared to the control group. The results of systolic and diastolic blood pressure indicate that acupuncture treatment was effective in improving the blood pressure of the patients.

Total PSQI score

A total of 9 articles assessed systolic blood pressure, involving a total of 719 patients (20, 21, 23, 25–27, 31–33). Given the large heterogeneity among these studies ($I^2 = 67\%$, $p = 0.002$), a random-effects model was used. Pooled results showed (Figure 5) that the difference in total PSQI scores was statistically significant (MD = −3.1, 95% [−3.77,−2.62], $p < 0.00001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study, indicating the robustness of the results (Table 4). This result suggests that the treatment group that used acupuncture was more effective in improving insomnia compared to the control group. In addition to this, subgroup analyses were performed based on patient age (<60 and >60 years) and method of comparison (the control group with the addition of Chinese herbs, the control group with conventional medication, and the treatment group with a combination of acupuncture and other treatments; Figure 6), which showed that none of the results were significant between subgroups. Notably, there was a great deal of heterogeneity between the two studies in the subgroup of combined treatment ($I^2 = 93\%$, $p = 0.002$).

Secondary outcome indicators

PSQI sleep quality score

PSQI sleep quality scores were included in eight studies involving a total of 646 patients (19, 20, 23, 26–29, 31). Given the

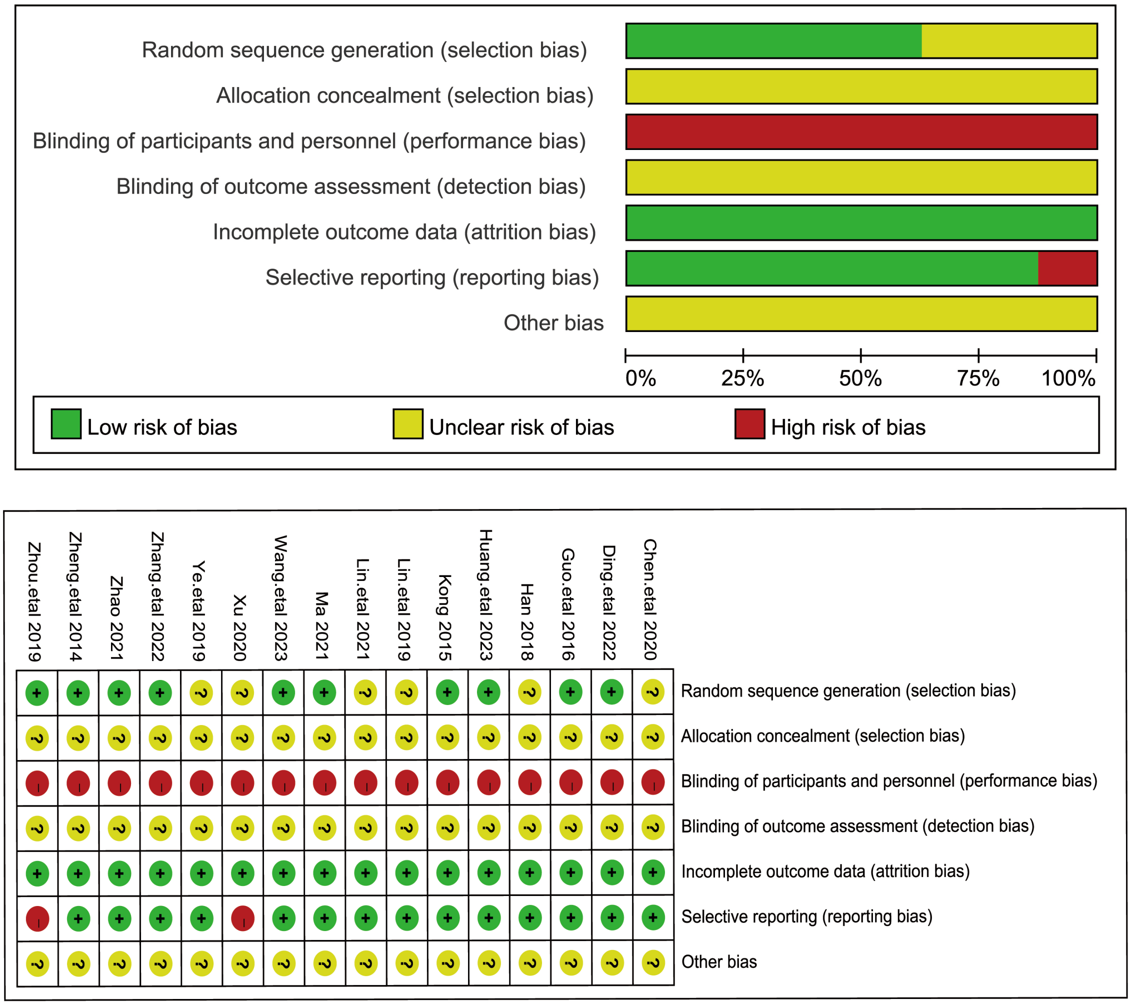

FIGURE 2
The figure represents the risk of bias assessment for the studies selected in the meta-analysis.

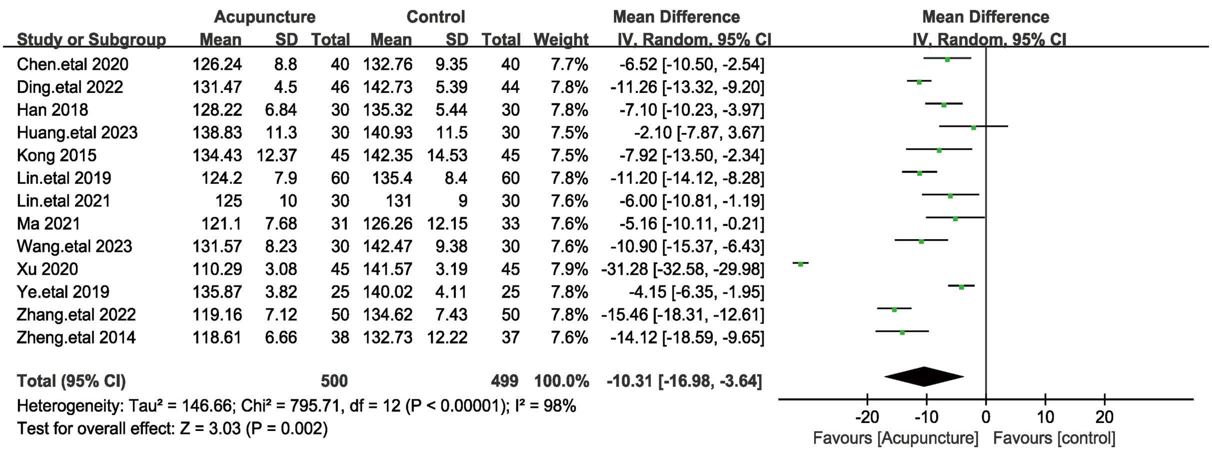

FIGURE 3
The figure represents a forest plot of the meta-analysis for systolic blood pressure (SBP). Each row represents a study and lists the name of the study, the mean systolic blood pressure and standard deviation for the acupuncture and control groups, the sample size, and the mean difference and its 95% confidence interval.

TABLE 3 Sensitivity analysis of blood pressure showing pooled results after excluding one study.

Study of removal	Chen et al. 2020	Ding et al. 2022	Han 2018	Huang et al. 2023	Kong 2015	Lin et al. 2019	Lin et al. 2021	Ma 2021	Wang et al. 2023	Xu 2020	Ye et al. 2019	Zhang et al. 2022	Zheng et al. 2014
MD of SBP	−10.63 [−17.64, −3.61]	−10.22 [−17.71, −2.73]	−10.58 [−17.65, −3.51]	−10.97 [−17.89, −4.06]	−10.50 [−17.49, −3.51]	−10.23 [−17.46, −3.00]	−10.66 [−17.65, −3.68]	−10.73 [−17.70, −3.77]	−10.26 [−17.32, −3.20]	−8.68 [−11.10, −6.26]	−10.84 [−17.68, −4.00]	−9.87 [−17.18, −2.56]	−9.99 [−17.08, −2.91]
MD of DBP	−5.94 [−8.53, −3.36]	−5.58 [−8.64, −2.52]	−5.45 [−8.08, −2.83]	−6.00 [−8.56, −3.45]	−5.98 [−8.55, −3.40]	−5.65 [−8.42, −2.88]	−5.85 [−8.44, −3.25]	−6.05 [−8.61, −3.50]	−5.74 [−8.35, −3.13]	−5.17 [−6.51, −3.82]	−5.85 [−8.53, −3.17]	−5.22 [−7.82, −2.63]	−5.89 [−8.48, −3.30]

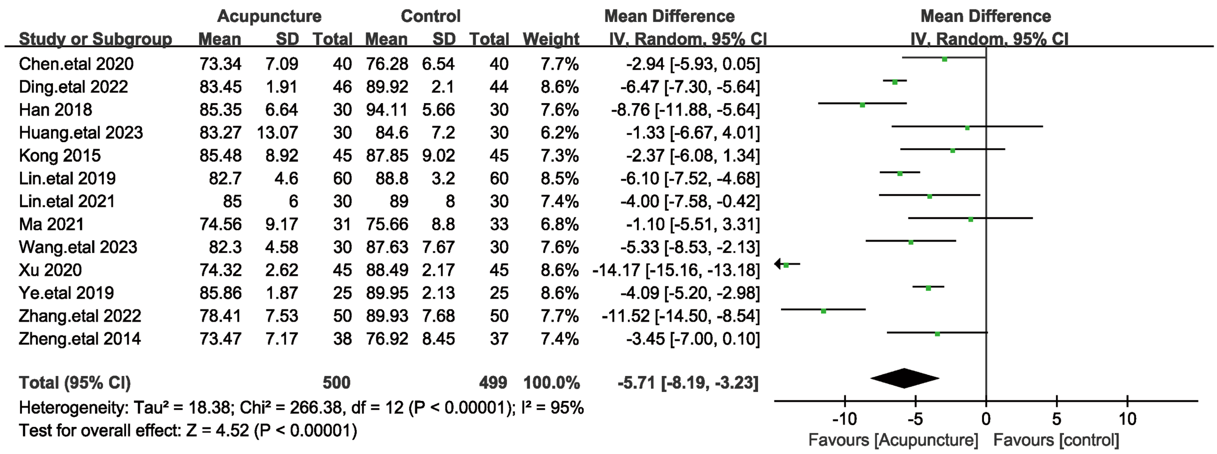

FIGURE 4
The figure represents a forest plot of meta-analysis against diastolic blood pressure (DBP).

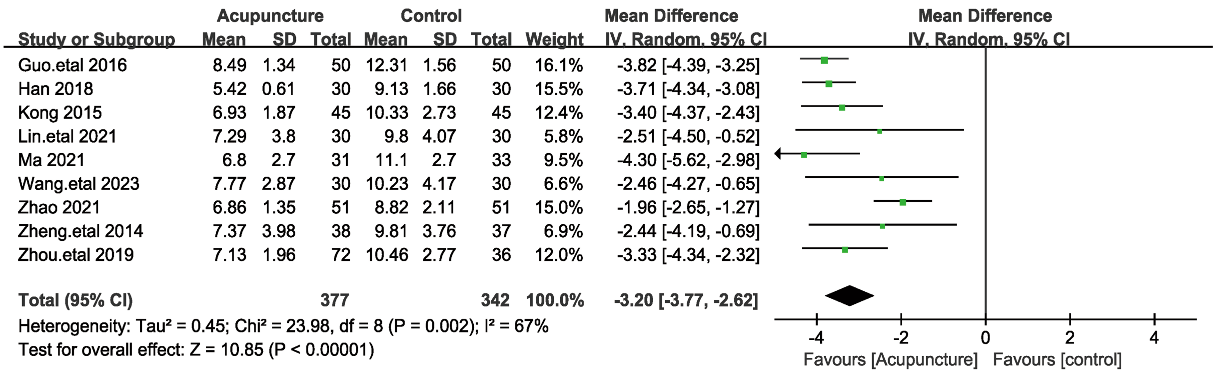

FIGURE 5
The figure represents the forest plot of the meta-analysis against total PSQI score.

TABLE 4 Sensitivity analysis of PSQI score showing pooled results after excluding one study.

Study of removal	Guo et al. 2016	Han 2018	Kong 2015	Lin et al. 2021	Ma 2021	Wang et al. 2023	Zhao 2021	Zheng et al. 2014	Zhou et al. 2019
MD	−3.08 [−3.72, −2.43]	−3.10 [−3.77, −2.42]	−3.16 [−3.82, −2.50]	−3.24 [−3.84, −2.63]	−3.08 [−3.68, −2.48]	−3.25 [−3.86, −2.64]	−3.59 [−3.92, −3.25]	−3.25 [−3.86, −2.64]	−3.17 [−3.83, −2.52]

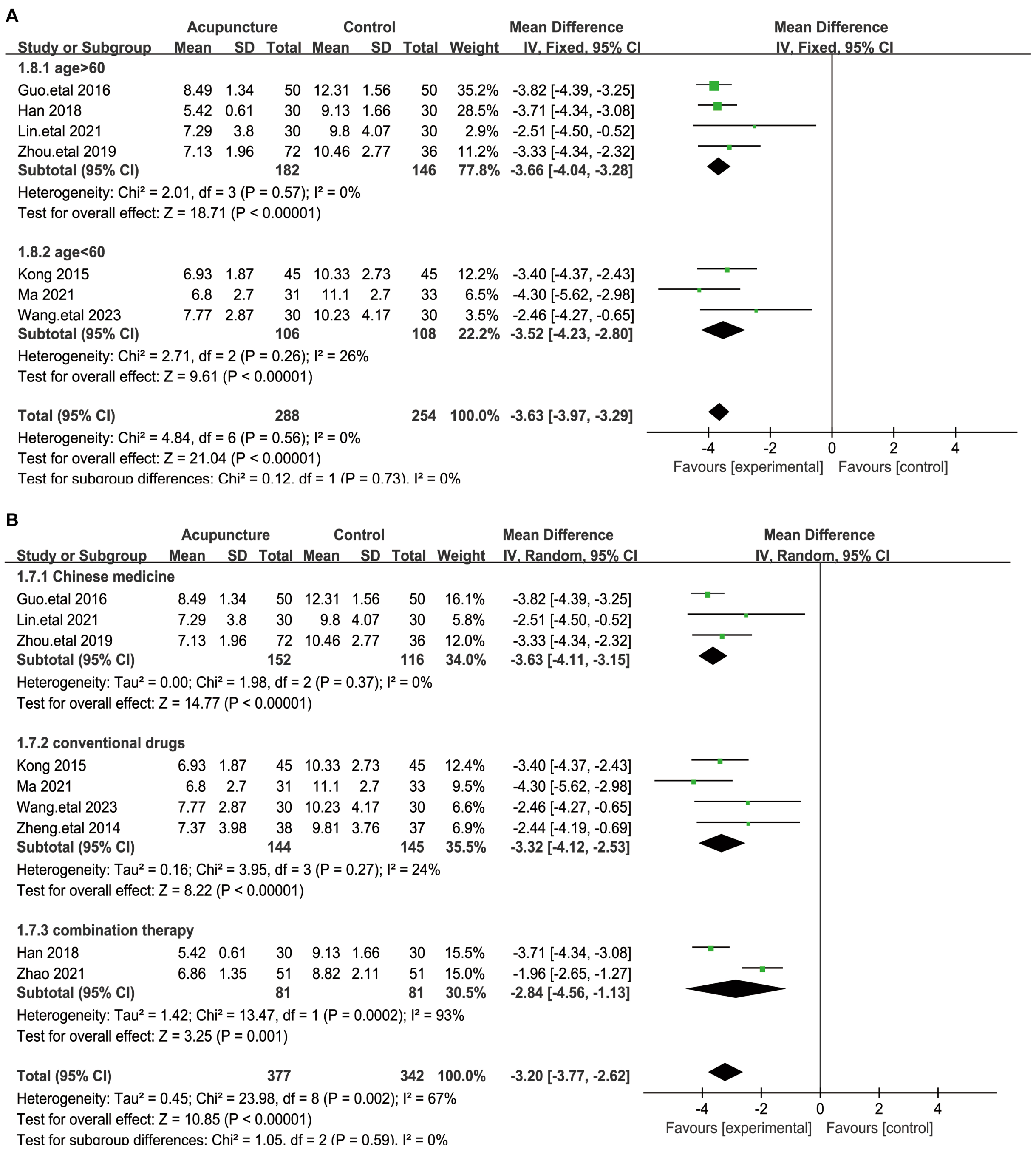

FIGURE 6
The figure represents a forest plot of subgroup analyses against total PSQI score. **(A)** Forest plots on different patient ages. **(B)** Forest plots on different interventions.

large heterogeneity among these studies ($I^2 = 92\%$, $p < 0.00001$), a random-effects model was used. Pooled results showed (Figure 7) that the difference in PSQI sleep quality scores was statistically significant (MD = −0.51, 95% [−0.64,−0.38], $p < 0.00001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study, indicating that the results were robust. This result suggests that the treatment group that used acupuncture had a better effect on the improvement of sleep quality compared to the control group.

PSQI sleep time score

The PSQI sleep quality score was included in 7 studies involving a total of 556 patients (19, 20, 23, 26, 27, 29, 31). Given the large heterogeneity among these studies ($I^2 = 95\%$, $p < 0.00001$), a random-effects model was used. Pooled results showed (Figure 8) that the difference in PSQI sleep quality scores was statistically significant (MD = −0.57, 95% [−0.76,−0.37], $p < 0.00001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study,

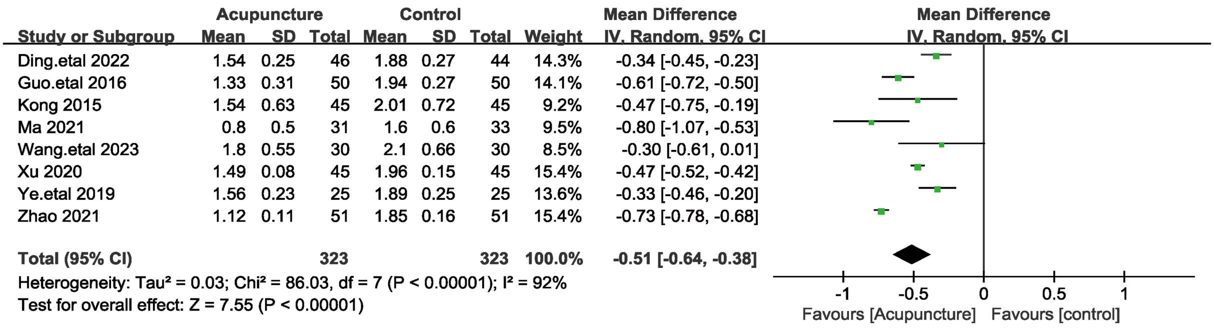

FIGURE 7
The figure represents a forest plot against the sleep quality score.

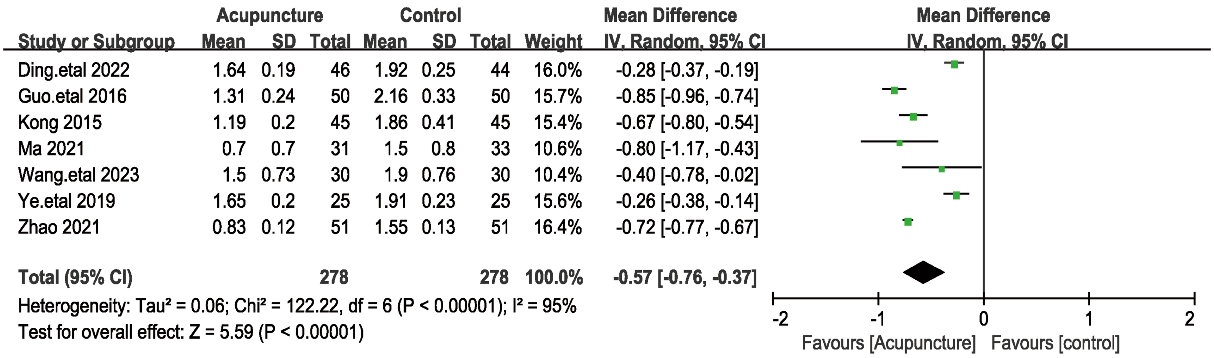

FIGURE 8
The figure represents a forest plot against the sleep duration score.

indicating that the results were robust. This result suggests that the treatment group that used acupuncture had a better effect on the improvement of sleep duration compared to the control group.

PSQI time to sleep score

The PSQI time to sleep score was included in 7 studies involving a total of 556 patients (19, 20, 23, 26, 27, 29, 31). Because of the low heterogeneity among these studies ($I^2 = 40\%$, $p = 0.12$), a fixed-effects model was used. Pooled results showed (Figure 9) that the difference in PSQI sleep quality scores was statistically significant (MD = −0.39, 95% [−0.43,−0.34], $p < 0.00001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study, indicating that the results were robust. This result suggests that the treatment group that utilized acupuncture had a better effect on the improvement of time to sleep compared to the control group.

Clinical research guidelines for Chinese medicine (new drugs) significant effectiveness and effectiveness rate

The PSQI score reduction rate was calculated by the nimodipine method in five studies using the clinical research guidelines for Chinese medicine (new drugs) (19, 23, 24, 31, 33) with reference to the relevant efficacy evaluation criteria in the Guiding Principles for the Clinical Research of New Traditional Chinese Medicines (Trial Implementation). Clinical recovery: PSOI total score reduction rate > 75%; significant effect: PSOI score reduction rate ≥ 50 and < 75%; progress: PSOI score reduction rate ≥ 25 and < 50%; ineffective: PSOI score reduction rate < 25%. We categorized cured and significantly effective together as significantly effective rates, and in view of some heterogeneity among these studies ($I^2 = 51\%$, $p < 0.09$), a random-effects model was used. The results showed (Figure 10A) that the combined results were statistically significant compared with the control group (RR = 1.65, 95% [1.29,2.11], $p < 0.0001$). We performed a sensitivity analysis of the results using the one-by-one exclusion method, and the results were statistically significant after arbitrarily excluding one study, indicating the robustness of the results. Next, we analyzed the total effective rate of treatment (Figure 10B), which was analyzed by meta-analysis using a fixed-effects model due to the low heterogeneity among these studies ($I^2 = 0\%$, $p = 0.98$). The results showed a statistically significant difference in total effective rate (RR = 1.22, 95% [1.12,1.32], $p < 0.00001$). The results of the significant effective rate and the total effective rate indicated that the treatment group that used acupuncture was more effective in the treatment of insomnia compared to the control group.

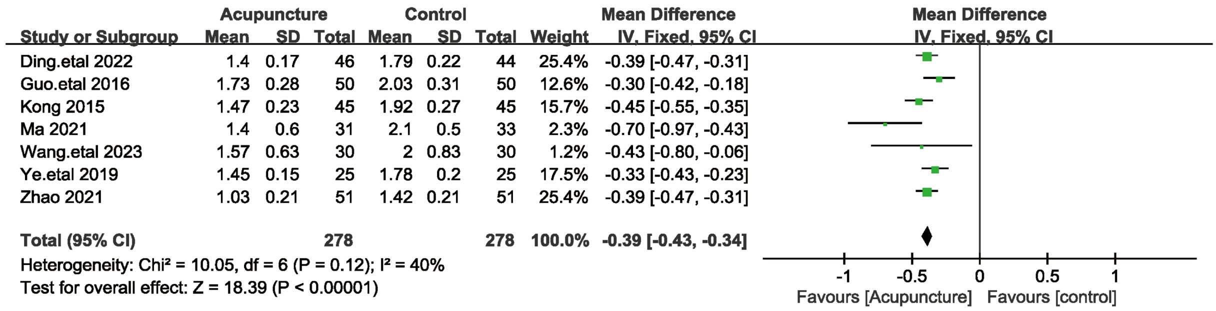

FIGURE 9
The figure represents a forest plot against the time to Sleep Score.

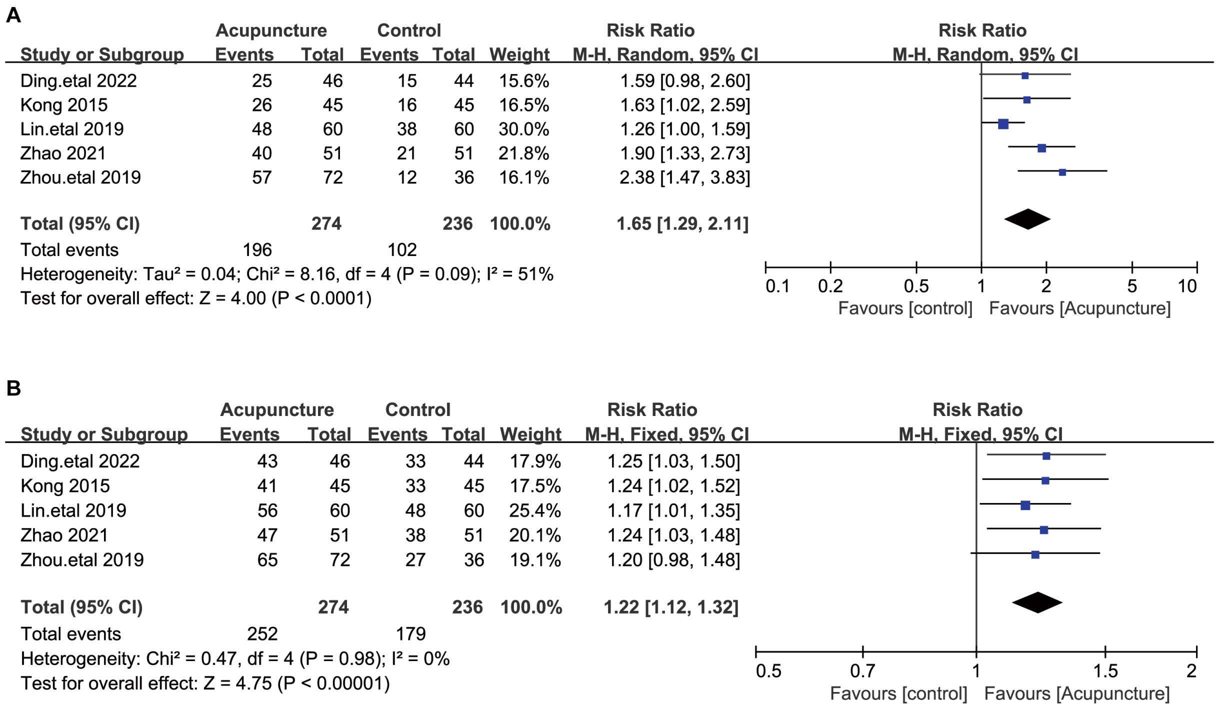

FIGURE 10
(A) The figure represents a forest plot against the significantly effective rates. **(B)** The figure represents a forest plot against the Overall effectiveness of insomnia treatment.

Discussion

The treatment of insomnia in hypertensive patients typically requires a comprehensive therapeutic approach encompassing improvements in sleep habits, behavioral therapy, potential pharmacological interventions, and hypertension management. Acupuncture, a traditional Chinese medicinal treatment, is widely used in clinical practice worldwide as a traditional Chinese medicine (TCM) intervention (34–36). Previous research has provided evidence of acupuncture's influence on the nervous system (37, 38). Investigations have also delved into the molecular mechanisms underlying acupuncture's impact on the nervous system (39). Simultaneously, the stimulation of specific acupoints has shown therapeutic effects by modulating the expression of proteins (40). Consequently, acupuncture has progressively gained acceptance in the treatment of insomnia among hypertensive patients (41). In a previous study, acupuncture was shown to influence neuroendocrine homeostasis by modulating the vagus nerve, effectively addressing both hypertension and insomnia (42). Additionally, acupuncture has been found to enhance the levels of certain sleep-related neurotransmitters, such as serotonin and gamma-aminobutyric acid, while decreasing sleep-inhibitory neurotransmitters, like norepinephrine, in the brain (38).

Our meta-analysis results indicate that acupuncture surpasses oral western medication alone in terms of efficacy. This superiority is demonstrated through lower blood pressure profiles, reduced PSQI scores, and a higher treatment success rate within the acupuncture group, and these differences are statistically significant. To delve deeper into the comparison of acupuncture-based treatments and drug efficacy, we conducted subgroup analyses based on differences in treatment protocols between the control and acupuncture groups. Following that, we performed another subgroup analysis considering the age of patients in various studies. Notably, the results from both subgroup analyses displayed no statistically significant differences. In terms of safety, it is important to note that no serious adverse effects were reported across all studies, underscoring the excellent safety record associated with acupuncture treatment. Sensitivity analyses conducted for each outcome indicator confirmed the stability and reliability of our results.

While our findings suggest that acupuncture is a more effective treatment for insomnia in hypertensive patients compared to medication alone, it's important to acknowledge that there was a substantial degree of heterogeneity among the studies we analyzed. This heterogeneity may arise from clinical variations, such as differences in acupoints selection and compatibility in the test group, variations in the duration of needle application, and discrepancies in the types and dosages of oral medications in the control group. The limited availability of multicenter studies suitable for inclusion in this systematic review also contributes to this limitation. Consequently, some level of bias is inherent in this analysis. To gain a more comprehensive understanding of the clinical efficacy of acupuncture in alleviating insomnia symptoms in hypertensive patients, future studies should focus on conducting prospective, multicenter, large-sample randomized controlled trials with robust study designs. We found that adverse effects were not systematically studied and documented in the included studies, which means that future studies are needed to validate the efficacy of treatment. Furthermore, these studies should aim to standardize the process of acupoint selection and treatment method in accordance with Traditional Chinese Medicine (TCM) evidence-based theories. This standardization would enhance the comparability between studies investigating such treatments and facilitate more effective quality control. Efforts are also needed to establish clinical acupuncture treatment protocols with demonstrated efficacy and high feasibility (43). This would contribute to the development of evidence-based guidelines for clinical practice.

Conclusion

In summary, our meta-analysis results indicate that the acupuncture group exhibits greater improvements in blood pressure control, PSQI scores, and treatment efficiency when compared to the control group. This provides a theoretical basis for the use of acupuncture in the treatment of insomnia symptoms in hypertensive patients. However, due to the limitations of the available literature, there is still a need for large-sample, multicenter, and well-designed clinical trials. It may be necessary to analyze different acupoints and intervention durations to further explore the factors influencing treatment outcomes.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JZ: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft. XZ: Data curation, Formal Analysis, Methodology, Writing – original draft. HJ: Data curation, Formal Analysis, Writing – original draft. WZ: Conceptualization, Data curation, Writing – original draft. HC: Methodology, Visualization, Writing – original draft. LJ: Software, Writing – original draft. SZ: Methodology, Writing – original draft. JY: Visualization, Visualization. SD: Supervision, Writing – original draft. BL: Investigation, Writing – original draft. BZ: Project administration, Writing – original draft. MZ: Formal Analysis, Writing – original draft. BC: Data curation, Writing – original draft. ZM: Funding acquisition, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fneur.2024.1329132/full#supplementary-material

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Sleep quality and associated factors among university students in Africa: a systematic review and meta-analysis study

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Background: Poor sleep quality significantly impacts academic performance in university students. However, inconsistent and inconclusive results were found in a study on sleep among university students in several African nations. Therefore, this study aimed to estimate the pooled prevalence and associated factors of poor sleep quality among university students in Africa.

Methods: The databases PubMed, Scopus, Cochrane Library, Science Direct, African Journal Online, and Google Scholar were searched to identify articles. A total of 35 primary articles from 11 African countries were assessed and included in this systematic review and meta-analysis. Data were extracted by using a Microsoft Excel spreadsheet and exported to STATA version 14 for analysis. The I^2 test was used to assess the statistical heterogeneity. A random effect meta-analysis model was employed with 95% confidence intervals. Funnel plots analysis and Egger regression tests were used to check the presence of publication bias. A subgroup analysis and a sensitivity analysis were done.

Results: A total of 16,275 study participants from 35 studies were included in this meta-analysis and systematic review. The overall pooled prevalence of poor sleep quality among university students in Africa was 63.31% (95% CI: 56.91-65.71) $I^2 = 97.2$. The subgroup analysis shows that the combined prevalence of poor sleep quality in East, North, West, and South Africa were 61.31 (95% CI: 56.91-65.71), 62.23 (95% CI: 54.07-70.39), 54.43 (95% CI: 47.39-61.48), and 69.59 (95% CI: 50.39-88.80) respectively. Being stressed (AOR= 2.39; 95% CI: 1.63 to 3.51), second academic year (AOR= 3.10; 95% CI: 2.30 to 4.19), use of the electronic device at bedtime (AOR= 3.97 95% CI: 2.38 to 6.61)) and having a comorbid chronic illness (AOR = 2.71; 95% CI: 1.08, 6.82) were factors significantly associated with poor sleep quality.

Conclusion: This study shows that there is a high prevalence of poor sleep quality among university students in Africa. Being stressed, in the second year, using electronic devices at bedtime, and having chronic illness were factors associated with poor sleep quality. Therefore, addressing contributing factors and implementing routine screenings are essential to reduce the burden of poor sleep quality.

Systematic Review Registration: https://www.crd.york.ac.uk/prospero/, identifier CRD42023493140.

KEYWORDS

sleep quality, university students, systematic review, meta-analysis, Africa

Introduction

Sleep is a naturally recurring physiological process that is important for psychological, physical, and emotional well-being (1). Sleep is also an important role in cognitive functions like judgment and memory consolidation, and vital for academic performance (2). Sleep quality is a combination of quantitative and qualitative aspects, including duration and subjective feeling of restfulness upon awakening (3). Africa is a continent that is bounded by the Mediterranean Sea to the north, the Indian and Atlantic Oceans to the east, the Atlantic Ocean to the west, and the confluence of the two oceans to the south (4). According to recent studies, non-communicable illnesses (NCDs), such as sleep disorders, are becoming more common at an alarming rate across Africa, placing a strain on healthcare resources in addition to communicable diseases (5). Due to factors including urbanization, socioeconomic development, and globalization, NCDs are becoming more common among young Africans. Taking care of these risk factors in today's youth can drastically change how NCDs are expected to develop in Africa (5–8). Nowadays, the majority of young individuals sleep for shorter periods of time than what is advised by science (9). Good sleep quality at night facilitates the brain's physiological repair processes and nerve cell growth. Regular engagement in these processes enhances an individual's memory and learning capacity (10, 11). Due to a lack of resources for education, young adults in Africa typically perform worse academically, especially if they live in rural areas (12). However, African students with lesser academic standing may experience sleep disturbances as a result, particularly if they attempt to find work and their grades fall short of most employer imposed requirements (13).

Poor sleep quality is a common problem for university students, and it has a detrimental effect on their academic performance (14, 15). Compared to the general population, university students had a twofold higher prevalence of poor quality of sleep (16). This is brought on by the change from high school to college, the lessening of the role of parents, and higher expectations for academic achievement (17, 18). Poor sleep quality was found to be highly prevalent among medical students 55.64% according to a global meta-analysis study (19). A cross-sectional study was carried out in seven countries the Dominican Republic, Egypt, Guyana, India, Mexico, Pakistan, and Sudan, and the prevalence of sleep quality among university students was found to be 73.5% (20). These rates are greater than those of the general population (21, 22). A complicated interaction between genetics, academic load, technology, environmental conditions, and comorbidities is blamed for this problem. In general, it has been noted that a sizable percentage of students have trouble sleeping, which may be connected to stress from their studies (22, 23).

Poor sleep quality among university students can lead to mental and physical health issues (24). Students who have poor quality of sleep typically report common mental health issues, which many will probably need to get support for in order to successfully resolve. Poor quality of sleep has an impact on several aspects of behavior, including executive function, hormone balance, emotional control, and attentiveness. Numerous studies that involved depriving small groups of healthy individuals of all sleep for one or two nights revealed a wide range of specific abnormalities (24–26). Among the findings in the field of emotional regulation is a rise in psychopathology symptoms, like depression (27–31), anxiety (28, 29), and stress (32–34) including substance use (18, 35). Sleep is also crucial for learning and memory processes. Nonetheless, there is still much to learn about the specifics of the connection between sleep and memory formation. According to the dual process theory, declarative memory may require non-REM sleep, and procedural memory may require rapid eye movement (REM) sleep. This is because different forms of memory are associated with different sleep states (36, 37). Therefore, poor sleep can impair attention, concentration, and memory and all this leads to poor academic performance (2, 36, 38, 39). It also leads to metabolic, hormonal, and immunologic effects, causing immune suppression (40–42). Undergraduate students often experience poor sleep quality due to various factors, including irregular sleep schedules fatigue, and co-morbid chronic illness (43, 44). Sleep disturbances can worsen a person's quality of life in addition to contributing to the early onset of chronic diseases (45). Factors such as internet addiction, substance use, depression, stress, and poor academic performance (20, 35, 46–48) are associated with poor sleep quality. New social

Abbreviations: AOR, Adjusted odd ratio; CI, Confidence interval; COVID, Corona Virus Disease; NCD, Non-Communicable Disease; REM, Rapid Eye Movement; WHO, World Health Organization.

and academic environments, reduced parental supervision, and increased academic demands contribute to poor sleep quality among this population (18, 22, 49).

Poor sleep quality among college students in African countries is a significant issue, with mixed findings across studies. It is crucial to investigate patterns of poor sleep quality to create efficient interventions and reduce the likelihood of the detrimental effects associated with poor sleep quality, such as school dropout, poor academic performance, suicide, burnout, depression, and anxiety. To date, no meta-analysis, and systematic review has been carried out to investigate the prevalence of poor sleep quality among this population. To better understand the prevalence and associated factors of poor sleep quality among university students in African countries, we did a thorough meta-analysis and systematic review study.

Research questions

- What is the estimated pooled prevalence of poor sleep quality among university students in Africa?
- What are the associated factors for poor sleep quality among university students in Africa?

Methods and materials

The current meta-analysis and systematic review was registered (ID CRD42023493140) in the Prospective Register of Systemic Review (PROSPERO). Our search strategy and selection of publication for the review were conducted according to the (PRISMA 2020) guideline (50) (Additional File 1).

Searching strategy

This study was conducted to determine the sleep quality and associated factors among university students in Africa. A search of published articles was found by using the following databases: EMBASE, PubMed, African Journals Online, Psychiatry Online, Scopus, World Health Organization (WHO) reports, Cochrane Library, and other gray literature from Google. A search strategy was developed for each database by using a combination of free texts and controlled vocabularies (Mesh). The search for these articles was carried out until January 2, 2024. The following search items were used ("prevalence" OR "magnitude" OR "epidemiology"), AND ("poor sleep quality" OR "poor sleep" OR "sleep quality") AND ("associated factors" OR "risk factors" OR "determinants" OR "predictors" OR "correlate") AND ("University" OR "College" AND using African search filter developed by Pienaar et al. to identify prevalence studies (51). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed in conducting this systematic review and meta-analysis.

Eligibility criteria

Inclusion criteria

Cross-sectional studies that reported the prevalence of poor sleep quality among university students published in peer-reviewed journals in English language only, conducted in the continent of Africa were included. The tool used was the Pittsburg Sleep Quality Index only to diagnose poor sleep quality, and published from March 2011 to June 2023 were included in this review and meta-analysis.

Exclusion criteria

Studies were excluded if they did not report the prevalence of poor sleep quality, case reports, reviews, poster presentations, and editorial letters. Studies published in non-English languages, and conducted outside the continent of Africa were excluded. Besides this studies without access to the full data and duplicated studies were also excluded.

Outcome of interest

The primary outcome of this review was to determine the pooled prevalence of poor sleep quality among university students in Africa. The second outcome was to identify the pooled effects of factors associated with poor sleep quality. STATA version 14.0 was used to determine the pooled prevalence of depression, and the odds ratio (OR) was used to identify the pooled effect size of factors associated with poor sleep quality.

Study selection and quality assessment

The articles that were retrieved were imported into EndNote X7 (Clarivate, London, UK) for gathering and arranging search results as well as eliminating duplicate entries. Three authors (GK, YAW, and GMT) evaluated the quality of the primary studies using the Joanna Briggs Institute (JBI) quality appraisal criteria. There are nine items on this quality assessment checklist, ranging from 0 to 9 (0–4 low, 5-7 medium, and 8 and above good quality (52). Those articles with high and medium quality (greater than or equal to 5) were included in the final analysis.

Data extraction

Using a standardized data extraction format, four reviewers (FA, MM, SF, and GR) independently extracted all the necessary data from primary articles. After a careful review of the article titles, abstracts, and full texts, this was arranged using Microsoft Excel. Finally, articles approved by the four reviewers in the selection processes were included in the study, and any disagreements were resolved through discussions with other authors to reach a consensus. For instance, the first author's name, study design, study year, publication year, country/region in which the study was conducted, a screening tool used to examine sleep quality, type of students, sample size, and prevalence of poor sleep quality were extracted. The combined estimated effects of the related covariates and prevalence of sleep quality together with their 95% confidence intervals (CIs) and odd ratios were also extracted.

Statistical procedure

The extracted data were entered into a Microsoft Excel spreadsheet and then exported to STATA version 14.0 for analysis. The pooled prevalence of poor sleep quality along with the 95% confidence intervals was visually displayed using a forest plot. The degree of heterogeneity among the included articles was determined by the index of heterogeneity (I^2 statistics) (53). A random-effect meta-analysis model was used to determine the pooled effect size of all the included studies due to variations of effects from individual studies. The potential sources of heterogeneity were identified using sub-group, and sensitivity analysis and meta regression. Subgroup analyses were done by using study area (Country), Region, and type of population (medical students only, health science students, and general university students). Publication bias was assessed by using both observation of the symmetry in the funnel plots and Egger weighted regression tests (54, 55). A p-value of <0.05 in Egger's test was considered to have statistically significant publication bias.

Results

Identified studies

A total of 1978 articles were retrieved through database literature searching, including manual searching. Of these, 658 articles were excluded due to duplication, and 1277 unrelated articles were excluded by their title and abstract. The remaining 43 full-text articles were assessed for inclusion; of them, 8 full-text articles were excluded with reasons. Despite the fact that these 8 articles included a complete skeleton, the necessary information like the outcome of interest (the prevalence of poor sleep quality), and the sample size was missing. Finally, all 35 studies were included in the final meta-analysis (Figure 1).

Characteristics of included studies

A total of 35 published articles from 11 countries among 16,275 university students were included in this review. All the articles included in these studies were a cross-sectional study design and the sleep quality was assessed with the Pittsburgh Sleep Quality Index. Of the 35 studies included, six studies were conducted in Nigeria, 6 in Ethiopia, 5 in Egypt, 4 in Tunisia, 3 in Ghana, 3 in Sudan, 2 in

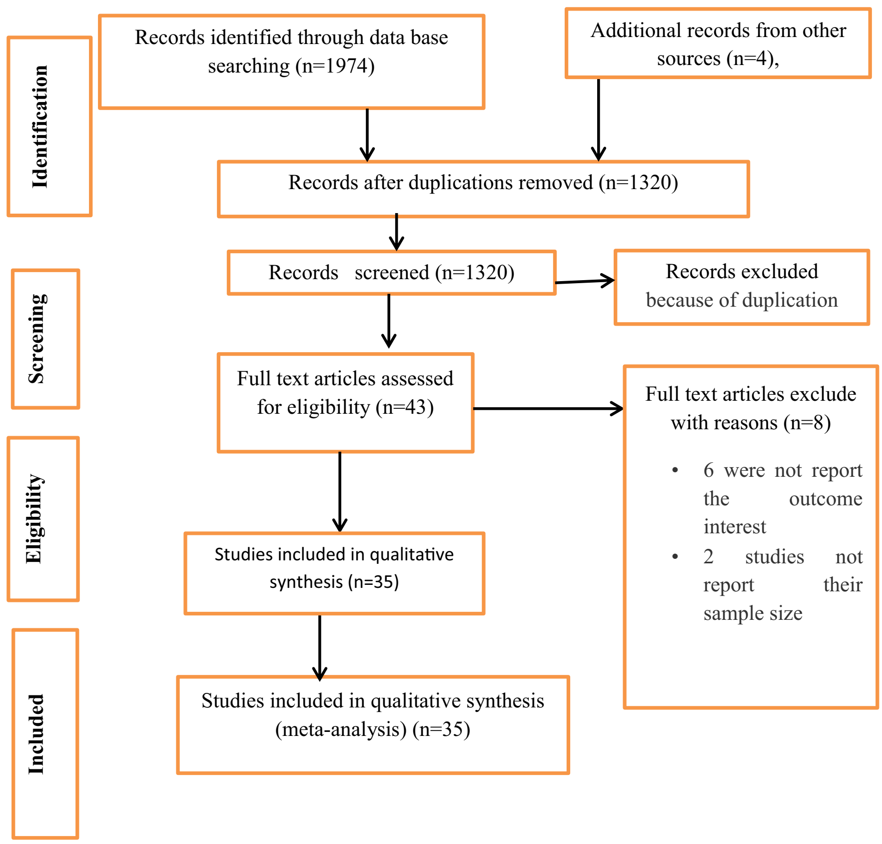

FIGURE 1
Flow charts to describe the selection of studies for the systematic review and meta-analysis on the prevalence of poor sleep quality among university students in Africa.

Kenya, 2 in Zambia, 2 in Morocco, 1 in Rwanda, and 1 in Libya. The study period of 25 articles were reported and conducted between March 2010 and March 2022 whereas ten studies did not report the study period. The included study was also published between March 2011 and June 2023. In terms of the study population that was involved, out of the total number of studies done, twenty-three were specifically undertaken among medical students, eight studies were conducted among general university students, and four studies were conducted among students studying health sciences (Table 1).

Prevalence of poor sleep quality

Thirty-five published articles were included in this systematic review and meta-analysis to estimate the pooled prevalence of poor sleep quality among university students. The minimum prevalence of the included study was 32.5% from Nigeria and the maximum was 82.5% from Sudan. The pooled prevalence of poor sleep quality was found to be 63.31% (95%CI: 56.91-65.71). The I^2 test result showed higher heterogeneity ($I^2 = 97.2$, P= 0.000) (Figure 2). Therefore, a random effect meta-analysis model was computed to estimate the pooled prevalence of poor sleep quality. To identify the possible sources of heterogeneity, different factors associated with the heterogeneity such as study areas that is countries and regions, and type of study population were investigated by using univariate meta-regression models.

Publication bias

A funnel plot and Egger's regression test were used to check the existence of potential publication bias. The result of the funnel plot triangle indicates a symmetric distribution indicating the absence of publication bias within the included studies (Figure 3). The Egger's regression weighted test for publication bias revealed also no statistically significant evidence (P = 0.099) (Table 2).

Subgroup analysis

To identify the possible source of heterogeneity, a subgroup analysis was performed based on the region, study area (country) where studies were conducted, and the type of study population of the included study. Accordingly, the combined prevalence of poor sleep quality in East, North, West, and South Africa were 61.31 (95% CI: 56.91-65.71), 62.23 (95% CI: 54.07-70.39), 54.43 (95% CI: 47.39-61.48), and 69.59 (95% CI: 50.39-88.80) respectively. Across countries relatively high prevalence of poor sleep quality were observed in Rwanda and Libya, Kenya, and Sudan, which results in 78.95 (95% CI: 75.14-82.75), 75.05 (95% CI: 65.155-84.946), 70.89 (95% CI: 57.60-84.17) respectively and the minimum was in Morocco (46.81 (95% CI: 24.37-69.25)). A sub-group analysis based on the study population also shows that the prevalence of poor sleep quality among health science students was 64.81 (95% CI: 52.36-77.25) whereas specifically among medical students was 60.33 (95% CI: 54.96-65.69) (Table 3).

Sensitivity analysis

The sensitivity analysis was conducted to examine the heterogeneity of those studies and determine the impact of each study's findings on the overall prevalence of poor sleep quality. The result showed that all values are within the estimated 95% CI, indicating that the omission of one study had no significant impact on the prevalence of this meta-analysis (Table 4).

Meta regression

In this study, meta-regression was done on continuous covariates including years of publication, type of study populations (general university students, general health science students, and medical students only), sample size, and countries. The results showed that only publication year (p = 0.021) was a source of heterogeneity for this study. However, the pooled prevalence of poor sleep quality was not associated with sample size (p = 0.772), countries (p = 0.24), and types of study populations (p = 0.896) (Table 5).

Associated factors of poor sleep quality among university students

From the included primary studies, there are different factors associated with poor sleep quality among university students, but we include those reported in more than one study. For instance, being stressed, having poor sleep hygiene, second year, using electronic devices at bedtime, and having comorbid chronic illness were factors reported and associated with poor sleep quality among university students more than once. The result of this meta-analysis indicated that being stressed is 2.4 times more likely to have poor sleep quality than not being stressed (AOR= 2.39; 95% CI: 1.63 to 3.51). The pooled odds ratio (AOR) demonstrated that the odds of poor sleep quality were 3.1 higher in participants who were in the second academic year (AOR= 3.10; 95% CI: 2.30 to 4.19) than students in other academic years. In addition, participants who use electronic devices at bedtime (AOR= 3.97 95% CI: 2.38 to 6.61) were nearly 4 times to have poor sleep quality than their counterparts. The current meta-analysis also shows that having a comorbid chronic illness was about 2.7 (AOR = 2.71; 95% CI: 1.08, 6.82) times more likely to have poor sleep quality than students who have not (Figure 4).

Discussion

Sleep is an important physiological process for humans. University students in African countries often report poor quality of Sleep due to changing social opportunities and increasing academic demands. However, the results of poor sleep quality among university students across nations and in between different studies vary. This systematic review and meta-analysis of 35 studies aimed to estimate the pooled prevalence and associated

TABLE 1 Characteristics of original articles included in this systematic review and meta-analysis on poor sleep quality among university students in Africa.

Authors	Country	Study year	Publication Years	Study population	Sample size	Poor sleep quality in %
Hauwanga (56)	Kenya	Not reported	2020	General health science students	378	80
Nyamute et al. (57)	Kenya	2019	2021	Medicine	336	69.9
Lemma et al. (17)	Ethiopia	NR	2012	General university students	2551	55.8
Seyoum et al. (58)	Ethiopia	2021	2022	Medicine	224	57.6
Zeru et al., 2020 (59)	Ethiopia	2017	2020	General health science students	404	54.2
Negussie et al., 2021 (60)	Ethiopia	2019	2021	General health science students	365	60.8
Thomas and Sisay, 2019 (61)	Ethiopia	2017	2019	Medicine	372	37.2
Wondie et al., 2021 (47)	Ethiopia	2019	2021	Medicine	576	62
Akowuah et al., 2021 (62)	Ghana	2020	2021	General university students	362	62.43
Lawson et al., 2019 (63)	Ghana	2014-2015	2019	Medicine	153	56.2
Yeboah et al., 2022 (64)	Ghana	2018-2019	2022	General university students	340	54.1
James et al., 2011 (65)	Nigeria	2010	2011	Medicine	255	32.5
Seun-Fadipe and Mosaku, 2017 (66)	Nigeria	NR	2017	General university students	505	50.1
Ogunsemi et al., 2018 (67)	Nigeria		2018	General health science students	186	64
Ahmadu et al., 2022 (68)	Nigeria	2019	2022	Medicine	181	53
Awopeju et al., 2020 (69)	Nigeria	NR	2020	General university students	400	68
Seun-Fadipe and Mosaku, 2017 (70)	Nigeria	NR	2017	General university students	317	49.5
Zafar et al., 2020 (71)	Sudan		2020	Medicine	199	82.5
Mirghani et al., 2015 (72)	Sudan		2020	Medicine	140	67.9
Abdelghyoum Mahgoub and Mustafa, 2022 (73)	Sudan	2021	2022	Medicine	273	62
Mohamed and Moustafa, 2021 (74)	Egypt	2018-2019	2021	Medicine	150	58.7
Elwasify et al., 2016 (75)	Egypt	2015	2016	Medicine	1182	53.3
Dongolet al., 2022 (76)	Egypt	2020	2022	General university students	2474	79.3
Elsheikh et al., 2023 (77)	Egypt	2021-2022	2023	Medicine	1184	63.1
Ahmed Salama, 2017 (78)	Egypt	2016-2017	2017	Medicine	505	58.5
Gassara et al., 2016 (79)	Tunisia	NR	2016	Medicine	74	63.5
Maalej et al., 2018 (80)	Tunisia	2015-2016	2018	Medicine	184	80.4
Amamou et al., 2022 (81)	Tunisia	2017-2018	2022	Medicine	202	47
Saguem et al., 2022 (82)	Tunisia	2020	2022	Medicine	251	72.5
Mvula et al., 2021 (83)	Zambia		2021	General university students	212	79.2

(Continued)

TABLE 1 Continued

Authors	Country	Study year	Publication Years	Study population	Sample size	Poor sleep quality in %
Mwape and Mulenga, 2019 (84)	Zambia	2018	2019	Medicine	157	59.6
Hangouche et al., 2018 (85)	Morocco	2017	2018	Medicine	457	58.2
Jniene et al., 2019 (86)	Morocco	2018	2019	Medicine	286	35.3
Nsengimana et al., 2023 (87)	Rwanda	2021	2023	Medicine	290	80
El Sahly et al., 2020 (88)	Libya	2019	2020	Medicine	150	76.67

factors of poor sleep quality among university students in 11 African countries.

In this meta-analysis and systematic review, the pooled prevalence of poor sleep quality was found to be 63.31% with a 95% CI (56.91-65.71). This result is in line with findings from other studies. According to a systematic review and meta-analysis, which was done to determine the global prevalence rate of poor sleep quality among university students, the result was 57% (89). The current finding is also comparable with a systematic review and a meta-analysis study conducted among Korean University Students yielded 59.2% (90). A global systematic and meta-analysis study of the general population found that 57.3% of respondents had poor sleep quality, which was consistent with the findings of the current study (91).The results of a systematic review of twelve studies among Indian university students range from 25 to 72%, which is consistent with the findings of the current meta-analysis on poor sleep quality among students in Africa (92).

On the contrary, the current finding was significantly higher than with a different systematic review and meta-analysis study that was carried out at a different period. For instance, in a global systematic review and meta-analysis study conducted on sleep disruption in medicine students and its relationship with impaired academic performance, 39.8% of them reported having poor sleep quality (93). The prevalence of poor sleep quality was 51.45% in the global systematic review and meta-analysis study on the prevalence of sleep problems among 59427 medical students from 109 Studies

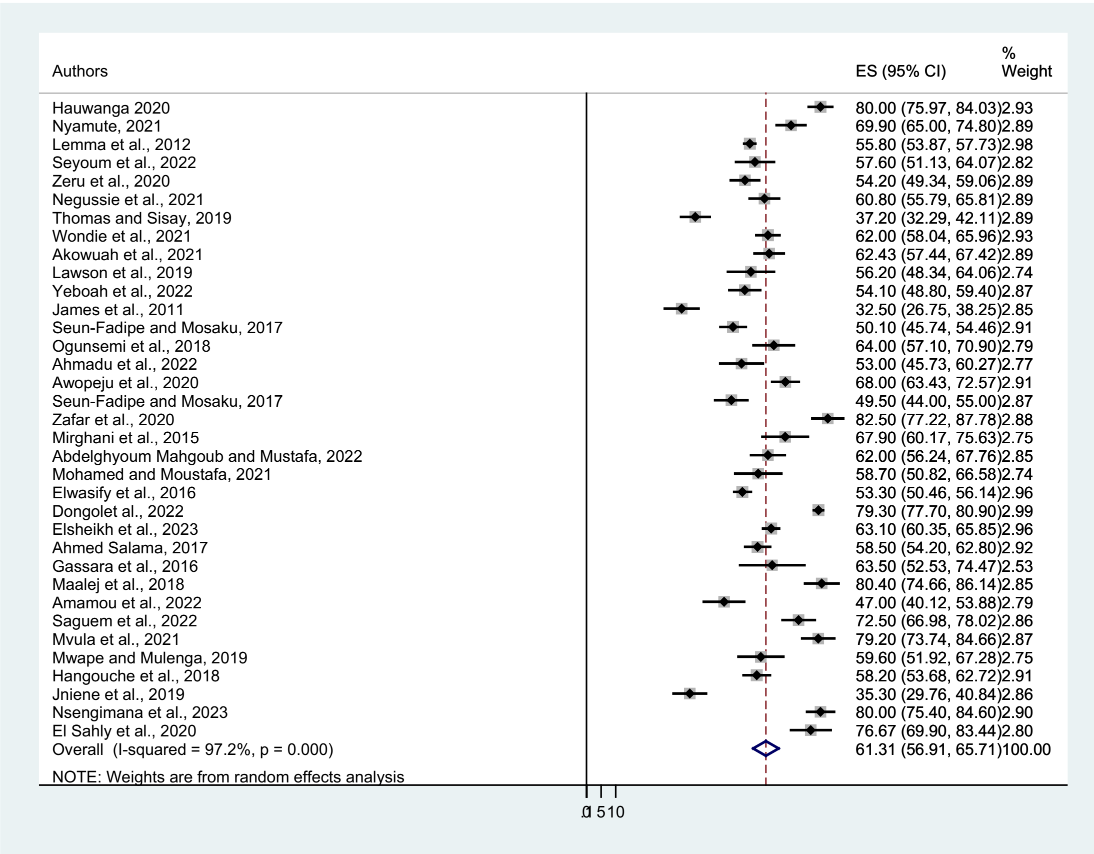

FIGURE 2
Forest plot showing the pooled prevalence of poor sleep quality among university students in Africa.

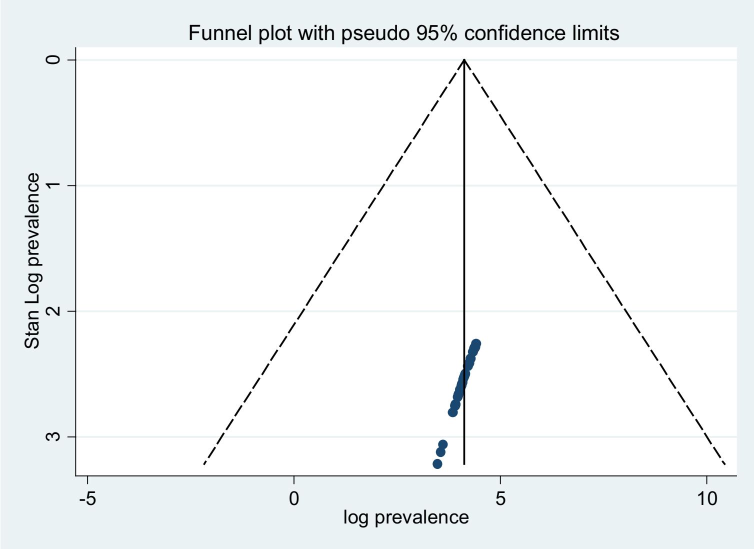

FIGURE 3
A funnel plot test of poor sleep quality among university students.

(19). However, the sub-group analysis in the current meta-analysis studies showed that the prevalence of poor sleep quality, specifically among African medical students was 60.33 (95% CI: 54.96-65.69). In a comprehensive meta-analysis of observational studies among 24,884 medical students across 50 studies, the prevalence of poor sleep quality was 52.7% (94). The current finding is also higher than the results of previous meta-analyses that were carried out in 28 different countries, with results of 9.6% (95), 55.6% in a global meta-analysis (19), 53% in the Ethiopian population (96), 51.0% in Brazil (97), 24.1% in China (98), and 43.4% in US college students (99). A review of the causes of poor sleep quality in African young dults indicates that poor sleep quality is higher in Africa than other continents (45). When young African people do manage to get into committed partnerships, they often wind up spending a large portion of their evenings on social media (100). Some of them may indulge in drug and alcohol abuse with several partners, frequent clubs, or spend a significant portion of their sleep hours in sexual activities (100, 101). Because of this, most young adults may suffer from sleep deprivation and excessive daytime sleepiness as their bodies attempt to harmonize their naturally delayed schedule with their daily social schedules and activities at school (102). The other possible reason could be the impact that an individual's race or ethnicity has on the quality of their sleep. It follows that mental health concerns and sleep disturbances are related health problems. According to two studies, black people are more likely to have sleep problems, which raises the likelihood of poor sleep quality in Africa (45, 103, 104).

Poor sleep quality among university students is also higher in Africa than in other studies because of the different genes involved in sleep activity (105–107), and the immune system (108–110) that Africans have. The other explanation could be because health care providers, insurance companies, governments, and the general population in Africa have little knowledge about sleep disorders and the grave repercussions they can have. One of the main problems in many African countries is the state of the health and insurance systems. The low socioeconomic level is frequently accompanied by a lack of sleep labs, clinics, and diagnostic equipment as well as a high cost of medications (111, 112).

However, the current finding is lower than a multinational cross-sectional study involving medical students during the COVID-19 pandemic, which found that 73.5% of students had poor sleep quality (20). The COVID-19 pandemic has led to increased stress, anxiety, and psychological distress among students, potentially affecting their sleep quality. The restrictions and fear of infection also led to a negative mood, which can negatively impact sleep quality. The virus primarily targets the respiratory system, and sudden outbreaks, rising death counts, and social disruptions have contributed to a decline in sleep quality. The pandemic indirectly affects college students' moods and sleep quality (113–117).

Regarding factors affecting poor sleep quality among university students, three of the included studies in this meta-analysis study disclosed that students who have been stressed were more likely to have poor sleep quality as compared with non-stressed. The pooled

TABLE 2 Egger's test of poor sleep quality among university students in Africa.

Std_Eff	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
slope	71.18823	4.769428	14.93	0.000	61.48476	80.8917
bias	-3.764017	2.220055	-1.7	0.099	-8.280753	0.752719

10.3389/fpsyt.2024.1370757

TABLE 3 Subgroup analysis of poor sleep quality among university students in Africa.

Characteristics	Studies	Sample	Prevalence in % (95% CI)	I^2 (%)	p-value	Egger test
Prevalence of poor sleep quality	35	16,275	61.31 (56.91-65.71)	97.2	0.000	0.099
Region						
East Africa	12	6,108	64.15 (58.99-71.31)	89.8	0.000	
North Africa	12	7099	62.23 (54.07-70.39)	98.0	0.000	
West Africa	9	2699	54.43 (47.39-61.48)	93.0	0.000	
South Africa	2	369	69.59 (50.39-88.80)	94.0	0.000	
Country						
Nigeria	6	1,844	52.84 (42.61-63.08)	95.2	0.000	
Ethiopia	6	4,492	62.0 (58.036-65.964)	92.7	0.000	
Egypt	5	5495	65.675 (50.676-74.673)	98.8	0.000	
Tunisia	4	711	65.991 (51.169-80.813)	94.7	0.000	
Ghana	3	855	57.786 (52.22-63.35)	62.3	0.070	
Sudan	3	612	70.89 (57.60-84.17)	92.8	0.000	
Kenya	2	714	75.05 (65.155-84.946)	89.7	0.002	
Morocco	2	743	46.81 (24.37-69.25)	97.5	0.000	
Zambia	2	369	69.60 (50.39-88.80)	94.0	0.000	
Rwanda and Libya	2	440	78.95 (75.14-82.75)	0.425	0.0	
Study population						
General University students	8	7161	62.34 (52.42-72.25)	98.6	0.000	
General Health science students	4	1333	64.81 (52.36-77.25)	95.9	0.000	
Medical students only	23	7781	60.33 (54.96-65.69)	96.0	0.000	

result of this meta-analysis indicated that stressed students were about 1.4 times more likely to have poor sleep quality as compared to their counterparts. University students' various activities and stressors, including studying during the night, can lead to poor sleep quality due to psychological distress (118). Compared to other students, especially medical students, they experience stress more frequently. Medical students face a stressful environment due to academic requirements and workload. They often reduce sleep to cope with the demands, leading to poor mental and physical health. Factors such as on-call duties, disease contact, and examinations contribute to this stress. Consequently, they may not prioritize sleep, leading to poor sleeping quality (34, 119). Stress plays a big role in how well people sleep, and many stresses from daily lifeare associated with poor sleep. For example, a longitudinal study of people with good sleep quality at baseline found that the most significant predictors of disrupted sleep at follow-up were daytime stress level and nighttime worries (120). Similar to this, as measured by polysomnography, healthy volunteers who experienced higher levels of stress at work had substantially more fragmented sleep and lower sleep efficiency (121). Chronic activation of stress responses, such as the sympathetic-adrenal-medullary axis and hypothalamic-pituitary-adrenal axis, can produce epinephrine and cortisol, known as stress hormones. This stress hormone has a negative effect on students sleep quality and their academic performances (118, 122). Uncontrollable worries about stress events trigger emotional arousal, leading to cognitive biases and distorted evaluations, resulting in subjective sleep quality decline (123–126).

In this meta-analysis, the year of study is also one of the factors contributing to poor sleep quality among university students. The year 2 students were more than 3 times to have poor sleep quality compared with students in other academic years. Several other investigations also discovered that the distribution of sleep quality varied across the years of study. A study in Saudi Arabian and Brazilian students showed that the odds of having poor sleep were significantly higher among second and fourth-year students (127, 128). However, according to a study in Greece, sixth-year medical students were more odds to have poor sleep quality than other students (129). A study conducted at a Chinese university revealed that fifth-year students were more negatively impacted by sleep deprivation (130), while other studies found no differences in the general quality of sleep by academic years (131). This variety may be the result of variations in the curriculum used in different countries and universities, as well as differences in social and academic demands (58, 132).

University students who use electronic devices at bedtime had approximately four times higher rates of poor sleep quality than their counterparts. This study is supported by a global meta-analysis study in which using electronic devices like smartphones was associated

TABLE 4 Sensitivity analysis of poor sleep quality among university students in Africa.

Study omitted	Estimate 95% CI	Heterogeneity	
		I^2 (%)	P value
Hauwanga 2020 (56)	60.75 (56.32-65.18)	97.1	0.000
Nyamute, 2021 (57)	61.05 (56.54-65.56)	97.3	0.000
Lemma et al., 2012 (35)	61.48 (56.84-66.12)	97.1	0.000
Seyoum et al., 2022 (58)	61.42 (56.93-65.91)	97.3	0.000
Zeru et al., 2020 (59)	61.52 (57.03-66.02)	97.02	0.000
Negussie et al., 2021 (60)	61.33 (56.81-65.84)	97.3	0.000
Thomas and Sisay, 2019 (61)	62.03 (57.73-66.33)	97.0	0.000
Wondie et al., 2021 (47)	61.29 (56.74-65.4)	97.3	0.000
Akowuah et al., 2021 (62)	61.28 (56.76-65.80)	97.3	0.000
Lawson et al., 2019 (63)	61.45 (56.98-65.93)	97.3	0.000
Yeboah et al., 2022 (64)	61.52 (57.04-66.01)	97.2	0.000
James et al., 2011 (65)	62.16 (57.87-66.45)	97.0	0.000
Seun-Fadipe and Mosaku, 2017 (66)	61.65 (57,19-66.11)	97.2	0.000
Ogunsemi et al., 2018 (67)	61.23 (56.74-65.73)	97.3	0.000
Ahmadu et al., 2022 (68)	61.55 (57.07-66.02)	97.3	0.000
Awopeju et al., 2020 (69)	61.11 (56.59-65.63)	97.3	0.000
Seun-Fadipe and Mosaku, 2017 (70)	61.66 (57.20-66.12)	97.2	.0.000
Zafar et al., 2020 (71)	60.68 (56.26-65.11)	97.2	0.000
Mirghani et al., 2015 (72)	61.12 (56.64-65.61)	97.3	0.000
Abdelghyoum Mahgoub and Mustafa, 2022 (73)	61.29 (56.78-65.80)	97.3	0.000
Mohamed and Moustafa, 2021 (74)	61.38 (56.90-65.87)	97.3	0.000
Elwasify et al., 2016 (75)	61.55 (57.04-66.07)	97.1	0.000
Dongol et al., 2022 (76)	60.76 (56.82-64.69)	95.7	0.000
Elsheikh et al., 2023 (77)	61.25 (56.62-65.89)	97.3	0.000
Ahmed Salama, 2017 (78)	61.39 (56.87-65.92)	97.3	0.000
Gassara et al., 2016 (79)	61.25 (56.78-65.72)	97.3	0.000
Maalej et al., 2018 (80)	60.75 (56.30-65.200	97.2	0.000
Amamou et al., 2022 (81)	61.72 (57.27-66.17)	97.2	0.000
Saguem et al., 2022 (82)	60.98 (56.49-65.47)	97.3	0.000
Mvula et al., 2021 (83)	60.78 956.33-65.24)	97.2	0.000
Mwape and Mulenga, 2019 (84)	61.36 (56.87-65.84)	97.3	0.000
Hangouche et al., 201 (85)	61.40 (56.88-65.92)	97.3	0.000
Jniene et al., 2019 (86)	62.08 (57.77-66.39)	97.0	0.000
Nsengimana et al., 2023 (87)	60.75 (56.31-65.19)	97.2	0.000
El Sahly et al., 2020 (88)	60.87 (56.40-65.34)	97.2	0.000

with poor sleep quality (133). Excessive use of electronic devices is significantly associated with poor sleep quality, according to two further global meta-analyses, one of which was conducted on medical students and the other on adolescents (89, 134). The quality of sleep is greatly impacted by using electronic devices before and during bedtime, including computers, music players, televisions, social networking sites, and cell phones. Intimate relationship-seeking young adults in Africa often find themselves interacting with their partners on mobile social media platforms like Facebook, Instagram, Snapchat, WhatsApp, and TikTok late at night, before going to bed early the next day (135, 136). Regular use of such material thus increases the likelihood of prolonged sleep onset, short duration, and extended start latency (136–138). There

TABLE 5 Meta regression of poor sleep quality among university students in Africa.

Variable	Coefficient	P-Value
Publication year	1.65	0.021
Sample size	0.016	0.772
Country	1.045	0.24
Types of study population	0.50	0.896

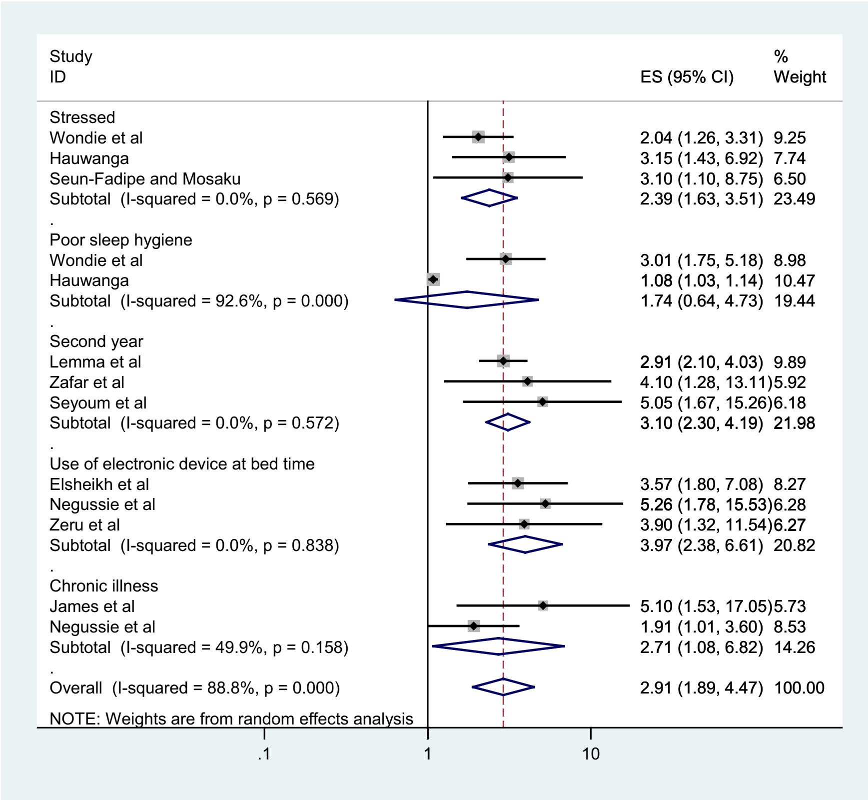

FIGURE 4
The forest plot shows associated factors of poor sleep quality among university students in Africa.

are physiological changes in students' circadian rhythm and homeostatic sleep patterns. Because of this, the majority of young adults may experience sleep deprivation and excessive fatigue during the day as their bodies try to adjust to their naturally delayed schedule in order to fit in with their everyday social routines and academic obligations (102, 139). Researchers have hypothesized that using mobile devices also affects the quality of one's sleep through a variety of mechanisms, including electromagnetic fields emitted by the device, which change melatonin rhythms, cerebral blood flow, and other related brain activities recorded in waking electroencephalograms (136, 140–142).

In this systematic review and meta-analysis study, a substantial association between having comorbid medical illness and poor sleep quality was also found. The prevalence of poor sleep quality among students was 2.7 times more common among students who had comorbid medical illnesses than those who did not. This was supported by a worldwide investigation involving seven nations as well as a US study on multi-campus students (20, 99). Poor sleep quality can also be brought on by the stress of a chronic condition. Heartburn, which is brought on by stomach acid backing up into the esophagus, is frequently linked to trouble sleeping. Uncontrolled diabetes can also contribute to trouble sleeping through night sweats, and frequent urination. Students with heart failure may experience dyspnea when they wake up in the middle of the night. People with arthritis pain may find it difficult to go off to sleep. Furthermore, a variety of over-the-counter and prescription drugs used to address these and other health issues might lower the quality of sleep (143–145).

Strengths and limitations of the study

The study's strength lies in its pooled effect of multiple studies (35 articles) and large sample size of 16,275 university students. Additionally, we included articles from all regions of Africa (North, South, East, and West) to help generalize the findings throughout the continent. The study's limitations include the fact that the age range was not adequately defined in the primary studies included in the review and meta-analysis and that only English-language publications were taken into consideration because of language bias. This review revealed significant between-study heterogeneity. Other than the ones currently listed, there may be more factors contributing to heterogeneity.

Conclusion and recommendations

According to this study, there is a high pooled prevalence of poor sleep quality among university students in Africa. Being stressed, using electronic devices in bed, being a second year, and having concomitant medical conditions were all associated with poor sleep quality. Thus, early detection and adequate intervention are important for improving sleep quality among university students. The establishment of academic counseling centers with an emphasis on improving sleep quality, bolstering students' study skills, and helping them cope with their stressful surroundings is advised for the management of the sleep quality of university students. University students can also benefit from improved physical health and reduced stress levels to get better sleep. Students are also recommended to limit their use of electronic devices, such as smartphones, right before bed.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

GN: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. GMT: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. GR: Methodology, Writing – original draft, Writing – review & editing. FA: Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. TT: Methodology, Writing – original draft. MAK: Data curation, Investigation, Writing – original draft. GT: Formal analysis, Writing – original draft, Writing – review & editing. SF: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. YW: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. TS: Formal analysis, Methodology, Writing – original draft. GK: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. MM: Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1370757/full#supplementary-material

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The effect of weighted blankets on sleep and related disorders: a brief review

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Background: Sleep disorders such as insomnia can lead to a range of health problems. The high risk of side effects and drug abuse of traditional pharmacotherapy calls for a safer non-pharmacotherapy.

Aims: To examine the use and efficacy of weighted blankets in improving sleep and related disorders in different populations and explore the possible mechanisms.

Methods: A literature search was conducted using PubMed, Embase, Web of Science, MEDLINE, Cochrane Library and CNKI databases. Eligible studies included an intervention with weighted blankets and outcomes covering sleep and/or related disorders (behavioral disturbance, negative emotions and daytime symptoms). Studies using other deep pressure, compression, or exercise-related interventions were excluded.

Conclusions: Most of the included studies showed that weighted blankets could effectively improve sleep quality and alleviate negative emotions and daytime symptoms in patients with sleep disorders, attention deficit hyperactivity disorder, autism spectrum disorder, and other related disorders, with a possible mechanism of deep pressure touch.

Recommendations: Weighted blankets might be a promising tool for sleep interventions among individuals with sleep disorders in clinical settings. More high-quality and large-scale randomized controlled trials are needed to further validate the safety and efficacy of weighted blankets and explore precise mechanisms.

KEYWORDS

weighted blanket, sleep disorder, insomnia, deep pressure, occupational therapy, psychiatric disorder

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1 Introduction

Quality sleep is essential for psychological, cardiovascular, metabolic, and other aspects of health (1). However, during the COVID-19 pandemic, with about 40% of people reporting sleep problems, sleep-related problems have become more severe and were particularly prominent in some populations, including children and adolescents (2, 3). Sleep disorders, such as insomnia, are common risk factors for many psychiatric disorders and may also be a symptom of mental health disorders (4, 5). In any case, effective interventions for insomnia should be provided to prevent the development of sleep disorders and alleviate other mental health problems (6, 7). Common treatments for insomnia are mainly pharmacotherapy and cognitive behavioral therapy (non-pharmacotherapy), with the latter being preferred for its safety and durability (8, 9). However, about 40% of patients with persistent insomnia do not respond to cognitive behavioral therapy combined medication treatment (10). In addition, pharmacotherapy for insomnia often leads to a high risk of side effects and drug abuse. In adverse drug reaction studies, the highest reporting odds ratios of somnolence are 7.1 and 13.3 for patients prescribed antidepressants (11) and antipsychotics (12), respectively. For patients prescribed higher dose Z-drugs, the hazard ratios of fractures, hip fractures, ischaemic stroke, and falls ranged from 1.33 to 1.96 (13). Thus, a safer non-pharmacotherapy needs to be explored.

Weighted blanket, an emerging non-pharmacotherapy, has gradually entered people's vision. A weighted blanket is usually made of special weight-adding materials such as beads and chains, allowing it to cover the body evenly and create a pleasant hugging sensation. As a non-invasive intervention assistive device, a weighted blanket was initially suggested as a prescription or treatment option by occupational therapists for patients with sleep problems (14). To date, weighted blankets have been increasingly used in sleep interventions for different populations, such as patients with insomnia, attention deficit hyperactivity disorder (ADHD), and autism spectrum disorder (ASD), and have shown positive effects on relieving insomnia, anxiety, and fatigue (15, 16). Only one previous review has evaluated the effect of weighted blankets on decreasing anxiety and insomnia using 8 studies conducted before March 1, 2018 (17). However, the use of weighted blankets for wider targets has surged in recent years, calling for an updated and comprehensive review of the effect of weighted blankets in different populations and the in-depth mechanisms.

Therefore, this narrative review summarized the use and efficacy of weighted blankets in sleep and other related disorders (e.g., behavioral disturbance, negative emotions and daytime symptoms) in different populations and discussed the relevant mechanisms to provide a reference for a comprehensive overview of the research status of weighted blankets and make recommendations for an alternative therapy to medications of sleep and sleep-related disorders in clinical settings.

2 Materials and methods

We searched in PubMed, Embase, Web of Science, MEDLINE, Cochrane Library and CNKI using optimized search strategies up to March 10, 2023. We determine the search terms using appropriate controlled vocabulary terms. The final search terms consisted of "weighted blankets", "gravity blankets", "ball blankets", "sleep", and "sleep quality". Studies were limited to those published in English.

A study was included if it met the following criteria: (1) it included an intervention with weighted blankets; (2) it reported parameters that assessed the sleep quality (e.g., sleep latency, sleep duration, sleep efficiency, and number of wakings) and/or related disorders (e.g., behavioral disturbance, negative emotions and daytime symptoms). A study was excluded if it used other deep pressure, compression, or exercise-related interventions. Furthermore, letters, study protocols, guidelines, dissertations, and thesis were excluded.

We read the titles and abstracts to identify all relevant studies using the inclusion and exclusion criteria above. Then, two reviewers worked independently to assess each included study and resolved any discrepancies through discussion (see flow chart in Supplementary Figure 1).

3 Results

3.1 Application of weighted blankets in improving sleep

Sleep disturbance, a symptom or harbinger of psychiatric problems, can be comorbid with psychiatric disorders and increases the risk of psychiatric relapse (18). To improve sleep quality and reduce the negative impact of sleep disturbance on psychiatric disorders, occupational therapists have attempted to use a weighted blanket as a safer physical therapy (19). A randomized controlled trial in Sweden has provided primary evidence for weighted blankets' efficacy in relieving insomnia and daytime fatigue in patients with psychiatric disorders (16). Besides, another randomized controlled study showed that after using weight blankets, insomniacs had improved sleep quality, shorter nighttime awakenings, reduced self-reported stress, and enhanced relaxation (20). For older people living in nursing homes, weighted blankets also have positive effect on improving sleep especially concerning waking up during the night (21). Furthermore, weighted blankets have also been used to treat sleep disorders in children with ADHD, ASD, and CHARGE syndrome (22–24). Interestingly, a review on non-traditional clinical treatments for improving sleep in children and young people suggested that although the weighted blankets intervention did not result in significant differences in sleep indicators, there was positive feedback on self-reports from subjects and caregivers (23). This finding revealed a difference in the efficacy between subjective and objective sleep measurements. Non-significant effects on subjective sleepiness and total sleep duration were observed in an

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in-laboratory crossover study. However, the significant increase of salivary melatonin in this study provided new evidence for the sleep-promoting mechanisms of weighted blankets (25).

3.2 Application of weighted blankets in ADHD and ASD

Several studies have used weighted blankets as an intervention for patients with neurodevelopmental disorders, including ADHD and ASD. Most of them indicated a beneficial impact of weighted blankets on the improvements in sleep quality (e.g., sleep onset latency) and ADHD/ASD-related symptoms (e.g., concentration and daily function) in patients with AHDH or ASD (Table 1).

Specifically, a case-control study found that after using a weighted ball blanket for 14 days, children aged 8-13 years with ADHD had improvements in sleep onset latency, awakening times, concentration, and physical activities (26). Another Danish study also provided evidence for the positive effects on sleep onset latency, daily functioning levels, and quality of life in children with ADHD in the same age range after using weighted ball blankets for 8 weeks (30). Similarly, A qualitative study based on parents' experiences of the impact of weighted blankets on children with ADHD and sleep disorders indicated that after 16 weeks of weighted blankets intervention, children could better master everyday life, and achieve satisfactory sleep and overall well-being (31). Another qualitative study based on children's experiences revealed that the use of weighted blankets improved the emotional regulation, everyday participation and sleep quality of children with ADHD and sleeping difficulties (33). Moreover, in Idaho, USA, a single-subject design study (28) and two continuation studies (15, 29) in children with ASD and sleep disorders indicated that weighted blankets were beneficial for the improvement of overall sleep quality, especially the sleep onset latency, awakening times, sleep duration, and morning mood, although the effects were not sufficient to recommend for clinical use. However, a randomized,

TABLE 1 Application of weighted blankets in attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD).

Country	Sample characteristics	Study design (intervention duration)	Primary outcomes	Effect
Danish (26)	21 children aged 8–13 years with ADHD vs 21 healthy control subjects	Case-control study (14 days)	Reduced sleep onset latency*; Activity level (ns); Attention (ns); Behavioural disturbance symptoms (ns)	Positive
England (27)	67 children aged 5–16 years with ASD and severe sleep problems	Randomized, placebo-controlled crossover design (4 weeks)	Better subjective feeling*; Total sleep time (ns); Sleep-onset latency (ns); Sleep efficiency (ns)	Uncertain
USA (28)	Two children with ASD and sensory over responsivity	Single case, multiple baseline design (14 days)	Improvements in time to fall asleep, number of wakings, hours of sleep, and morning mood	Positive
USA (29)	Two children with ASD and sensory over responsivity	Intervention study (14 days)	Improvements in hours of sleep, morning mood, and waking times in the intervention phase; Reduced hours of sleep, a more agitated mood, and increased waking times in the withdrawal phase	Positive
Sweden (22)	85 individuals with ADHD and/or ASD	Retrospective follow-up study	Improved abilities related to falling asleep, sleeping the whole night, relaxing during the day; Improved morning/evening daily routine	Positive
Danish (30)	36 children aged 8–13 years with ADHD	Intervention study (8 weeks)	Improved sleep onset latency*; Reduced score on core symptoms of ADHD*; Increased daily level of functioning and the quality of life*	Positive
Switzerland (31)	24 parents of children with ADHD and sleep problems	Qualitative study (16 weeks)	Improvements in achieving satisfactory sleep; achieving overall well-being; mastering everyday life	Positive
Sweden (32)	1785 adult individuals with a psychiatric diagnosis	Population-based register study (12 months)	The proportion of patients without a prescription of sleep medication increased by 3.3%*; Melatonin prescription increased by 3.6%*; ADHD was associated with decreased use of sleep medication*	Positive
USA (15)	Two 4-year-old children with ASD	Single-subject design study (14 days)	Enhanced morning mood; Decreased time to fall asleep	Positive
Sweden (33)	26 children aged 6-15 years with ADHD and sleeping difficulties	Qualitative study (16 weeks)	Improvements in emotional regulation, sleep routines, sleep quality, and everyday participation	Positive

*$P < 0.05$.
ADHD, Attention Deficit Hyperactivity Disorder; ASD, Autism Spectrum Disorder; ns, non-significant.

placebo-controlled crossover design trial observed that the use of weighted blankets did not help children aged 5-16 years with ASD and severe sleep problems obtain longer sleep duration, faster sleep onset, or fewer awakenings (27).

In addition to children, a randomized controlled study in Stockholm, Sweden, found that in adult patients with ADHD, a weighted chain blanket was also a safe and effective intervention for insomnia, which could improve adult patients' daytime symptoms and activity levels (16). Interestingly, a population-based registry study indirectly demonstrated the positive effect of weighted blankets intervention on reducing the use of common sleep medication among ADHD patients (32). Moreover, another registry study found that patients with ADHD retained the weighted blankets longer than others, indicating a possible benefit from using weighted blankets (34). Likewise, a retrospective follow-up study in 2021 found that after interventions of a weighted chain or ball blanket, both adults and children with ADHD or ASD showed improvements in sleep, daytime relaxation, and morning/evening routine (children significantly benefited more in falling asleep than adults.) (22).

3.3 Application of weighted blankets in improving negative emotions

There are 17 studies (including one systematic review) related to weighted blankets intervention and psychological behaviors (e.g., anxiety, depression, and stress). Two single-subject design studies found that patients with nighttime weighted blanket intervention had a better morning mood, which could be agitated and unstable when the intervention was discontinued (15, 29). A retrospective follow-up study showed that weighted blankets benefited daytime relaxation in patients with ADHD/ASD (22). Furthermore, a randomized controlled study showed a positive effect of weighted chain blankets on depression and anxiety symptoms (16). However, two similar conference abstracts argued that weighted blankets could not reduce stress in patients with pain (35, 36), while another conference abstract indicated that weighted blanket could reduce self-reported stress and increase relaxation in patients with sleep disorders (20).

A few studies have focused on the effect on alleviating anxiety. A systematic review suggested that weighted blankets might be an appropriate therapeutic tool for reducing anxiety (17). Additionally, a controlled clinical trial in the United States based on a repeated crossover design found that compared to standard care, the use of weighted blankets for 30 minutes resulted in significantly lower anxiety levels (based on the visual analog scale for anxiety) in cancer patients undergoing outpatient chemotherapy infusion (37). Significant alleviation in anxiety (measured by pulse and a shortened form of the Spielberger State-Trait Anxiety Inventory [STAI: Y-6]) was also found among adult patients in mental health institutions after using weighted blankets (38). Moreover, a pilot study at a liberal arts university in the Midwest suggested that a weighted blanket may improve sleep quality and reduce anxiety among college students (39). Similar results were also found in patients with ADHD/ASD. Two qualitative studies on nursing home staff (40) and children with ADHD and sleep problems (31) also provided positive evidence that weighted blankets helped relax and reduced anxiety.

3.4 Application of weighted blankets in special populations

3.4.1 In patients with chronic pain

A total of three studies were conducted on patients with chronic pain. A randomized controlled trial showed that heavier-weighted blankets produced a greater alleviation in widespread chronic pain than the lighter-weighted blankets, and the effects were stronger in individuals with high trait anxiety (41). However, two of the Danish conference abstracts (36, 42) indicated that no difference of HbA1C, a reflection of stress, was found between patients with chronic pain in the weighted ball blanket group and the control blanket group.

3.4.2 In patients with dementia

Four studies have explored the effect of weighted blankets on patients with dementia. One intervention trial in female patients with late-stage of dementia found a significant reduction in the duration of sustained vocalizations after 10 min of weighted blanket intervention, suggesting that it was a promising non-pharmacological treatment for patients with dementia (43). Likewise, a prospective, within subjects, pre-post design study with a 4-week intervention indicated that weighted blankets were of high feasibility and acceptability for families living with dementia (44). Another case report in Japan demonstrated the effects of weighted blankets on alleviating sleep disorders in patients with Alzheimer's and easing the caregiver's burden (45). In addition, the longer use time of weighted blankets in patients with dementia provided indirect evidence that weighted blankets may be beneficial (34).

3.4.3 In patients with psychiatric disorders

Three studies were conducted on patients with different psychiatric disorders. A randomized controlled trial in Sweden showed that weighted blankets could improve insomnia, daytime symptoms, and activity levels in various psychiatric disorders (16). Another clinical trial concluded that weighted blankets could help patients in psychiatric hospitals better manage anxiety (38). A registry study also observed a statistically significant association between weighted blankets intervention and decreased use of common sleep medication in patients with psychiatric disorders (32).

3.4.4 Others

Several studies focused on the impact of weighted blankets on other special populations. One exploratory study showed that parents of children with CHARGE syndrome found weighted blankets slightly effective in improving children's sleep problems (24). The positive effects of weighted blankets were also found in children under general anesthesia, indicating that weighted blankets can be safely used for hospitalized children (46). Another crossover randomized controlled trial in 16 infants with neonatal withdrawal syndrome (NAS) found no adverse events during 67 30-minute sessions with weighted blanket, confirming the safety, feasibility, and efficacy of weighted blanket in reducing NAS symptoms (47). Only one study proved that using weighted blankets for 30 minutes could reduce anxiety better than standard care among cancer patients (37).

3.5 Comparison of weighted blankets and drug therapy

Although sleep drugs have been widely used in clinical practice, the side effects of drugs (e.g., drug resistance and drug tolerance) could rebound after drug withdrawal, making it not a good option. Also, the adverse outcomes caused by drug abuse were still great troubles for patients with sleep disorders (48, 49). For these reasons, sleep drugs are not recommended for treating chronic sleep disorders and anxiety disorders, or people over 65 years old (50). Weighted blankets were considered one of the non-pharmacological approaches to alleviate sleep disorders in patients with ASD without adverse effects (51). Several studies directly compared weighted blankets with drug therapy from the rate of prescription (32), perceived efficacy (24), and economic cost (34), respectively. First, a population-based register study of 1785 adult individuals with a psychiatric diagnosis directly compared the subscription of common sleep drugs (benzodiazepine receptor agonists, antihistamines, melatonin, and mirtazapine) before and after receiving a weighted blanket prescription, and found a significant association between weighted blanket use and the reduced use of common sleep drugs except melatonin that increased slightly (32). Second, however, in a cross-sectional study of children with CHARGE syndrome, their parents rated weighted blankets less effective than melatonin in improving their sleep quality. One possible reason is that melatonin is a common treatment that is more trusted by parents when recommended by doctors (24). Besides, the cost of weighted blankets as a prescription is higher than sleep drugs, which may lead to easier use and acceptance of sleep drugs. The average cost of a weighted blanket prescription for six months is just under €190, compared with sleep medications for the same period that was slightly below €86 in western Sweden. The higher cost of weighted blankets was mainly due to the more lengthy and complex prescription process and less to the material (34). In general, a weighted blanket is a non-drug supplement nearly without side effects, which might be safer than drug therapy in sleep intervention. Due to lower adverse effects but higher economic cost, the prescription pattern of weighted blankets should be revised and systemized to reduce the costs and better identify the target populations who may benefit from weighted blankets.

4 Discussion

Our review summarized all available studies examining the use and efficacy of weighted blankets in improving sleep quality, ADHD/ASD-related symptoms, negative emotions, and other related disorders in different populations, indicating a variability in the results, but a majority of studies showed positive results. Although the efficacy in individuals with sleep disorders and ADHD/ASD showed stronger supporting evidence, further validations are still needed due to the non-significant or negative results reported by a few studies. Meanwhile, due to the differences in the populations, outcomes, and intervention strategies (e.g., duration and frequency) in the included studies, particular caution is required when generalizing the findings to other populations.

4.1 Mechanisms of weighted blankets

Deep pressure touch (DPT) is the most recognized mechanism of weighted blankets by researchers (Figure 1) (52, 53). DPT is a form of tactile input which can be provided by holding, touching, embracing, stepping, and squeezing (14). A weighted blanket can cause changes in sensory nerve endings through continuous mechanical stimulations such as touch and pressure to the skin, leading to the opening of mechanically gated sodium channels, Na+ influx, and the generation of receptor potentials. The sympathetic nerve deals with the body's decision to fight or flight; if it takes over, individuals can experience nervousness, anxiety, fear, irritability, poor sleep, and even digestive problems (54). The parasympathetic nervous system has a calming effect, which determines the "rest and digestion" of the body (55). A weighted blanket is a typical application of DPT, and can stimulate the parasympathetic nervous system, which has been

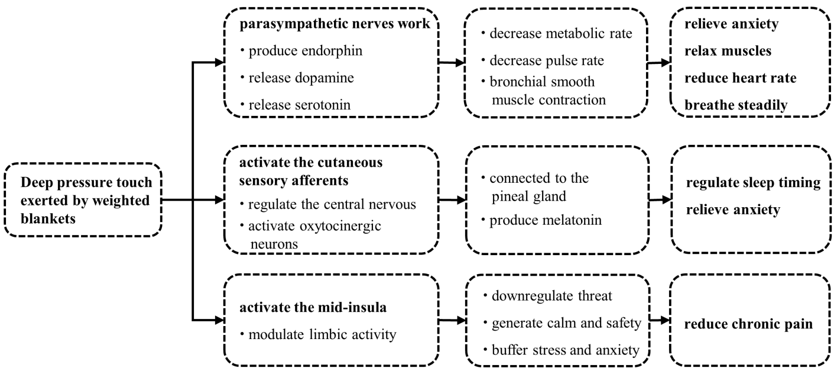

FIGURE 1
Mechanisms of weighted blankets.

supported by previous physiological studies (53, 56). When the parasympathetic nerve works, it can produce endorphins and release dopamine and serotonin (57), while endorphins and dopamine can result in reduced heart rate, relieved anxiety, relaxed muscles, and steady breath (58), and consequently, conducing to staying asleep. In a study of various tactile stimulations ending apnea in preterm infants, deep pressure stimulation was effective in helping preterm infants return to spontaneous breathing quickly (59).

Furthermore, a recent in-laboratory crossover study found that weighted blankets increased pre-sleep salivary concentrations of melatonin in young, healthy adults (25), providing new evidence for the sleep-promoting mechanisms of weighted blankets. Melatonin is released by the pineal gland and plays a critical role in sleep timing and anti-anxiety (60, 61). One explanation could be that the deep pressure provided by the weighted blankets activates cutaneous sensory afferents that transmit sensory information to the nucleus tractus solitarius through the spinal cord. The nucleus tractus solitarius projects to the paraventricular nucleus of the hypothalamus, which hosts parvocellular oxytocinergic neurons (62). They subsequently connect to the pineal gland to affect the release of melatonin (63). Notably, a previous study showed that a total loss of afferent sensory signals was related to a complete absence of nocturnal melatonin increase, reinforcing that the peripheral sensory nervous system plays a critical role in regulating the release of melatonin from central nervous system (64).

Interestingly, weighted blankets also contributed to relieving perceived bodily pain (41). This may result from several mechanisms. First, given that chronic pain is determined in part by social and/or emotional factors (65, 66), we speculate that the deep pressure provided by a weighted blanket may downregulate threat and generate calm and safety through activation of the insula, thereby alleviating stress and anxiety and ultimately reducing perception of bodily pain (67, 68). Second, the deep pressure can increase local tissue oxygenation and blood flow. These peripheral effects may account for the antinociceptive function of the weighted blankets (69, 70).Third, studies have reported that deep pressure sensation is transmitted by A-beta afferents (71), which was found to suppress laser pain in the same dermatome at the spinal cord level (72), suggesting that deep pressure provided by a weighted blanket might reduce bodily pain through A-beta stimulation.

4.2 Current research gaps and potential developments

This review reflects several current research gaps in weighted blankets therapy. First, the sample size of most existing studies did not reach 100, calling for more large-scale studies. Second, there was a lack of prospective, parallel and controlled studies, with many existing studies being poor clinical trials or observational studies, indicating a huge evidence gap. High-quality randomized controlled trials with longer intervention duration are required to strengthen the level of evidence. Third, sleep measurements were mostly subjective, hence, the results lack credibility. Objective measurements such as actigraphy covering multiple sleep outcomes should be applied. In addition, it is necessary to distinguish between subjective and objective effects of the weighted blankets. For instance, a review on non-traditional sleep treatments in children and young people reported that the subjects and caregivers using weighted blankets had positive feedbacks, despite a lack of significant differences in their objective sleep indicators (23). Forth, a few studies were relatively weak in statistical analysis, such as uncontrolled confounding factors, inappropriate use of statistical methods, etc. Moreover, several studies were qualitative, and these conclusions need to be further confirmed by empirical research with rigorous statistical methods. Fifth, the limited evidence of how weighted blankets work indicates a need for more research into the potential mechanisms. Future research could explore how weighted blankets can improve sleep through its effects on the brain using objective measurements such as electroencephalogram. Sixth, future studies could try to test the effects of weighted blankets in healthy people without insomnia or to test the non-inferiority of weighted blankets using a well-recognized sleep medication as a positive control.

4.3 Clinical implications

The efficacy of weighted blankets in sleep quality in different populations provides scientific recommendations for a non-pharmacotherapy of sleep disorders such as insomnia in clinical settings. Nevertheless, given the limited evidence available, the clinical application should be especially cautious. Clinicians should help patients make a reasonable decision by informing them of the uncertainty of the efficacy and other alternative approaches, considering the patients' core needs and preferences. In practice, clinicians should evaluate whether the patients have characteristics unsuitable for using weighted blankets, such as a history of serious diseases including coronary heart disease, cerebral infarction, respiratory problems, and cancer; active abuse of sleeping pills; severe cognitive dysfunction, etc. Once a patient starts using, it is better for clinicians to monitor closely, collect the feedbacks in time, and discontinue immediately if the patient feels uncomfortable. It is important to note that weighted blankets can be dangerous, especially for children and the elderly. The higher weight of weighted blankets may cause pain, anxiety, and panic to a few children (33, 73). In general, children under 3 years of age or weighing less than 50 pounds should not use weighted blankets due to the risk of suffocation or entrapment. It is best for children to use a weighted blanket under the supervision of their parents and will need to go through a period of adaptation. We advise parents to avoid covering the children's face with a blanket. For the elderly, it is worth emphasizing that they should have the physical capacity to remove the weighted blanket from the head if needed to avoid the risk of suffocation. If the blanket is too heavy that they have to struggle to get it off, they could end up injuring themselves. Therefore, if the elderly have frailty, limited mobility, or severe dementia, they should use the lightest weighted blanket possible after consulting medical doctors (45).

In summary, weighted blankets might be a safe and effective intervention for insomnia and various sleep disturbances and psychiatric disorders, with fewer side effects than drug therapy. More research is needed further to explore the application of weighted blankets in a wider range of populations. At present, deep pressure touch has been recognized as an essential mechanism of weighted blankets. Further studies aiming at identifying more mechanisms of weighted blankets are needed. The long-term safety and efficacy of weighted blankets must be further validated in high-quality, large-scale randomized controlled trials.

Author contributions

JY: Methodology, Visualization, Writing – original draft, Writing – review & editing. ZY: Methodology, Writing – original draft. SS: Methodology, Visualization, Writing – original draft. KS: Investigation, Writing – review & editing. WC: Investigation, Writing – review & editing. LMZ: Investigation, Writing – review & editing. JX: Investigation, Writing – review & editing. QX: Investigation, Writing – review & editing. ZL: Conceptualization, Funding acquisition, Supervision, Writing – review & editing. JK: Investigation, Writing – review & editing. LSZ: Supervision, Writing – review & editing. YZ: Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1333015/full#supplementary-material

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The role of arts therapies in mitigating Sleep Initiation and Maintenance Disorders: a systematic review

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Introduction: Arts therapies offer effective non-pharmacological intervention for Sleep Initiation and Maintenance Disorders (SIMDs), encompassing both passive and active modalities. This review assesses their effectiveness and ethical considerations, focusing on music therapy, meditation, and Tai Chi.

Methods: Following PRISMA guidelines, a detailed search across PubMed, the Cochrane Library, Web of Science, and CNKI identified 17 relevant RCTs. Utilizing the Joanna Briggs Institute (JBI) quality criteria and the PICO(S) framework for data extraction ensured methodological integrity.

Results: Analysis shows arts therapies significantly improve sleep quality. Music therapy and meditation yield immediate benefits, while Tai Chi and Qigong require longer commitment for significant outcomes.

Discussion: The link between SIMDs and mental health issues like anxiety, stress, and depression suggests arts therapies not only enhance sleep quality but also address underlying mental health conditions. The evidence supports a wider adoption of arts therapies in treating SIMDs due to their dual benefits.

Systematic review registration: PROSPERO, ID: CRD42024506393.

KEYWORDS

Arts Therapies, sleep disorders, psychotherapy, complementary interventions, mental health

1 Introduction

In the rapid pace of modern life, Sleep initiation and maintenance disorders (SIMDs) have emerged as a global health challenge, exacerbated by the aftereffects experienced by many in the wake of the pandemic, severely impacting physical health and daily routines (1). A study by the World Health Organization (WHO) estimates that approximately 1.7 billion people globally suffer from sleep disturbances, accounting for 27% of the world's population (2). The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) characterizes insomnia as a prevalent clinical condition, with approximately one-third of adults reporting symptoms of insomnia, and 6 to 10% meeting the diagnostic criteria for an insomnia disorder (3). SIMDs encompass a variety of abnormalities during sleep, including excessive daytime sleepiness, insomnia, abnormal movements or behaviors during sleep, and difficulty initiating sleep when desired (4, 5), often accompanied by other physical conditions or mental health issues, including insomnia, obstructive sleep apnea, somnambulism, narcolepsy, and restless legs syndrome among different types (6, 7). More than 50% of adults globally have experienced a sleep disorder at least once in their lives (8). The distribution of sleep problems across certain age groups and populations is even broader, becoming a significant and growing public health issue (9). Sleep, as a fundamental human need, plays a crucial role in maintaining overall health, cognitive function, and quality of life (10). Research indicates that most SIMDs are preventable or treatable (11), yet the majority of sufferers do not seek professional help. The consequences of SIMDs are wide-ranging, adversely affecting individual health and socioeconomic well-being. Conditions such as insomnia, obstructive sleep apnea (OSA), and restless legs syndrome (RLS) continue to have high prevalence rates and exert profound effects on physical and mental health (12–14). Studies have shown a close correlation between sleep and an increased risk of obesity, diabetes, cardiovascular diseases, and mental health disorders, including depression and anxiety (15–17). Sleep issues not only have a strong bidirectional relationship with mood disorders such as depression and anxiety but are also associated with cognitive decline, physical health problems, and decreased work efficiency (18–21). Particularly among the elderly, over 50% suffer from sleep issues, impacting their physical and mental well-being (22). Furthermore, approximately 80% of individuals with clinical depression experience sleep disturbances (23). Research also reveals that sleep problems are prevalent in high-stress groups, such as college students (24). Traditional sleep interventions have relied on pharmacological treatments, which may come with side effects that limit their long-term application (25), such as residual drowsiness, tolerance, dependence, altered sleep architecture, and rebound insomnia (26–29). Common medications used in traditional treatments include sleep aids like zopiclone, zolpidem, and eszopiclone, as well as medications used to alleviate anxiety or depression associated with sleep issues, such as alprazolam, quetiapine, and fluoxetine (30, 31). These medications often result in side effects during the medication-induced sleep process, such as nasal congestion, convulsions, nightmares or hallucinations, and breathing difficulties, and are accompanied by side effects such as dizziness, nausea, dry mouth, muscle weakness, and headache upon waking. Moreover, these drugs carry the risk of dependency and resistance, often leading to withdrawal reactions upon cessation, and place significant financial stress on many patients over the long term (32, 33). This has paved the way for non-pharmacological interventions (34), given the burdens of pharmacotherapy, exploring benign non-pharmacological interventions for sleep issues becomes the focus of this article.

Among the numerous methods for sleep healing, various forms of arts therapies as non-pharmacological treatments have shown unique advantages and potential. To refine and expand our definition of arts within arts therapies, it's crucial to adopt a nuanced and comprehensive perspective that acknowledges the wide array of non-pharmacological therapeutic arts as defined by the five senses: visual, auditory, olfactory, gustatory, and tactile. For example, visual art and color therapy utilize form, color, and imagery to engage the visual sense, potentially evoking feelings of calmness and relaxation that can improve sleep quality (35). Similarly, music therapy leverages auditory stimuli to influence emotional states and stress levels, indirectly promoting healthier sleep patterns (36). Aromatherapy, targeting the olfactory sense, uses essential oils and fragrant extracts to harmonize the mind and body, with certain scents known for their sedative properties that aid sleep. While gustatory arts, such as culinary arts therapy, may indirectly influence sleep through mood and wellbeing improvements, tactile forms of therapy like body movement and dance therapy emphasize physical expression and the tactile experience to relieve stress and enhance sleep quality (37, 38). This inclusive approach not only broadens the review's scope but also underscores the multifaceted nature of arts therapies in mitigating sleep initiation and maintenance disorders by alleviating mental stress and emotional tension. Moreover, arts therapies promote and encourage individuals to actively manage their own health, placing a greater emphasis on intrinsic motivation and personal involvement. By engaging with art, individuals improve their mood and mental health, releasing inner stress and uneasy emotions, which in turn reduces levels of anxiety and depression (39). This engagement in creative activities provides an outlet for emotional release and self-exploration, not only offering immediate relief from sleep issues but also increasing individual life satisfaction and happiness over the long term. As a non-pharmacological treatment, arts therapies not only highlights its uniqueness in addressing sleep problems but also robustly supports the improvement of sleep quality, promising to become an important tool for enhancing individual and community health (40).

Therefore, this review explores a gentler approach to improving sleep health through non-pharmacological interventions. Focusing on various art forms, this review examines diversified alternative therapies including mindfulness-based stress reduction (MBSR) (41), yoga (42), music therapy (43), virtual reality (VR) (44), and meditation (45) that offer sensory engagement. Studies indicate that these therapies assist in regulating both physiological and psychological states, thus improving sleep quality. These arts therapies not only eliminate the need for injections or oral medications but also provide multidimensional benefits unreachable by traditional treatment methods (46). For instance, group yoga not only promotes relaxation and improves sleep quality but also enhances social interaction, boosts self-esteem, and positively affects posture (47). Beyond sleep, these interventions also include stress reduction, enhanced emotional regulation, and improved cognitive function (48, 49). These intervention methods offer assistance not just to the elderly but have also shown potential in ICU patients, college students, and other populations affected by high stress levels.

This review aims to comprehensively examine and compare evidence supporting various non-pharmacological interventions for SIMDs, delving into how these measures can improve sleep issues across different populations and assessing their benefits and potential limitations in clinical practice. Specifically, this review will focus on the following research questions:

1) Which arts therapies have been effective in addressing SIMDs?
2) How do different art forms and practices leverage their unique advantages in the intervention of SIMDs?
3) What are the mechanisms of effect when these arts therapies are used as alternative treatments, and what hypotheses can be explored?

This review intends to provide healthcare professionals with practical guidelines to make more informed decisions in treating SIMDs and offer value to patients seeking alternative and complementary treatments. By considering the multidimensional benefits of arts therapies, this article aims to present a new perspective and direction for the management of SIMDs within the healthcare system.

2 Methods

This systematic review adheres to the PRISMA statement for systematic reviews and meta-analyses (PRISMA) (50, 51) and is registered with PROSPERO (52) under the registration number CRD42024506393. We developed the research question using the PICOS acronym, as follows:

PICOS

- P: Any patient associated with SIMDS.
- I: Interventional arts therapies.
- C: Conventional therapy.
- O: Improved clinical and/or mental health outcomes.
- S: randomized controlled trials, quasi experimental studies (non-randomized controlled trials), and single-arm, pre-test/post-test studies.

2.1 Study inclusion and exclusion criteria

In the systematic review, we rigorously defined the inclusion and exclusion criteria to ensure a thorough examination of the impact of arts therapies on Sleep Initiation and Maintenance Disorders (SIMDs). Studies eligible for inclusion are those that adhere to the Joanna Briggs Institute (JBI) research design guidelines, involve participants diagnosed with SIMDs, and implement arts therapies, including but not limited to music, visual arts, dance/movement, drama therapy, and bibliotherapy as a primary intervention. The interventions could be carried out across various settings and delivered by arts therapy professionals. These studies should compare the outcomes against any type of control group and report on sleep quality indicators such as sleep latency and efficiency. Our focus is on gathering empirical evidence from randomized controlled trials, quasi-experimental studies, and analytical cross-sectional studies that meet ethical and methodological standards.

Conversely, the review excludes non-peer-reviewed documents, studies not employing art-based interventions, and those concerning individuals without SIMDs diagnoses. Additionally, research designs such as non-experimental studies, narrative reviews, animal studies, and publications not in English are omitted to maintain the review's integrity and manageability. This selectivity ensures the inclusion of studies with robust methodologies and relevant outcomes, thereby providing reliable evidence on the effectiveness of arts therapies in treating sleep disorders. The exclusion of non-English articles and grey literature is acknowledged as a limitation but is necessary for ensuring thorough analysis and interpretation within the language proficiency of the review team.

2.2 Electronic databases

This systematic search was conducted across five electronic databases: PubMed, Cochrane Library, Web of Science, Embase, and the Chinese database CNKI, for publications spanning from 2004 to 2024.

2.3 Search strategy

A meticulously structured search strategy was implemented by a team of three independent researchers. This strategy aimed to capture a wide array of studies that investigate the intersection of arts therapies and sleep disorders. Table 1 of the original article delineates the search strategy, highlighting the employment of specific keywords and Medical Subject Headings (MeSH) to guide the literature search. The primary keywords included 'Arts Therapies' and 'Sleep Disorders,' which were chosen for their broad applicability to studies exploring the therapeutic use of art in the context of sleep-related issues.

TABLE 1 Search strategies for English databases or Chinese databases.

Number	Search Terms
#1	Music Therapy [MeSH]
#2	Color Therapy [MeSH]
#3	Art Therapy [MeSH]
#4	Meditation [MeSH]
#5	Mindfulness [MeSH]
#6	Tai ji [MeSH]
#7	Qigong [MeSH]
#8	Yoga [MeSH]
#9	Exercise Movement Techniques [MeSH]
#10	Dance Therapy [MeSH]
#11	Virtual Reality [MeSH]
#12	Play Therapy [MeSH]
#13	Psychodrama [MeSH]
#14	Drawing [MeSH]
#15	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14
#16	Sleep Initiation and Maintenance Disorders [MeSH]
#17	Insomnia [MeSH]
#18	Sleep [MeSH]
#19	#16 OR #17 OR #18
#20	#15 AND #19
#21	Yinyue liaofa (Music Therapy)
#22	Secai liaofa (Color Therapy)
#23	Yishu liaofa (Art Therapy)
#24	Minxiang liaofa (Meditation)
#25	Zhengnian liaofa (Mindfulness)
#26	Tai ji (Tai ji)
#26	Qigong (Qigong)
#27	Yujia (Yoga)
#28	Yundong (Exercise Movement Techniques)
#29	Wudao liaofa (Dance Therapy)
#30	Xunixiangshi (Virtual Reality)
#31	Youxi liaofa (Play Therapy)
#32	Xiju liaofa (Psychodrama)
#33	Huihua (Drawing)

MeSH, Medical Subject Headings.

To ensure a comprehensive gathering of relevant literature, various forms of art therapy were considered, encompassing visual arts and color-related therapies, auditory music-related therapies, and tactile movement-related therapies. This approach acknowledges the multifaceted nature of arts therapies and their potential impact on sleep disorders across different sensory modalities. Furthermore, to mitigate the risk of overlooking pertinent studies, a manual search was conducted through the reference lists of key reviews and articles identified during the initial search phase. This dual-faceted search strategy, combining both electronic database searches with manual reference checking, was aimed at creating a thorough and all-encompassing review of the literature available on the subject matter, enhancing the reliability and depth of the systematic review.

2.4 Study selection

Three independent reviewers, LXX, HL, and AJZ, engaged in the screening, eligibility, and selection review processes. LXX was tasked with downloading and reviewing the filtered articles, excluding those deemed irrelevant. Subsequently, pertinent literature was forwarded to HL for an eligibility review. Upon determining the eligibility of 17 documents, AJZ conducted a meticulous evaluation and scoring based on JBI's critical appraisal tools (53, 54). These instruments are designed to assess the methodological quality of the studies and ascertain the extent to which the studies address the potential for bias in their design, execution, and analysis. Moreover, literature meeting the eligibility criteria was subjected to a dual examination by LXX and HL. Every one of the 17 included studies, particularly those identified as randomized controlled trials, underwent a thorough data extraction process using the PICO(S) framework (55). This approach allowed for the systematic organization and assessment of pertinent information extracted from the documents, enhancing the clarity and conciseness of the analysis.

2.5 Data extraction

In the systematic review process, the task of data extraction was meticulously planned and executed by three independent researchers, ensuring a thorough and unbiased collection of data from the selected studies. This critical phase was structured around the creation of four distinct tables, each designed with a specific function to aid in the systematic organization and analysis of the collected data.

The first table was developed to provide a clear visualization of the core content extracted from each piece of literature, organized into categories such as Study Aims, Participants, Methods, Results, and Discussion. This table aimed to facilitate an immediate understanding of each study's key components, allowing for a quick yet comprehensive overview of the collected data. The second table was tailored to display subgroups of different arts therapies, enabling the researchers to categorize and compare the results and author names within specific therapeutic groups, thereby highlighting the diversity and specific outcomes associated with each art therapy type.

To ensure the quality and reliability of the included studies, a third table was utilized for conducting a quality review of the literature. This table employed checklists derived from the Joanna Briggs Institute (JBI) guidelines, which are renowned for their robustness in assessing the methodological quality of research. The fourth table was dedicated to extracting detailed data about patient samples, intervention and control group methodologies, and outcomes, specifically from randomized controlled trials (RCTs). For this purpose, the researchers adopted the PICOS (Population, Intervention, Comparator, Outcomes, and Study Design) model, which facilitated a structured and comprehensive analysis of the RCTs. This strategic approach to data extraction not only enhanced the clarity and organization of the data but also laid a solid foundation for the systematic review's subsequent analysis and discussions.

2.6 Quality appraisal of the included studies

The initial comprehensive search yielded 17,262 publications, from which irrelevant studies were excluded through a meticulous screening of titles and abstracts, followed by a detailed full-text review as required. This rigorous selection process leveraged the PICO(S) framework (Population, Intervention, Comparison, Outcome, and Study design) to systematically define inclusion and exclusion criteria, ensuring focus and relevance in the selection of studies, to uphold the methodological integrity of the review, the Joanna Briggs Institute (JBI) critical appraisal tools were employed, facilitating the evaluation of the studies' quality. This approach underlined our commitment to incorporating only the most methodologically sound literature into our analysis (53–56).

The quality appraisal of randomized controlled trials (RCTs) within our dataset was conducted using a scoring system informed by JBI guidelines. This involved assigning a score of one point for each criterion adequately met 'yes', zero points for unmet criteria 'no' and 'unclear'. This scoring facilitated a horizontal comparison of study quality, ranking them based on their aggregate scores. A score of ≤6 was considered as low quality, from 7 to 9 as moderate and ≥ 10 as high quality. No studies were excluded based on methodological quality. Vertically, this method allowed for the assessment of commonalities across the reviewed literature, evaluating the proportion of studies that successfully met each quality criterion.

Furthermore, the application of the PICO(S) framework extended beyond initial study selection, informing the structured tabulation of the research data. This included organizing studies and ranking them by the number of participants, recognizing that larger sample sizes typically contribute to a stronger evidence base.

3 Results

3.1 Study characteristics

This manuscript incorporates 17 studies focusing on experimental design, wherein 10 studies juxtapose art therapy with a standard routine, and three compare art therapy to sleep hygiene education, see in Figure 1. The control groups in other investigations employed a variety of methods including daily routine sleep intervention, self-monitoring, low-impact exercise,

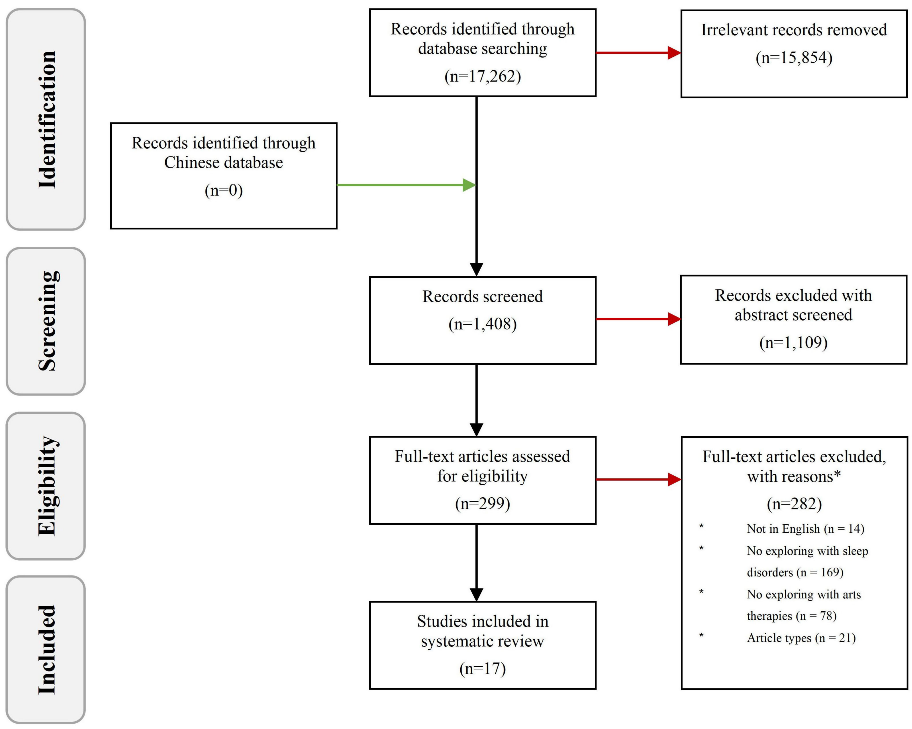

FIGURE 1
Flow diagram for the included and excluded articles.

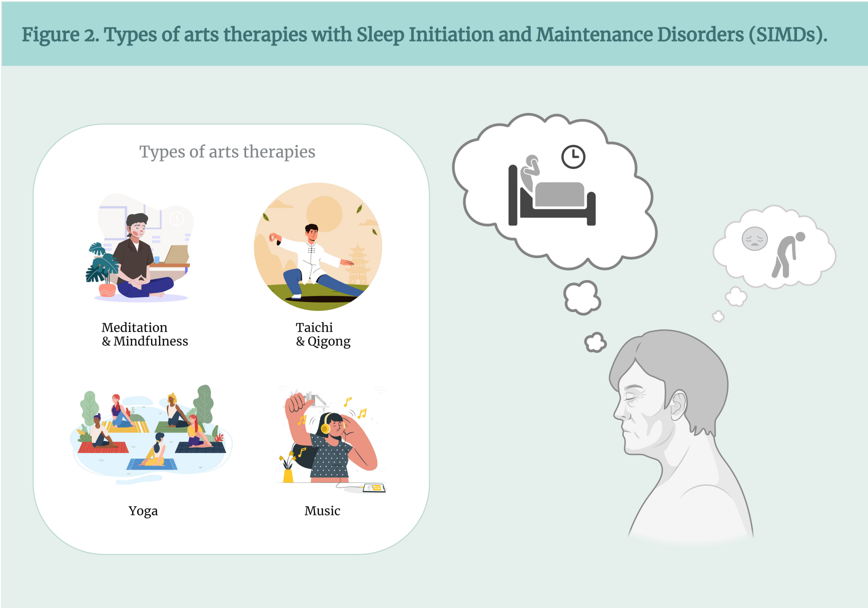

FIGURE 2
Types of arts therapies with Sleep Initiation and Maintenance Disorders (SIMDs).

and health education, see in Figure 2, primarily encompassing Virtual Reality (VR) (57), meditation (58–60), qigong (61), tai chi (62, 63), Biodanza (64), music therapy (65–70), yoga (71, 72), and Mindfulness-Based Stress Reduction (MBSR)/Mindfulness-Based Cognitive Therapy (MBCT) (73).

Tables 2, 3 synthesize the principal characteristics of the qualifying studies. The 17 included studies comprise 1,300 participants (treatment conditions= 694, control conditions= 606) hailing from South Korea (57), the USA (58–60, 62, 63, 71, 72), China (61, 65–67, 70), Spain (64), Hungary (68), Singapore (69), and Iran (73), with the largest sample consisting of 237 individuals (58) and the smallest of 18 (71). The age range of participants was broad, from teenagers aged 19 to senior citizens aged 92, encompassing healthy individuals (61–63, 66, 69, 72), cardiac

TABLE 2 Record of citations and full text reviewed.

Name	Types	Region	study aims	Participants	Methods	Results	Discussion
Soon Young, et al. (57)	RCT	South Korea	investigate the effect of virtual reality meditation on sleep quality of intensive care unit patients.	48 cardiac intensive care unit patients in a university hospital in Korea randomly allocated to the experimental (24) and the control group (24).	meditation was provided for 30 minutes using a head-mounted display for virtual reality, on the evening of the admission day.	the awake time was shorter, deep sleep time was longer and sleep efficiency was significantly higher in the experimental group than in the control group.	Although VR meditation did not improve total sleep time (TST) and light sleep time, it did enhance the overall quality of sleep.
Jennifer, et al. (58)	RCT	USA	1) determine the effects of a meditation app on depression and anxiety in adults with sleep disturbance, and 2) explore the potential mediating effects of fatigue, daytime sleepiness, and pre-sleep arousal on the relationship between use of the meditation app and changes in depression and anxiety.	239 adults with elevated insomnia symptoms (i.e., scores ≥ 10 on the Insomnia Severity Index) and limited or no previous experience with meditation.	Depression, anxiety, fatigue, daytime sleepiness, and pre-sleep arousal were assessed at baseline, four weeks, and eight weeks. Repeated-measures ANCOVAs assessed intervention effects on depression and anxiety.	Participants in the meditation group had more improvement in depression and anxiety symptoms during the intervention period than did those in the control group	The study emphasizes the importance of pre-sleep arousal as a potential target for intervention in treating mental health issues.

(Continued)

TABLE 2 Continued

Name	Types	Region	study aims	Participants	Methods	Results	Discussion
Jason, et al. (59)	RCT	USA	evaluate the efficacy of mindfulness meditation for the treatment of chronic insomnia.	54 adults with chronic insomnia, Participants were randomized to either mindfulness-based stress reduction (MBSR).	8-week group intervention that includes weekly 2.5-hour sessions, plus a 6-hour meditation retreat held between the 5th and 7th week.	Participants who received mindfulness meditation interventions (either MBSR or MBTI) showed significantly greater reductions in total wake time (TWT) in bed, pre-sleep arousal (PSAS), and clinically significant changes in treatment response and remission compared to the self-monitoring (SM) control group.	The effect sizes observed in this study are generally like those reported in behavioral clinical trials on chronic insomnia, providing preliminary support that meditation-based treatments are viable non-pharmacological treatments for adults with insomnia.
David, et al. (60)	RCT	USA	determine the efficacy of a mind-body medicine intervention, called mindfulness meditation, to promote sleep quality in older adults with moderate sleep disturbances.	Randomized clinical trial with 2 parallel groups conducted among an older adult sample (mean [SD] age, 66.3 [7.4] years) with moderate sleep disturbances (Pittsburgh Sleep Quality Index [PSQI] >5).	mindful awareness practices (MAPs) intervention (n = 24) or a sleep hygiene education (SHE) intervention (n = 25) was randomized to participants, who received a 6-week intervention (2 hours per week) with assigned homework.	The MAPs group showed significant improvement relative to the SHE group on secondary health outcomes of insomnia symptoms, depression symptoms, fatigue interference, and fatigue severity (P <.05 for all).	The study suggests that mindfulness meditation could be a promising short-term treatment for sleep issues in this population, with potential mechanisms involving cognitive and neurocognitive processes.
Shu-chuan, et al. (61)	RCT	Taiwan	examine the effect of a 12-week 30-minute-a-day Ping Shuai Qigong exercise program on climacteric symptoms and sleep quality in perimenopausal women.	Thirty-five (35) women from one community were assigned to a Ping Shuai Qigong intervention group, while 35 women from the other community were assigned to the control group	12-week, 30-minute-a-day Ping Shuai Qigong program, Descriptive analysis and repeated-measures analysis of variance were used.	found to have significant improvements in sleep quality in those times.	the program appears to have a greater effect on sleep latency, habitual sleep efficiency, and sleep disturbance than on subjective sleep quality, sleep duration, and daytime dysfunction.
Fuzhong, et al. (62)	RCT	USA	this program appears to have a greater effect on sleep latency, habitual sleep efficiency, and sleep disturbance than on subjective sleep quality, sleep duration, and daytime dysfunction.	One hundred eighteen women and men aged 60 to 92.	Participants were randomized into tai chi or low-impact exercise and participated in a 60-minute session, three times per week, for 24 consecutive weeks.	older adults with moderate sleep complaints who participated in a tai chi program reported significant improvements in self-rated sleep quality and daytime sleepiness compared to those in a low-impact exercise group.	tai chi participants experienced better physical performance and quality of life compared to the low-impact exercise group.
Michael, et al. (63)	RCT	USA	determine the efficacy of a novel behavioral intervention, Tai Chi Chih, to promote sleep quality in older adults with moderate sleep complaints.	Volunteer sample of 112 healthy older adults, aged 59 to 86 years.	Random allocation to Tai Chi Chih or health education for 25 weeks.	Tai Chi Chih (TCC) can be considered a useful nonpharmacologic approach to improve sleep quality in older adults with moderate sleep complaints.	TCC training is related to improvements in self-rated sleep quality among older adults with moderate sleep complaints.
Marı´a, et al. (64)	RCT	Spain	determine the effectiveness of Biodanza in reducing symptoms of perceived stress and depression and in promoting sleep quality in young adults, comparing the changes	121 university students with perceived stress were randomly placed into either a Biodanza group or a wait-list control group.	Study participants attended Biodanza sessions for 90 min a week, over a period of 4 weeks.	no significant differences in sleep quality were observed between the groups (p = 0.666).	the Biodanza group reported a significant reduction in stress and depression levels compared to the control group, which showed a slight

(Continued)

TABLE 2 Continued

Name	Types	Region	study aims	Participants	Methods	Results	Discussion
			with those observed in a control group.				worsening of stress levels.
Chiung-Yu, et al. (65)	RCT	Taiwan	compare the effects of music and music video interventions on objective and subjective sleep quality in adults with sleep disturbances.	71 adults who were recruited from the outpatient department of a hospital with 1100 beds and randomly assigned to the control, music, and music video groups.	During the 4 test days (Days 2–5), for 30 min before nocturnal sleep, the music group listened to Buddhist music and the music video group watched Buddhist music videos.	the music group reported a significantly longer subjective total sleep time (TST) compared to the music video group ($p = 0.04$).	The study's findings suggest that while music and music video interventions did not improve objective sleep parameters, listening to music before bedtime did improve subjective TST in adults with sleep disturbances.
Qun, et al. (66)	RCT	China	examine the effects of music intervention on sleep quality in community-dwelling elderly people.	64 elderly people with a mean age of 69.38 – 5.46 years were randomly assigned to the control group ($n = 32$) or the intervention group ($n = 32$).	Each participant in the intervention group received an MP3 player with a music database. The participants selected the preferred music and listened for 30–45 minutes per night for 3 months.	The intervention group showed continuous improvements in sleep quality, with significant reductions in global PSQI scores from baseline to 3 months.	music intervention is a safe and effective nonpharmacological approach for improving sleep quality in community-dwelling elderly people, particularly in reducing sleep latency, improving sleep efficiency, and reducing daytime dysfunction.
En-Ting, et al. (67)	RCT	Taiwan	evaluate the effect of soothing music on objective and subjective sleep quality in adults with chronic insomnia.	Fifty participants were enrolled in a randomized controlled trial conducted in the sleep laboratory of a hospital, with 25 participants allocated to the music group and 25 to the control group.	For four days, the experimental group was exposed to soothing music selected by the participants or researchers for 45 min at nocturnal sleep time, whereas the control group was not exposed to music.	After controlling for baseline data, the music group had significantly better scores for rested rating, shortened stage 2 sleep, and prolonged REM sleep compared to the control group.	Listening to soothing music at nocturnal sleep time improved the rested rating scores, shortened stage 2 sleep, and prolonged REM sleep, but had little effect on sleep quality as measured by PSG and self-reported questionnaires.
La´szlo´, et al. (68)	RCT	Hungary	investigate the effects of music on sleep quality in young participants with poor sleep.	94 students (aged between 19 and 28 years) with sleep complaints.	Participants listened for 45 minutes either to relaxing classical music (Group 1) or an audiobook (Group 2) at bedtime for 3 weeks.	music significantly improved sleep quality ($P < 0.0001$), Sleep quality did not improve significantly in the audiobook and control groups.	relaxing classical music is an effective intervention in reducing sleeping problems. The results suggest that music can improve sleep quality and depressive symptoms in young adults with poor sleep.
Angela, et al. (69)	RCT	Singapore	examine the effects of music listening on sleep quality among older community dwelling adults in Singapore.	a cohort of older adults ($N = 60$) age 55 years or above.	Participants were asked to listen to soft, instrumental slow sedative music without lyrics, of approximately 60—80 beats per minute, and 40 min in duration, for 6 weeks.	Significant reductions in PSQI scores were found in the intervention group from baseline to week 6, with a mean decrease from 10.2 to 5.9 ($p < 0.001$), while the control group showed no changes.	healthcare professionals could engage elderly clients in music listening therapy to improve sleep quality, individualizing, and enhancing the quality of care provided.
Hui-Ling, et al. (70)	RCT	Taiwan	investigation of the effects of soft music on sleep quality in older	Sixty people aged 60–83 years with difficulty in	Participants listened to their choice among six 45-	music significantly improved sleep quality in the experimental group,	music can induce relaxation and distraction responses,

(Continued)

TABLE 2 Continued

Name	Types	Region	study aims	Participants	Methods	Results	Discussion
			community-dwelling men and women in Taiwan.	sleeping were recruited through community leaders and screened using the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale.	minute sedative music tapes at bedtime for 3 weeks.	with better perceived sleep quality, longer sleep duration, greater sleep efficiency, shorter sleep latency, less sleep disturbance, and less daytime dysfunction (P values ranging from 0.04 to 0.001).	leading to decreased activity in the neuroendocrine and sympathetic nervous systems, which in turn can reduce anxiety, heart rate, respiratory rate, and blood pressure, and improve sleep.
Erica, et al. (71)	RCT	USA	examine trial feasibility plus physiological and psychological effects of a guided meditation practice, Yoga Nidra, in adults with self-reported insomnia.	22 adults with self-reported insomnia were recruited.	half of participants were randomized to practice Yoga Nidra for the first 30-min.	Yoga Nidra produced sleep in 89% of participants during and after the practice, and the participants reported feeling more relaxed after the intervention.	the lack of significant changes in EEG alpha power and HRV parameters indicates that further research is needed to confirm the specific mechanisms through which Yoga Nidra may facilitate relaxation and sleep.
Sat Bir, et al. (72)	RCT	USA	Prior studies have suggested a benefit of yoga for alleviating sleep disturbance; however, many studies have had methodological limitations. This trial study aimed to extend that literature by including an active sleep hygiene comparison.	a total of 44 participants were randomly assigned to either the yoga group or the sleep hygiene (SH) treatment group, with 22 participants in each group.	The yoga intervention included Kundalini yoga practices with a focus on meditation, relaxation, and breathing techniques.	The yoga group showed significant improvements in SOL, TST, and SE, with medium-to-large effect sizes.	The yoga intervention demonstrated greater overall improvements compared to the active SH intervention, suggesting that yoga may be a valuable addition to cognitive behavioral therapy for insomnia (CBT-I) or an initial treatment option in a stepped care approach.
Nima, et al. (73)	RCT	Iran	determine the effect of mindfulness-based stress reduction program on emotion regulation and sleep problems in depressed elderly.	60 elderly individuals with depression using purposive sampling.	The MBSR sessions were held for the experimental group in 8 sessions of 90 min each, once a week.	significant reduction in depression symptoms ($p < 0.001$) and improvement in emotion regulation and sleep quality ($p < 0.001$) among the elderly participants with depression in the intervention group.	significant reduction in depression symptoms ($p < 0.001$) and improvement in emotion regulation and sleep quality ($p < 0.001$) among the elderly participants with depression in the intervention group.

SOL, sleep onset latency; TST, total sleep time; SE, sleep efficiency; EEG, Electroencephalogram; PSQI, Pittsburgh sleep quality index; PSG, polysomnography; REM, rapid eye movement; SH, sleep hygiene; MBSR, Mindfulness-Based Stress Reduction.

patients (57), those with chronic insomnia and moderate SIMDs (58–60, 65–68, 70, 71), stressed university students (64), and individuals with depression (73).

Regarding the evaluation of study outcomes, the research included varied in their focus on therapeutic outcomes, hence employing diverse testing methodologies. The studies measured characteristics related to sleep quality (57, 59–73), or outcomes in other categories such as anxiety (58, 65), depression (58, 64, 68), stress (64), heart rate (71), electroencephalography (65, 71), or mood (73). The Pittsburgh Sleep Quality Index and scales were the most frequently utilized measures for assessing sleep quality. Additionally, the activity tracker FitBit Charge 2 (57), electroencephalography (65, 71), and heart rate variability (71) represented the latest measurement techniques.

An analysis using the JBI Critical Appraisal Checklist indicates that the quality of evidence from the included studies is relatively high. However, nearly all studies did not rigorously implement a double-blind experimental methodology (Table 4).

3.2 Description of the population

The comprehensive review of literature on the application of arts therapies in addressing Sleep Initiation and Maintenance Disorders (SIMDs) culminated in the selection of 17 pivotal papers. These studies are meticulously tabulated in Tables 3, 5, adhering to the PICOs methodological framework, thereby illustrating the core experimental data extracted from each

TABLE 3 Principal characteristics of all included RCTs in this review.

Reference	ID	Design	Sample Size T/ C (whole)	Sample Ranking	Outcomes Measure	Treatment group		Control Group
						Intervention	Procedure Times	
Soon Young, et al.	1 (57)	RCT	24/24 (48)	15	SSA/ATFC2/PSQI	VR	30 min	DRSI
Jennifer, et al.	2 (58)	RCT	124/ 113 (237)	1	HADS	Meditation	8 weeks	NR
Jason, et al.	3 (59)	RCT	19/19/ 16* (54)	12	TWT/PSAS/ISI	MBSR/MBTI	8 weeks	SM
David, et al.	4 (60)	RCT	24/25 (49)	14	PSQI	MAPs	6 weeks	SHE
Shu-chuan, et al.	5 (61)	RCT	35/35 (70)	7	PSQI	Qigong	12 weeks	NR
Fuzhong, et al.	6 (62)	RCT	62/56 (118)	2	PSQI/ESS	Tai Chi	2 months	L-IE
Michael, et al.	7 (63)	RCT	59/53 (112)	3	PSQI	Tai Chi Chih	25 weeks	HE
Marı´a, et al.	8 (64)	RCT	42/53 (95)	4	PSQI/PSS/CES-D	Biodanza	4 weeks	NR
Chiung-Yu, et al.	9 (65)	RCT	23/24/ 24* (71)	6	STAI/PSQI/EEG	M/MV	6 days	NR
Qun, et al.	10 (66)	RCT	32/32 (64)	8	PSQI	Music	3 months	SHE
En-Ting, et al.	11 (67)	RCT	25/25 (50)	13	PSQI/PSG	Music	3 days	NR
La´szlo´, et al.	12 (68)	RCT	35/30/ 29* (94)	5	PSQI/ESS/BDI	Music/ Audiobook	3 weeks	NR
Angela, et al.	13 (69)	RCT	28/32 (60)	9	PSQI	Sedative music	6 weeks	NR
Hui-Ling, et al.	14 (70)	RCT	30/30 (60)	9	PSQI/ESS	Music	3 weeks	NR
Erica, et al.	15 (71)	RCT	9/9 (18)	17	EEG/HRV	Yoga Nidra	30 min	NR
Sat Bir, et al.	16 (72)	RCT	20/20 (40)	16	TEQ/ISQ/PSQI/ SES/PSAS	Kundalini yoga	8 weeks	SHE
Nima, et al.	17 (73)	RCT	30/30 (60)	9	GDS/ERQ/PSQI	MBSR	8 weeks	NR

SSA, Sleep Scale A; ATFC2, activity tracker FitBit Charge 2; PSQI, Pittsburgh Sleep Quality Index; VR, Virtual Reality; DRSI, daily routine sleep intervention; HADS, Hospital Anxiety and Depression Scale; NR, Normal Routine; TWT, total wake time; PSAS, pre-sleep arousal scale; ISI, Insomnia Severity Index; MBSR, mindfulness-based stress reduction; MBTI, mindfulness-based therapy for insomnia; SM, self-monitoring; Maps, mindful awareness practices; SHE, sleep hygiene education; ESS, Epworth Sleepiness Scale; L-IE, Low-Impact Exercise; HE, Health Education; PSS, Perceived Stress Scale; CES-D, Center for Epidemiologic Studies Depression Scale; STAI, Spielberger's State-Trait Anxiety Inventory; EEG, electroencephalography; M/MV, music/music video; PSG, polysomnography; BDI, Beck Depression Inventory; HRV, Heart rate variability; TEQ, Therapy Evaluation Questionnaire; ISQ, Insomnia Symptom Questionnaire; SES, Self-Efficacy for Sleep scale; PSAS, Pre-Sleep Arousal Scale; GDS, Geriatric Depression Scale; ERQ, the Gratz and Roemer Emotion Regulation Questionnaire; MBSR, mindfulness-based stress reduction.
*ID-60 (3) group has split into 3 different intervention therapy which is N = 19/19/16, the whole count number is 54; ID-65 (9) group has split into 3 different intervention therapy which is N = 23/24/24, the whole count number is 71; ID-69 (12) group has split into 3 different intervention therapy which is N = 35/30/29, the whole count number is 94.

randomized controlled trial (RCT) article. Collectively, these papers encapsulate a population of 1,300 patients, underscoring the substantial empirical effort directed toward exploring the efficacy of diverse art therapy interventions in mitigating SIMDs.

Among this aggregation of research, the RCTs conducted by Jason, Chiung-Yu, and László are particularly notable for their methodological rigor. By segregating patients into three distinct groups, these studies not only facilitated a nuanced examination of the therapeutic outcomes attributable to various arts interventions and settings but also implemented strategic measures to curtail potential data bias (references 59, 65, 68). Contrasting with these, the remainder of the corpus, comprising 14 papers, predominantly adopted a dual-group treatment versus control design, which is a conventional approach within clinical trial methodologies.

Within this diverse array of studies, Jennifer's research stands out due to its scale, encompassing a total of 237 patients divided into two groups (124:113), marking it as the study with the highest number of trials among the 17 papers reviewed (reference 58). Following closely, the works of Fuzhong and Michael also contribute significantly to the dataset with totals of 118 and 112 patients, respectively (references 62, 63). Conversely, the study led by Erica, involving a comparatively modest cohort of 18 patients, commands attention not for its volume but rather for its profound implications. Despite its smaller scale, the depth of insights and the meticulous attention to minimizing data bias within Erica's study necessitate a detailed examination of its experimental outcomes and methodological strengths (reference 71).

3.3 Analysis the function with arts therapies

The main effects of each art therapy on sleep quality are shown in Table 6. In modern society, sleep issues have become a common health concern, not only affecting the quality of individual lives but also leading to a range of physical and mental health problems (74). As research into non-pharmacological treatments for SIMDs deepens, art therapy has gained attention as an alternative method. This review aims to explore the effectiveness and mechanisms of various arts therapies in improving sleep quality through a systematic analysis of 17 research articles.

With technological advancements, meditation practices using virtual reality (VR) technology have become feasible (75). By simulating natural environments and combining deep breathing and guided meditation, VR meditation has shown significant effects in shortening the time to fall asleep, reducing the number of awakenings during the night, and increasing deep sleep duration, offering a new perspective and method for sleep therapy (57, 76).

Meditation, especially mindfulness meditation, has proven to be an effective self-regulation method for chronic insomnia sufferers by reducing anxiety and stress before sleep, shortening the time to fall asleep, and improving sleep quality (77). Research indicates that meditation not only alleviates SIMDs but also reduces negative emotions such as anxiety and depression, thereby enhancing daytime function and quality of life. These multiple benefits make meditation a powerful tool for treating SIMDs (59).

Qigong and Tai Chi, ancient Chinese mind-body practices (78), improve sleep quality through a series of slow, orderly movements and breathing techniques. These practices not only promote physical relaxation and reduce psychological stress but also regulate the endocrine system, effectively improving SIMDs (79). For example, a 12-week Qigong training for premenopausal women successfully improved their sleep quality and daytime drowsiness (61). Similarly, Tai Chi practice has been shown to enhance self-reported sleep quality and physical function in the elderly, indicating its positive effect on sleep improvement (62).

Biodanza therapy, a dance movement therapy that integrates music, movement, and emotional expression (64), did not show significant differences in directly improving sleep quality but effectively alleviated stress and depression, indirectly promoting a better rest state. Its significant effect in relieving stress, anxiety, and depression indirectly helps attain better sleep (80). Music therapy, including listening to soothing music and music videos, has also shown potential in improving sleep quality in adults and the elderly (65). Music can extend subjective sleep duration, shorten stage two sleep duration, prolong rapid eye movement sleep, and overall improve participants' sleep experience (67, 81). These studies emphasize music as a non-pharmacological intervention that improves sleep quality by reducing stress responses, relaxing the body and mind, and diverting attention (82).

Yoga therapy, particularly Kundalini yoga and Yoga Nidra, has been proven to have a positive impact on improving sleep quality (71, 72). By improving physical flexibility, enhancing muscle strength, deep breathing, and meditation practices, it not only improves sleep quality but also has a significant therapeutic effect on emotional disorders such as depression and anxiety (83). These improvements suggest that yoga can be an effective treatment method for SIMDs. This effectiveness is not only immediate at the end of yoga practice but can last up to six months after the practice has ended (84), implying that the improvement in sleep quality through yoga is not temporary but has a certain durability. This underscores yoga practice as a long-term effective non-pharmacological treatment method, not just a short-term intervention.

Mindfulness-Based Stress Reduction (MBSR)/Mindfulness-Based Cognitive Therapy (MBCT) courses have had a positive effect on improving emotional regulation and sleep problems (73), significantly reducing depressive symptoms and improving sleep quality in the elderly population with depression.

Overall, these arts therapies provide a diverse range of non-pharmacological treatment options for SIMDs. They significantly improve sleep issues through various mechanisms such as emotional regulation, stress reduction, improving the wakefulness state before sleep, and enhancing sleep quality. Future research should further explore the specific mechanisms of action, sustained effects, and how these arts therapies can be effectively integrated into existing sleep disorder treatment frameworks.

3.4 Literature quality assessment

Leveraging Table 4, our analysis meticulously appraised the comprehensive quality of each study through the Joanna Briggs Institute (JBI) methodology, assigning a one-point increment for every "Yes" response, culminating in an aggregate score out of 13. Within this cohort of 17 randomized controlled trials (RCTs), the paper authored by Sat Bir distinguished itself with a high-quality score of 12 (reference 72), closely trailed by the contributions from En-Ting, László, and Erica, each securing a commendable score of 11 (references 67, 68, 72). This echelon of papers stands apart for their rigorous alignment with quality parameters, whereas the corpus of remaining studies predominantly manifested moderate quality, with the exception of Shu-chuan's work, which uniquely aligns with the aforementioned group by also securing a score of 11 (references 67, 68, 72). One RCT article notably diverged from this trend, recording a modest score of 6 (reference 61) upon JBI evaluation.

TABLE 4 Quality of evidence in the included 17 reports based on JBI's critical appraisal tools.

Study Design	ID	Authors	Year	Journal	Evaluation for Evidence Reported													
					1	2	3	4	5	6	7	8	9	10	11	12	13	Ranking
RCT	1 (57)	Soon Young, et al.	2020	Intensive and Critical Care Nursing	Y	Y	Y	N	UN	N	Y	N	Y	Y	Y	Y	Y	9
RCT	2 (58)	Jennifer, et al.	2021	General Hospital Psychiatry	Y	UN	Y	N	UN	UN	N	Y	Y	Y	Y	Y	Y	8
RCT	3 (59)	Jason, et al.	2014	Sleep	Y	Y	Y	N	UN	UN	N	Y	Y	Y	Y	Y	Y	9
RCT	4 (60)	David, et al.	2015	JAMA internal medicine	Y	Y	Y	N	UN	UN	N	Y	Y	Y	Y	Y	Y	9
RCT	5 (61)	Shu-chuan, et al.	2012	The Journal of Alternative and Complementary Medicine	N	UN	Y	N	UN	UN	N	Y	Y	Y	Y	Y	N	6
RCT	6 (62)	Fuzhong, et al.	2004	Journal of the American Geriatrics Society	Y	Y	Y	N	UN	Y	N	Y	Y	Y	Y	Y	Y	10
RCT	7 (63)	Michael, et al.	2008	Sleep	Y	Y	Y	Y	UN	UN	N	Y	Y	Y	Y	Y	Y	10
RCT	8 (64)	Marı´a, et al.	2017	The Journal of Alternative and Complementary Medicine	Y	UN	Y	N	UN	UN	N	Y	Y	Y	Y	Y	Y	8
RCT	9 (65)	Chiung-Yu, et al.	2017	Complementary therapies in medicine	Y	Y	Y	N	UN	Y	N	Y	Y	Y	Y	Y	Y	10
RCT	10 (66)	Qun, et al.	2016	The Journal of Alternative and Complementary Medicine	Y	Y	Y	N	UN	Y	N	Y	Y	Y	Y	Y	Y	10
RCT	11 (67)	En-Ting, et al.	2012	International journal of nursing studies	Y	Y	Y	UN	UN	Y	Y	Y	Y	Y	Y	Y	Y	11
RCT	12 (68)	La´szlo´, et al.	2008	Journal of advanced nursing	Y	Y	Y	UN	UN	Y	Y	Y	Y	Y	Y	Y	Y	11
RCT	13 (69)	Angela, et al.	2014	Complementary therapies in medicine	Y	N	Y	N	UN	UN	Y	Y	Y	Y	Y	Y	Y	9

(Continued)

TABLE 4 Continued

Study Design	ID	Authors	Year	Journal	Evaluation for Evidence Reported													Ranking
					1	2	3	4	5	6	7	8	9	10	11	12	13	
RCT	14 (70)	Hui-Ling, et al.	2006	Journal of advanced nursing	Y	Y	Y	N	UN	UN	Y	Y	Y	Y	Y	Y	Y	10
RCT	15 (71)	Erica, et al.	2023	Journal of Psychosomatic Research	Y	Y	Y	UN	UN	Y	Y	Y	Y	Y	Y	Y	Y	11
RCT	16 (72)	Sat Bir, et al.	2021	Journal of Clinical Sleep Medicine	Y	Y	Y	Y	Y	UN	Y	Y	Y	Y	Y	Y	Y	12
RCT	17 (73)	Nima, et al.	2024	BMC public health	Y	UN	Y	UN	UN	UN	N	Y	Y	Y	Y	Y	Y	8
		Y%			94%	70%	100%	11%	5%	35%	41%	94%	100%	100%	100%	100%	94%	

JBI, the Joanna Briggs Institute; Y, Yes; N, No; UN, Unclear.
JBI Critical Appraisal Checklist for Randomized Controlled Trial: 1. Was true randomization used for assignment of participants to treatment groups? 2. Was allocation to treatment groups concealed? 3. Were treatment groups similar at the baseline? 4. Were participants blind to treatment assignment? 5. Were those delivering treatment blind to treatment assignment? 6. Were outcomes assessors blind to treatment assignment? 7. Were treatment groups treated identically other than the intervention of interest? 8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? 9. Were participants analyzed in the groups to which they were randomized? 10. Were outcomes measured in the same way for treatment groups? 11. Were outcomes measured in a reliable way? 12. Was appropriate statistical analysis used? 13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

A deeper dive into the JBI quality assessment criteria across these 17 RCT articles revealed that questions 3, 9, 10, 11, and 12 witnessed unanimous affirmative responses. This uniformity underscores a foundational concordance among the studies with regards to the critical aspects of including treatment groups based on clear baseline characteristics, ensuring randomness in subgroup allocations, maintaining uniformity and authenticity in measurement techniques, and employing appropriate statistical analyses. Such consistency is pivotal for establishing the foundational integrity of trial methodologies.

Conversely, a nuanced examination reveals that questions 4 and 5, which probe the implementation of double-blind or single-blind protocols in RCTs, presented a spectrum of "No" and "Unclear" responses across all examined literature. This variance highlights a prevalent methodological vulnerability within the domain, signifying a crucial area for future methodological refinement and adherence to ensure the elimination of bias and elevation of research quality standards.

3.5 Description of the control intervention

According to Table 3, within the ambit of the 17 randomized controlled trials (RCTs) scrutinized in the presented literature, a discernible allocation of control group methodologies is observed. Notably, a majority, specifically 10 RCTs, embraced a 'Normal Routine' strategy for their control groups, an approach characterized by the absence of any specialized methodological intervention for participants afflicted with sleep disorders (58, 61, 64, 65, 67–71, 73). This strategy ostensibly serves to mirror the unaltered daily routines of individuals, thereby establishing a baseline for comparative analysis. An integrative approach was adopted in three RCTs, employing 'Sleep Hygiene Education' as the control group intervention. This methodological choice is predicated on the dissemination of essential medical knowledge, aiming to cultivate an awareness among patients regarding the principles conducive to healthy sleep patterns (60, 66, 72).

Complementing these, the remainder of the dataset, comprising four RCTs, instituted a varied spectrum of control conditions, specifically 'Daily Routine Sleep Intervention,' 'Self-Monitoring,' 'Low-Impact Exercise,' and 'Health Education.' These interventions (57, 59, 62, 63) were distinctively implemented.

3.6 Main results on the primary outcomes

Under PICO(S) design in Table 3, In the analytical examination of 17 randomized controlled trials (RCTs) delineated in our systematic review, the utilization of the Pittsburgh Sleep Quality Index (PSQI) emerged as the predominant tool for outcome measurement, with an overwhelming 14 studies (57, 60–70, 72, 73) electing the PSQI as their principal evaluative instrument. This universal adoption underscores the PSQI's acknowledged efficacy in gauging the multifaceted aspects of sleep quality within clinical research paradigms. The Pre-Sleep Arousal Scale (PSAS) was employed as the measurement methodology in two distinct RCTs

TABLE 5 Clinical setting, country, and characteristics of the participants.

Name	Setting hospital	Nation/ Region	Treatment location	Types of SIMDs	Sample size	Gender	Mean age
Soon Young, et al.	Dong-A University Hospital	South Korea	Cardiac ICU	Sleep fragmentation	48	M,F	66.42
Jennifer, et al.	Arizona State University	USA	Mobile app	Insomnia symptoms	237	M,F	44.24/ 44.15
Jason, et al.	Academic medical center	USA	Rush University Medical Center	Chronic Insomnia	54	M,F	42.9
David, et al.	University of California, Los Angeles	USA	UCLA medical research center	Difficulty maintaining sleep	49	M,F	66.3
Shu-chuan, et al.	two communities	Taiwan	No description	Sleep Disorders	70	F	48.60/ 48.69
Fuzhong, et al.	General community	USA	residential areas	No description	118	F	75.30/ 75.45
Michael, et al.	General community	USA	No description	Chronic Insomnia	112	F	69.6/69.7/ 69.8/70.7
Marı´a, et al.	the Faculty of Health Sciences of the University of Almerı´a	Spain	the Faculty of Health Sciences of the University of Almerı´a	No description	95	M,F	22.33/ 21.77/ 22.45
Chiung-Yu, et al.	No description	Taiwan	Participants' homes	No description	71	F	41.06
Qun, et al.	Urban community centers	China	Participants' homes	Difficulty maintaining sleep	64	M,F	69.38
En-Ting, et al.	Sleep Laboratory	Taiwan	Sleep Laboratory	Chronic Insomnia	50	M,F	31.82
La´szlo´, et al.	Semmelweis University	Hungary	Institute of Behavioural Sciences	poor sleep quality	94	M,F	22.6
Angela, et al.	community center	Singapore	Participants' homes	poor sleep quality	60	M,F	64.0
Hui-Ling, et al.	General community	Taiwan	Participants' homes	Trouble falling asleep	60	M,F	67
Erica, et al.	National University of Natural Medicine	USA	Helfgott Research Institute	insomnia	18	M,F	30/33
Sat Bir, et al.	Brigham and Women's Hospital	USA	No description	sleep onset insomnia	40	M,F	43.5/40.8
Nima, et al.	No description	Iran	nursing homes	insomnia	60	M,F	66/67

(59, 72), signifying its specialized application in assessing pre-sleep cognitive and somatic arousal levels. Of note, one study (57) innovatively combined the PSQI with both the Sleep Scale A (SSA) and an activity tracker (FitBit Charge 2, ATFC2), thus broadening the spectrum of sleep-related data acquisition. Similarly, an additional study (59) integrated Total Wake Time (TWT) alongside the PSQI, thereby enriching the dimensional coverage of sleep disturbances being investigated.

The Epworth Sleepiness Scale (ESS), a tool designed to measure daytime sleepiness, was cohesively utilized across three studies (62, 68, 70). Notably, the sophisticated technology of electroencephalography (EEG) was harnessed for data collection in two studies (65, 71).

3.7 Therapeutic with SIMDs

Music therapy, featured prominently as the most frequently cited intervention method among the 17 studies reviewed, distinguishes itself from other modalities by its passive nature, as opposed to the active engagement required by the others (65–70).

TABLE 6 Comparative analysis of results across modalities.

Method	Name	Types	Results
meditation	Jennifer, et al. (58)	RCT	using the Calm app can lead to improvements in depression and anxiety in adults with sleep disturbance, as well as reductions in fatigue, daytime sleepiness, and pre-sleep arousal.
	Jason, et al. (59)	RCT	mindfulness meditation, especially MBSR and MBTI, significantly reduces wakefulness, pre-sleep arousal, and insomnia severity. MBTI was more effective than MBSR after 6 months, with both maintaining long-term benefits, suggesting mindfulness as a potential chronic insomnia treatment.
	David, et al. (60)	RCT	mindfulness meditation is a feasible and effective treatment option for older adults with mild sleep problems, improving sleep quality and reducing daytime impairment. The intervention had a large effect size on sleep quality.
Qigong	Shu-chuan, et al. (61)	RCT	A 12-week Qigong exercise program improved menopausal symptoms and sleep quality in perimenopausal women.
Tai Chi	Fuzhong, et al. (62)	RCT	A 6-month tai chi program significantly improves self-rated sleep quality and reduces daytime sleepiness in older adults with moderate sleep complaints.
	Michael, et al. (63)	RCT	TCC showed greater benefits compared to health education, with a higher proportion of participants achieving improved sleep quality. TCC can be considered as an effective option for enhancing sleep quality.
Biodanza	Marı´a, et al. (64)	RCT	Biodanza effectively reduces stress and depression in university students, as well as improves sleep quality. Biodanza group showed significant improvements in depression, perceived stress, and subjective sleep quality compared to the control group.
Music	Chiung-Yu, et al. (65)	RCT	music and music video interventions did not have a significant effect on objective sleep parameters, but the music group had a longer subjective total sleep time compared to the music video group.
	Qun, et al. (66)	RCT	The sustained improvement in sleep quality in the intervention group compared to the control group suggests that music intervention is an effective non-pharmacological therapy for improving sleep quality in older adults.
	En-Ting, et al. (67)	RCT	listening to soothing music improves both objective and subjective sleep quality in adults with chronic insomnia.
	La´szlo´, et al. (68)	RCT	listening to music significantly improved sleep quality in students with poor sleep, while the audiobook and control groups did not show any improvement.
	Angela, et al. (69)	RCT	After 6 weeks of listening to calming music, the intervention group had significantly better sleep quality scores than the control group.
	Hui-Ling, et al. (70)	RCT	music therapy improves sleep quality in older adults, including better perceived sleep quality, reduced sleep latency, increased sleep efficiency, less daytime dysfunction, and improved sleep duration after two weeks.
yoga	Erica, et al. (71)	RCT	Yoga Nidra is a feasible and well-tolerated intervention for individuals with insomnia, showing a potential decrease in respiratory rate.
	Sat Bir, et al. (72)	RCT	Kundalini yoga, as a primary treatment for insomnia, led to improvements in sleep onset latency and other sleep measures compared to sleep hygiene intervention, sustained at 6-month follow-up.
MBSR/ MBTI	Nima, et al. (73)	RCT	The mindfulness-based stress reduction (MBSR) program led to a significant reduction in depression symptoms and improvement in emotion regulation and sleep quality among depressed elderly individuals.
VR	Soon Young, et al. (57)	RCT	VR meditation improved ICU patients' sleep quality, including subjective sleep ratings and objective sleep measures such as shorter awake times and longer deep sleep times compared to the control group.

TCC, Tai Chi Chih; MBSR, mindfulness-based stress reduction; MBTI, mindfulness-based therapy for insomnia.

This form of therapy, characterized by the passive auditory reception of music, serves to alleviate emotional tension and soothe neural stress without necessitating physical movement, making it particularly well-suited for improving sleep disturbances among the elderly with limited mobility. According to Table 4 of the PICO(S) framework, in the elderly population, two randomized controlled trials (RCTs), each involving around 60 participants split into two groups, conducted interventions over periods of 3 and 6 weeks. The pre and post-intervention data, gauged by the Pittsburgh Sleep Quality Index (PSQI), demonstrated a comprehensive amelioration of SIMDs in the elderly (69, 70). In studies targeting younger demographics, such as college students, La´szlo´ divided participants into three groups of 35, 30, and 29. After a 3-week intervention, data from the PSQI and Beck Depression Inventory (BDI) indicated that music therapy could concurrently suppress depressive symptoms and sleep disorder manifestations (68). A 3-day experiment focusing on adults with chronic insomnia revealed that listening to soothing music for 45 minutes before sleep significantly prolonged the rapid eye movement (REM) sleep phase (67). As a form of passive intervention, music therapy, a non-pharmacological measure, has been shown to effectively enhance sleep initiation and maintenance in patients with sleep quality issues (85), particularly benefiting those who prefer natural remedies or are concerned about the side effects of sleep medications, without requiring physical movement (86). Allowing participants to select their preferred music enhances the effectiveness of the intervention, as personal preference plays a critical role in the therapeutic impact of music. However, choices in music can vary greatly, and there is no standardized method for selecting the type or duration of music to be used for sleep therapy. Nevertheless, according to Table 4 of the PICO(S) framework, most studies on music therapy interventions had short durations, lacking data on the long-term efficacy and sustainability of music therapy for treating SIMDs (65, 67, 68, 70).

Besides music therapy's passive interventions, all other methods included in the 17 studies fall under active interventions, with meditation and mindfulness being primary modalities (57–60, 73), followed by physical movement-based interventions like Qigong, Tai Chi, dance, and yoga (61–64, 71, 72). Tai Chi and Qigong therapies, among these active interventions, had the longest durations of engagement, spanning 2 months, 3 months, and 6 months, utilizing slow, rhythmic movements and deep breathing to achieve relaxation and equilibrium of body and mind. Studies have shown that Qigong improved menopausal symptoms and sleep quality in the intervention group after 6 and 12 weeks compared to the control group, while Tai Chi required long-term intervention, such as more than 24 weeks, to exhibit a significant improvement in sleep, with the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale (ESS) serving as primary measurement tools (61–63). Meditation is a commonly employed method in the treatment of SIMDs, typically involving 6–8 week interventions focused primarily on elderly individuals, especially those experiencing sleep disturbances. Research suggests that mindfulness meditation may correlate with reduced concentrations of NF-κB (a transcription factor associated with inflammatory responses), indicating a potential anti-inflammatory effect beneficial to seniors. Furthermore, meditation therapy has been found to improve mental health issues in the elderly, alleviating depression, anxiety, and feelings of loneliness. Meditation, often linked to Buddhism or yoga, typically incorporates techniques such as silence, breath counting, and visualization during training, aimed at reducing stress and intrusive thoughts, thereby psychologically remedying non-organic insomnia (58–60, 73). Yoga and dance, requiring some degree of physical effort, have shown varying impacts. Despite no significant intergroup differences in EEG alpha-wave power, heart rate variability (HRV), or sleep latency observed with Yoga Nidra (a form of guided meditation practice), a statistically significant difference in respiratory rate between the Yoga Nidra group and the control group suggests that Yoga Nidra may aid in relaxation, though further research is necessary to confirm (71). The effects of Kundalini yoga and Sleep Hygiene Education (SH) on chronic primary insomnia showed the yoga group had greater improvements in sleep onset latency (SOL), total sleep time (TST), and sleep efficiency (SE), with these improvements persisting at a 6-month follow-up. Over 50% of participants in the yoga group reported a decrease of at least 8 points in the Insomnia Severity Index (ISI) at the end of treatment and during the follow-up period (72). The dance therapy Biodanza, after a 4-week intervention among university students, significantly reduced stress, tension, and depressive moods, indirectly ameliorating sleep issues to some extent (64).

Virtual reality (VR) devices, with their immersive capabilities, offer a promising complement to meditation or mindfulness therapies. However, caution is warranted when applying this emerging technology to older populations, as it may induce fear, stress, and anxiety, potentially exacerbating sleep disorder issues (57).

In conclusion, music therapy emerges as the most extensively documented passive intervention within the study, utilizing auditory reception to mitigate emotional and stress-related issues. It has proven effective in improving sleep disturbances among both the elderly and younger populations, requiring no physical exertion and allowing for personalized music selection to enhance intervention outcomes. Despite the absence of data on long-term effectiveness, music therapy remains a beneficial non-pharmacological intervention (87). Concurrently, the study also explores active interventions such as meditation, Qigong, Tai Chi, yoga, and dance, which are also effective in improving sleep quality among specific groups. The nascent combination of VR technology with meditation shows potential therapeutic effects but should be approached cautiously when applied to older individuals to avoid eliciting adverse emotional responses.

4 Discussion

Given the comprehensive analysis of the results surrounding different arts therapies for mitigating SIMDs, our discussion will explore the optimal combination of these therapies to achieve maximum effectiveness for various demographics. The results highlight the varying benefits of passive and active interventions, including music therapy, meditation, Tai Chi, Qigong, Yoga, and Biodanza, as well as emerging technologies like virtual reality (VR) meditation. By understanding the unique advantages of each method, we can propose tailored, multimodal therapy regimens that cater to specific needs.

The evidence strongly suggests that a combination of passive and active therapies might offer a synergistic effect on improving sleep quality and duration (88–90). Music therapy, the most extensively studied passive intervention in the included literature, demonstrated significant potential in improving sleep quality for both elderly and younger populations without the necessity of physical movement (91, 92). This points to the utility of integrating music therapy into the bedtime routine of individuals across different age groups, particularly those with limited physical mobility or preference for less physically demanding interventions (93, 94).

On the other hand, active therapies like Meditation, Tai Chi, Qigong, and Yoga, have shown promise in not only improving sleep quality but also enhancing psychological well-being and reducing stress, anxiety, and depressive symptoms. These findings suggest that active interventions, which often incorporate elements of mindfulness, physical movement, and breathwork, can address both the physiological and psychological contributors to SIMDs.

The diversity in demographics across the studies, including varying age groups, health statuses, and cultural backgrounds, underscores the necessity of personalized therapy plans. For instance, older adults may benefit more from a combination of music therapy with gentle Qigong exercises, which mitigate the risk of falls while promoting relaxation and improving sleep (95). Conversely, younger individuals, particularly those experiencing stress and anxiety (e.g., college students), might find a combination of high-intensity Biodanza and meditation more effective, leveraging the physical exertion of dance to alleviate stress and the mindfulness aspect of meditation to prepare the mind for rest (96, 97).

Additionally, for those experiencing more profound psychological issues, such as depression, integrating therapies that specifically target emotional well-being—like meditation with music therapy (98)—can be particularly beneficial. This combination can leverage the stress-reducing and mood-enhancing benefits of music alongside the mindfulness and self-awareness cultivated through meditation, offering a holistic approach to treating SIMDs.

The integration of VR technology into meditation practices presents an innovative approach to enhancing the immersion and effectiveness of mindfulness exercises for SIMDs. However, given the potential for VR to induce anxiety or discomfort in certain populations, its application should be carefully considered. Tailoring VR experiences to match individual preferences and introducing these technologies gradually can mitigate potential adverse reactions. Furthermore, combining VR-enhanced meditation with more traditional, familiar therapeutic practices like music therapy could offer a balanced approach, providing the novel benefits of VR while ensuring comfort and accessibility (99).

For the integration of arts therapies to be most effective, ongoing assessment and adaptation of therapy plans are crucial. This includes regular monitoring of individual responses to therapy, readiness to modify or switch therapies based on efficacy and preference, and continually updating the therapy plan as new evidence emerges. Future research should focus on longitudinal studies to better understand the long-term effectiveness of combined therapies and to refine these recommendations further.

SIMDs frequently coexist with, or are exacerbated by, psychological conditions such as anxiety, depression, and stress, suggesting a bidirectional relationship between sleep disturbances and mental health issues (100). The complex interplay between these factors highlights the importance of emotional regulation in the effective management of SIMDs. As sleep problems often serve as both a symptom and a contributor to mental health issues, addressing the psychological underpinnings is paramount (101). This underscores the necessity for therapeutic approaches that not only target the physiological aspects of SIMDs but also focus on psychological de-escalation. Arts therapies, with their inherent capacity for emotional expression and regulation, offer a unique conduit for this purpose (102). In the forward trajectory of research, it is imperative that experimental designs embody stringent rigor, with the incorporation of single-blind and double-blind methodologies in randomized controlled trials (RCTs) being non-negotiable to mitigate the potential for data skewness. Furthermore, the endeavor to extend art therapy over protracted durations for the amelioration of sleep disorders poses a formidable challenge in the context of healthcare personnel ratios. The paucity of healthcare professionals in numerous developing nations presents a tangible barrier to the scalable application of art therapy to a broad demographic afflicted with sleep disturbances. This scenario necessitates a considerable investment of resources and dedication, thereby underscoring the exploration of artificial intelligence (AI) as a plausible adjunct or enhancer of art therapy practices. The potential for AI to bridge the gap in patient care and augment the efficacy of arts therapies represents a nascent yet promising paradigm, meriting earnest scholarly attention.

5 Limitations

The systematic review of randomized controlled trials (RCTs) evaluating the efficacy of arts therapies in addressing SIMDs provides strong evidence supporting the potential advantages of these interventions. Nonetheless, the presence of several methodological limitations within the analyzed studies necessitates thorough scrutiny, as it could affect the interpretation of results and guide the trajectory of subsequent research in this domain.

The systematic review highlights a prevalent issue in the included randomized controlled trials (RCTs) regarding participant blinding and the blinding of individuals administering treatments. As identified using the Joanna Briggs Institute (JBI) critical appraisal tool, a majority of the studies (11 out of 17) lacked participant blinding, raising serious concerns about bias in self-reporting of symptoms and treatment response. This lack of blinding could lead participants to have heightened expectations or placebo effects, which are well-documented phenomena in clinical research. These biases can significantly skew the reported efficacy of the arts therapies, leading to potentially inflated outcomes.

The absence of blinding among treatment administrators in 16 out of the 17 reviewed studies poses a critical threat to the validity of the study findings. Unblinded facilitators might unconsciously convey their expectations to participants, affecting the latter's responses and engagement. This methodological oversight complicates the interpretation of the efficacy of arts therapies, as the observed benefits could be attributed to non-specific effects rather than the therapeutic intervention itself. Restricting the systematic review to English-language studies introduces another significant limitation by potentially overlooking valuable research conducted in other languages. This limitation not only restricts the diversity of the data but also introduces a cultural bias, limiting the generalizability of the findings to English-speaking populations. Art therapy practices, being deeply influenced by cultural contexts, might show different levels of efficacy and engagement in diverse cultural settings. Therefore, extending future systematic reviews to include multiple languages and cultural contexts could uncover more nuanced insights about the applicability and effectiveness of arts therapies across different global populations.

The short duration of interventions reported in four of the RCTs presents another limitation regarding the sustainability of the therapy benefits. While immediate improvements in sleep quality were noted, the long-term efficacy of these interventions remains uncertain. This limitation is significant as the chronic nature of SIMDs requires sustained management strategies. Future research should focus on longitudinal studies that assess the effects of arts therapies over extended periods to better understand and validate the longevity of the therapeutic benefits.

6 Conclusion

This comprehensive review, through an extensive analysis of 17 studies, examines the efficacy and mechanisms of arts therapies—including music therapy, meditation, Tai Chi, Qigong, yoga, Biodanza, and VR meditation—in improving Sleep Initiation and Maintenance Disorders (SIMDs). The findings reveal that these arts therapies, whether employed singularly or in conjunction, serve as effective non-pharmacological interventions to enhance sleep quality. Notably, music therapy, as a passive modality, significantly improves sleep quality in both elderly and younger populations, indicating its suitability as a pre-sleep routine across various age groups. Active therapies such as meditation, Tai Chi, Qigong, and yoga not only aid in augmenting sleep quality but also demonstrate positive effects on mental health, offering relief from stress, anxiety, and symptoms of depression. These active interventions, integrating mindfulness, physical movements, and breathing techniques, provide a holistic approach to addressing both physiological and psychological factors associated with SIMDs. The research underscores the importance of tailoring personalized arts therapy programs based on age, health status, and cultural backgrounds—for instance, combining music therapy and Qigong to improve sleep in the elderly, while Biodanza and meditation are more effective in stress relief among the younger demographic. Integrating new technologies like VR with traditional therapies offers innovative experiences in treating sleep disorders. Specific to practical applications in existing medical protocols, integration strategies such as professional training on arts therapies and infrastructural enhancements in healthcare settings can facilitate their adoption. Challenges such as cultural and institutional resistance, alongside hurdles in cost and resource allocation, may impede implementation, yet growing patient preference for non-drug treatments and supportive research outcomes provide favorable conditions for their integration. Future research should focus on the long-term effects of these interventions, integration of technological innovations like artificial intelligence, and the execution of cross-cultural studies to better understand global applicability and cultural influences on therapy effectiveness. Although this review confirms the effectiveness of arts therapies in treating SIMDs, future research should focus on the longevity of therapeutic outcomes, refinement of personalized treatment plans, and innovation through new technology integration, emphasizing longitudinal study designs to understand the long-term effects of combined therapies more comprehensively and further refine treatment recommendations.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

XL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AZ: Writing – original draft, Writing – review & editing. HL: Writing – original draft, Writing – review & editing. YL: Conceptualization, Data curation, Formal analysis, Writing – review & editing. FY: Funding acquisition, Writing – review & editing. XW: Data curation, Software, Writing – review & editing. QY: Data curation, Software, Writing – review & editing. ZZ: Investigation, Writing – review & editing. GH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Current perspectives and trends in acupuncture for sleep disorders: a bibliometric analysis

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Background: Limitations of conventional treatment methods for sleep disorders have driven the use and development of complementary and alternative therapies such as acupuncture. However, despite the surge in related studies, there is still a lack of visual analysis and detailed elaboration regarding the current status, international collaborations, and research hotspots of acupuncture for sleep disorders.

Methods: We conducted a bibliometric analysis of publications on acupuncture for sleep disorders using the Web of Science Core Collection database from 2004 to 2023. We utilized the R package "bibliometrix" to count publications and citations, VOSviewer to create an inter-institutional referencing network, and CiteSpace to identify references and keywords with the highest citation bursts. Additionally, we employed a bibliometric online analysis platform designed for analyzing national partnerships.

Results: A total of 432 pertinent papers were retrieved, with China being the most prolific contributor, accounting for 61.6% of the publications, followed by the United States and South Korea. Despite China's high output, its average article citation rate and proportion of international collaborations were notably lower than those of the United States. Key research institutions such as the University of Hong Kong, Shanghai University of Traditional Chinese Medicine, Memorial Sloan Kettering Cancer Center, and Guangzhou University of Chinese Medicine have played significant roles in this field. Among authors, Ka-Fai Chung from the University of Hong Kong stood out as the most productive. In terms of journals, MEDICINE was the most active, while SLEEP was considered the most authoritative. The clinical effects of acupuncture for insomnia have garnered significant attention in recent years, with electroacupuncture emerging as the prevailing technique for addressing sleep disorders.

Conclusion: This bibliometric study effectively outlines the basic framework of knowledge surrounding acupuncture for sleep disorders over the past two decades, covering publications, countries, institutions, authors, and sources. It highlights promising clinical effects and underlying mechanisms of acupuncture, particularly for secondary insomnia and specific sleep disorders like restless legs syndrome. Moving forward, the focus and challenge for future research lie in the development of standardized study protocols and harmonization of efficacy assessment metrics.

KEYWORDS

acupuncture, sleep disorders, bibliometrics, visualization, insomnia, electroacupuncture

1 Introduction

Sleep disorders encompass abnormalities in the rhythm, quality, and behavior of sleep, frequently arising from disruptions in the intrinsic mechanisms of sleep-wakefulness or as a result of psychiatric or somatic disorders (1). They represent a prevalent concern among patients seeking medical consultations. To address the intricate clinical manifestations of sleep disorders, the third edition of the International Classification of Sleep Disorders edition 3 classifies them into seven groups: insomnia disorders, sleep-related breathing disorders, circadian rhythm sleep-wake disorders, central disorders of hypersomnolence, sleep-related movement disorders, parasomnias, and other sleep disorders (2). Sleep disorders have a pervasive impact on individuals across all age groups, with a trend towards younger demographics (3, 4). Incomplete statistics indicate that the occurrence of insomnia alone accounts for more than one-third of the global population, resulting in a substantial annual medical expenditure of approximately $100 billion (5, 6). In the short term, sleep disorders can contribute to the development of neurasthenia, memory impairment, and weakened immune function. Over the long term, these disorders significantly elevate the susceptibility to mood disorders such as anxiety and depression, as well as physical ailments including stroke, cancer, and heart disease, thereby posing a severe threat to both the physical and mental well-being of individuals (7).

Currently, the clinical treatment options for sleep disorders are very limited, primarily falling under the categories of pharmacologic and nonpharmacologic treatments. Pharmacotherapy is commonly used to treat patients with acute sleep disorders, but its long-term efficacy is uncertain and has been associated with withdrawal symptoms, cognitive deficits, and cardiac arrhythmias (8, 9). Nonpharmacological approaches encompass cognitive behavioral therapy, exercise, acupuncture, and transcranial magnetic stimulation (10). According to traditional Chinese medicine theory, meridians are the channels for qi and blood flow, and acupoints are specific locations on the meridians where qi and blood from organs enter and exit (11). Yin and yang are a group of relative concepts, and disease is often the outward manifestation of an imbalance of yin and yang. As one of the nonpharmacological treatments for sleep disorders, acupuncture enhances the body's immunity to eradicate pathogenic elements, harmonizes yin and yang, and reinstates the organism to its optimal physiological state by stimulating specific acupoints on the body's surface (12). Empirical investigations have substantiated the safety and efficacy of acupuncture in addressing diverse sleep disorders, including insomnia, restless leg syndrome, jet lag syndrome, and sleep-related bruxism (13–15). Basic research has confirmed that acupuncture restores circadian rhythms in sleep-deprived rodents and improves their performance on behavioral tests (16, 17). It may involve brain-derived neurotrophic factors, inflammatory cytokines, the hypothalamic-pituitary-adrenal axis, the gut microbiota, and other cellular events (18). With the growing global interest in sleep-related issues and the recent advocacy for acupuncture, there has been a noticeable surge in publications concerning the application of acupuncture in sleep disorder management. However, existing reviews have mainly focused on the clinical efficacy and specific techniques of acupuncture interventions for different sleep disorders while neglecting to comprehensively summarize and reflect on the history, research status, impact, and emerging themes of relevant publications in the field (19, 20).

Bibliometric analysis is a commonly used method of quantitative research on publications that summarizes the progress of a research topic and analyzes the contributions of authors, institutions, journals, and countries or regions through collecting, processing, and managing data from previous publications (21). In addition, bibliometric analysis can identify hotspots, emerging trends, and knowledge networks in a given field. In 2019 Wenya Pei et al. published a bibliometric analysis on acupuncture for insomnia (22). However, this study mainly quantitatively analyzed and ranked the countries, journals, authors, and references in this field based on the number of publications and citations. It did not elaborate on the international cooperation situation of countries and institutions, the development trend of authors, keywords, and citations, or a qualitative analysis of the research hotspots. There is a lack of bibliometric studies that provide an in-depth and comprehensive discussion of publications on acupuncture for the broad category of sleep disorders.

The Web of Science (WoS) is a comprehensive, multidisciplinary, core journal citation indexing database for accessing global scholarly information (23–25). With over 1.7 billion searchable citation records, it offers a rigorous screening process for academic journals, making it more internationally recognized compared to other databases such as Scopus and Google Scholar (24). Therefore, we conducted a systematic bibliometric analysis of publications on acupuncture for sleep disorders published in the Web of Science Core Collection (WoSCC) database between 2004 and 2023, including publication distribution, country, institution, source, authors, references, and keyword clustering. In addition, this paper provides an overview of research progress over the past 20 years and identifies research hotspots and trends in the field. In short, this is the first description of a bibliometric overview of research on acupuncture for sleep disorders. With this study, we aim to fill a gap in the existing literature and provide researchers, clinicians, and specialists with a comprehensive understanding of the field's current outlook and potential future directions.

2 Materials and methods

2.1 Data collection and search strategy

On October 6, 2024, we searched the WoSCC database for relevant publications. We used title searches to minimize the impact of non-directly related studies. Inclusion criteria were publication between January 1, 2004, and December 31, 2023, publication in English, and titles containing search terms related to "acupuncture" and "sleep disorders." Exclusion criteria were the absence of two or more elements, such as title, abstract, source, publication date, references, authors, organization, duplication of studies, or inconsistent year of publication. The records of eligible publications were extracted and saved as "BibTex" and "plain text file" formats for further analysis. The specific search strategy and data collection process can be seen in Table 1 and Figure 1.

2.2 Data analysis

For bibliometric analysis, five tools were used, namely Citespace (version 6.2.R4), R software (version 4.1.2), Bibliometric Online Analysis Platform (https://bibliometric.com/), VOSviewer (version 1.6.19) and Scimago Graphica (version 1.0. 44). CiteSpace, a citation visualization and analysis software based on the JAVA programming language, with Years per slice set to 1, G-index to 21, and pruning followed by visualization, was used to identify keywords with citation bursts and to perform clustering (25). The biometrics package in the R software ran and automatically invoked the default browser to open the biblioshiny web page to count the number of publications and citations by country, journal, and author (26). The bibliometrics online analysis platform analyzed national partnerships through World Wide Web services (27). The threshold was set to at least five publications, and a visualization network for institutional co-authorship analysis was constructed using VOSviewer, and combined with Scimago Graphica for beautification (28).

TABLE 1 Search strategy.

Date run	Sunday, October 6, 2024	
Database	Web of Science Core Collection	
Search formula	AND	TI = ("acupuncture" OR "needling" OR "electroacupuncture" OR "electro-acupuncture" OR "warm needling" OR "warm acupuncture" OR "fire needle" OR "dry needling" OR "scalp acupuncture" OR "body acupuncture" OR "ear acupuncture" OR "auricular acupuncture" OR "abdominal acupuncture" OR "wristankle acupuncture" OR "manual acupuncture" OR "Moxibustion" OR "acupoint" OR "acupoint injection")
		TI = ("sleep*" OR "insomnia" OR "sleep-related" OR "hypoventilation" OR "hypersomn*" OR "narcolepsy" OR "Kleine-Levin syndrome" OR "sleep-wake" OR "jet lag" OR "nightmare" OR "Parasomnia*" OR "confusional arousals" OR "exploding head syndrome" OR "restless legs syndrome" OR "periodic limb movement disorder")
Publication year	Thursday, January 1,2004 - Sunday, December 31,2023	
Language	English	

3 Results

3.1 Summary of publications

Based on the eligibility criteria, a total of 432 English-language publications on acupuncture for sleep disorders published between 2004 and 2023 were included, with 251 regular articles (58.1%) and 97 review articles (22.45%). Figure 2A illustrates the quantity and trend of annual publications on acupuncture for sleep disorders. The average annual growth rate of pertinent publications over the previous two decades has been 11.77%. Among them, the yearly and cumulative number of publications from 2004 to 2018 increased gradually, with an average of 10.67 publications per year. It was not until 2015 that the cumulative number of publications exceeded 100, indicating that research on acupuncture for sleep disorders is still in its infancy. In the last five years, the number of publications has increased dramatically compared to the previous period, with the total number of articles not yet exceeding 500, potentially due to the limited prevalence of acupuncture techniques for treating sleep disorders.

The papers' impact can be assessed by examining the average number of citations. Figure 2B shows that only seven articles on acupuncture for sleep disorders were published in 2009, However, each article received an average of 71.71 citations, and the average number of citations per year also peaked. This result indicates a high level of research output for that year. The average number of citations per article and per year has generally decreased since 2018. This decline may be attributed to the notable rise in relevant publications over the past five years compared to the previous period, while new publications are cited less frequently.

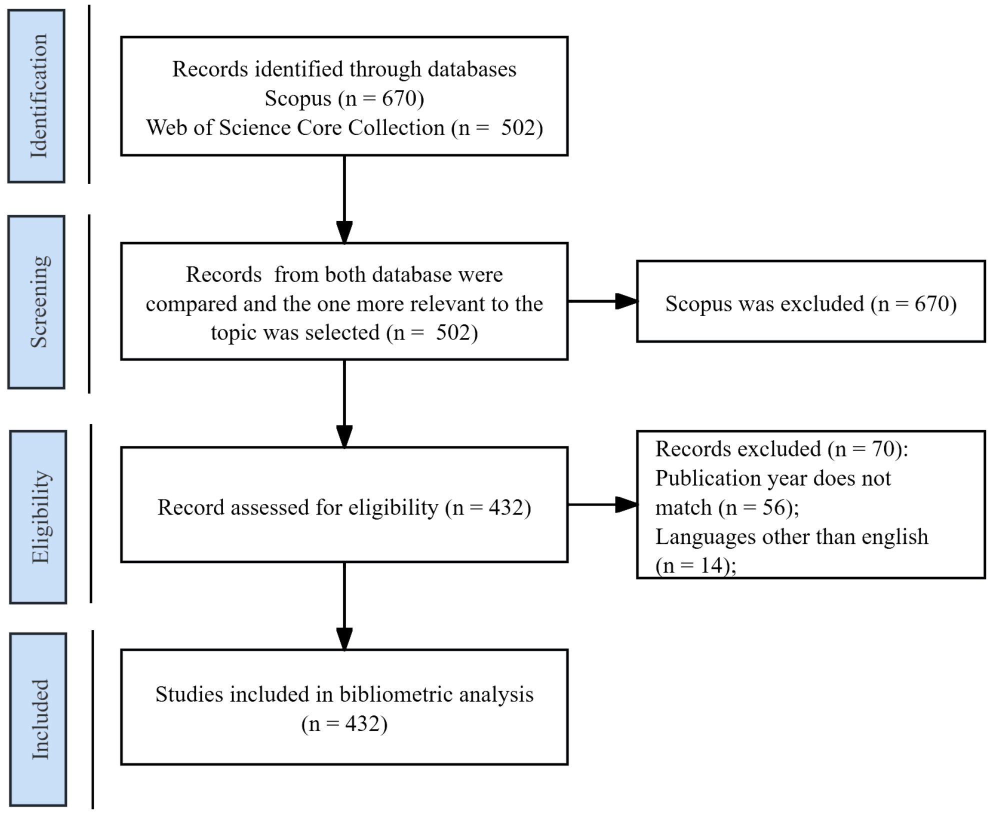

FIGURE 1
Study selection flowchart.

3.2 Country analysis

A total of 27 countries have contributed to scientific research on acupuncture for sleep disorders. China emerged as the leading contributor, accounting for 61.6% of the publications, followed by the United States (U.S.), South Korea, and Brazil, while the rest of the countries had fewer than ten relevant publications (Figure 3A). It is worth noting that China published 266 papers, with transnational cooperation only accounting for 7.1% of the total research outputs, suggesting that China places more emphasis on domestic cooperation. Nonetheless, China continued to excel in international collaboration, working with ten countries, with the U.S. being its closest partner, with 17 collaborations (Figure 3B). The U.S. has cooperated with five countries, in particular with Canada on 14 occasions, and more than one-third of its publications were multinational and widely recognized internationally.

Table 2 elucidates the correlation between the number of publications and citations among the top ten prolific countries. Intriguingly, China has emerged as the foremost contributor in terms of publications and total citations, but its average article citation rate fell considerably below that of the subsequent countries, the U.S. and South Korea. This indicates that China's relevant publications exhibit an uneven quality and necessitate further attention. Canada has published only three articles, with an average of 53 citations, demonstrating its enormous international influence.

3.3 Institutional analysis

Between 2004 and 2023, a total of 465institutions globally published scholarly works related to acupuncture for sleep disorders. Figure 4 illustrates a visual network for inter-institutional co-authorship analysis, with nodes representing institutions and the size of the nodes reflecting the number of publications. The lines represent cooperative relationships between institutions, and the thickness of the lines is proportional to the strength of the association. Institutions with at least five publications were included in the analysis, which contained six clusters and 33 nodes after removing isolated unconnected nodes. The University of Hong Kong (papers: 81; total link strength: 44), Shanghai University of Traditional Chinese Medicine (papers: 75; total link strength: 60), Memorial Sloan-Kettering Cancer Center (papers: 50; total link strength: 21), and Guangzhou University of Traditional Chinese Medicine (papers: 41; total link strength: 16) occupied the pivotal positions of the visualized network graph. Cluster 1 (red) consisted of nine institutions, dominated by the Guangzhou University of Traditional Chinese Medicine, Chengdu University of Traditional Chinese Medicine, and Beijing University of Traditional Chinese Medicine. The cluster's sphere of influence extended to five provinces in China and linked to all four other clusters. Cluster 2 (green) was divided into two sub-clusters based on the proximity of the nodes: one dominated by the University of Hong Kong and the Hong Kong Baptist University, and the other

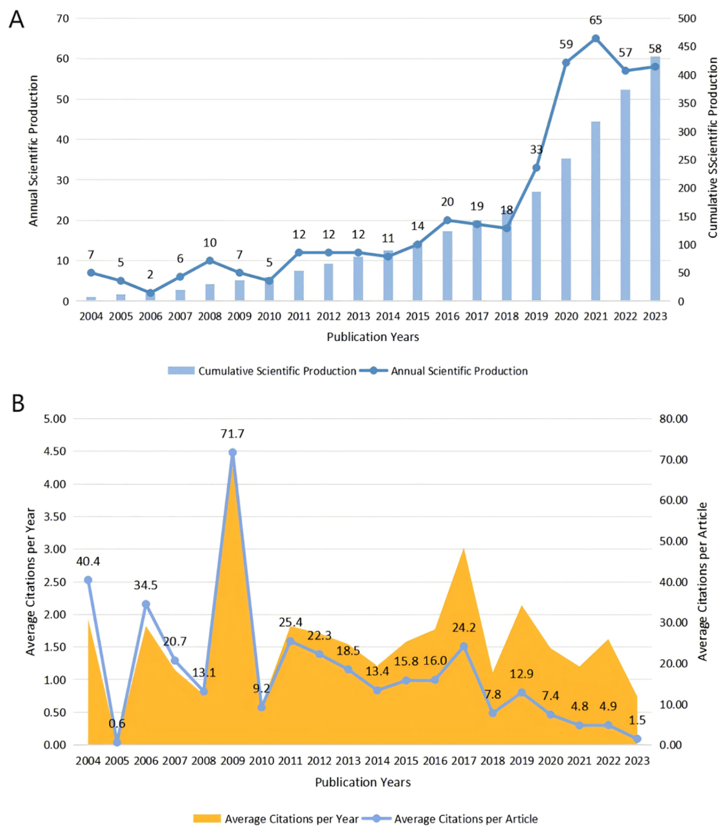

FIGURE 2
(A) Annual and cumulative scientific production; **(B)** average citations per article and per year.

consisting of institutions in Shanghai, such as the Shanghai University of Traditional Chinese Medicine and Fudan University. Cluster 3 (blue) consisted primarily of North American research institutions such as Emory University, Sloan-Kettering Cancer Institute, and the University of Pennsylvania. Cluster 4 (yellow) concentrated on early research institutions engaged in acupuncture for sleep disorders, such as China Medical University and National Taiwan University. Cluster 5 (purple) was an emerging research collective that included institutions such as RMIT University, Tongji University, and Shanghai Sanda College. Cluster 6 (ice) was small and consisted mainly of Chinese universities, led by Changchun Medical University. A clear geographical pattern can be seen in the cooperation of these institutions.

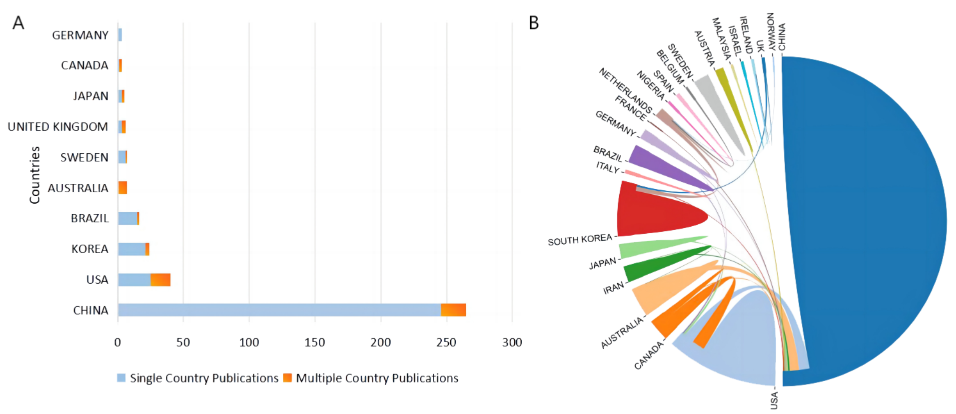

FIGURE 3
(A) National distribution of relevant authors; **(B)** National cooperation. The connecting lines indicate that the countries at either end of the line have cooperated; the thicker the line, the more frequent the cooperation. The area of each panel represents the percentage of relevant publications in each country; the larger the area, the greater the number of relevant publications.

TABLE 2 Number of publications and citations by country.

Countries	Articles	Total Citations	Average Article Citations
China	266	2747	10.3
US	40	663	16.6
South Korea	24	397	16.5
Brazil	16	150	9.4
Australia	7	156	22.3
Sweden	7	145	20.7
UK	6	109	18.2
Japan	5	24	4.8
Canada	3	159	53.0
Germany	3	21	7.0

3.4 Sources analysis

Over the past two decades, 146 sources have published articles on acupuncture for sleep disorders. According to Table 3, the top 11 sources were all journals, accounting for 45.83% (198/432) of the total publications. Analysis of the journal citation reports reveals that only 27.27% of these journals were classified as Q1 or Q2. Among them, 45.45% belonged to the field of complementary medicine, while 36.36% were associated with clinical neurology. The local citation score indicates the number of citations an article receives from other publications in the same field and can reflect the publication's impact (29). MEDICINE was the most published journal in the field (9.72% of the total), but it received only 69 local citations. As shown in Figure 5, the journal experienced a significant surge in publications in this field starting in 2020, exceeding 40 in 2023. In contrast, SLEEP has established itself as a leading authority in the field, boasting the highest number of local citations, amounting to 651. The identification of such authoritative journals is helpful for researchers in acupuncture for sleep disorders to gain insight into current research trends and hotspots.

3.5 Authors analysis

A total of 1,657 authors were associated with the 432 publications selected. Figure 6 illustrates the productivity of the top 10 authors in the respective field throughout the years. Leading the list is Ka-Fai Chung from the Department of Psychiatry at the University of Hong Kong. He initiated his research on acupuncture for sleep disorders in 2007 and has contributed 18 papers on the subject, accumulating a total of 518 citations. Furthermore, the most influential article in the field, published in 2017, is a collaborative clinical study on the effectiveness and safety of acupuncture for primary insomnia by Shifen Xu from the Shanghai University of Traditional Chinese Medicine and Lixing Lao from the University of Hong Kong, with 129 total citations and 16.13 citations per year. Figure 6 also demonstrates an increasing number of researchers exploring acupuncture as a potential treatment for sleep disorders within the past five years, suggesting a promising outlook for its application.

3.6 Analysis of research hotspots

3.6.1 Most cited articles

Citation analysis helps to elucidate the interconnections and influence of publications within a specific research domain (30).

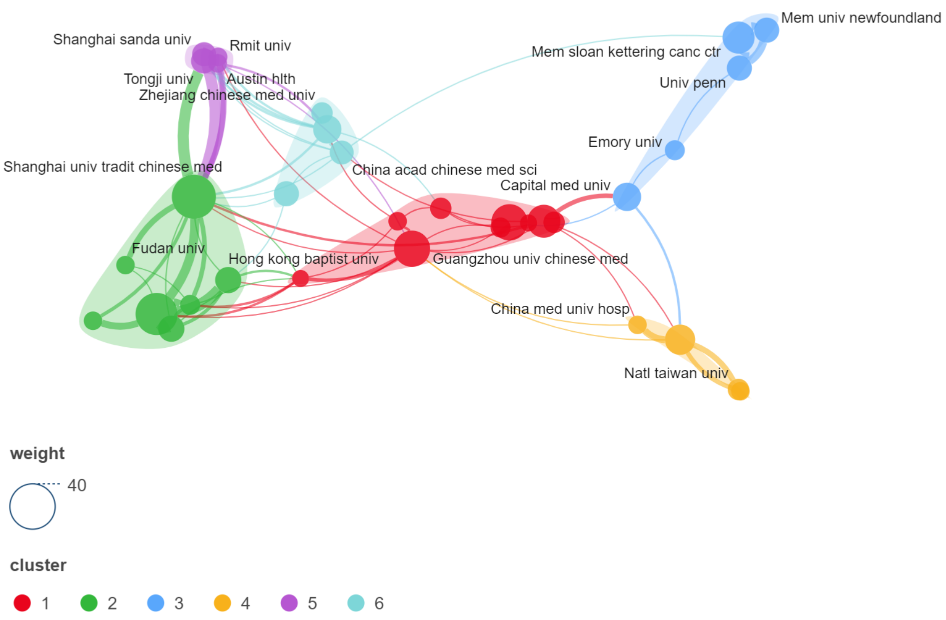

FIGURE 4
Institutional co-authorship analysis visualization network.

 10.3389/fpsyt.2024.1338455

TABLE 3 Most relevant sources.

Ranking	Sources	Articles	Local Citations	JCR-c (IF)
1	MEDICINE	42	69	Q3 (1.60)
2	EVIDENCE-BASED COMPLEMENTARY AND ALTERNATIVE MEDICINE	32	306	Q3 (2.65) *
3	ACUPUNCTURE IN MEDICINE	21	193	Q3 (2.50)
4	WORLD JOURNAL OF ACUPUNCTURE - MOXIBUSTION	20	29	Q4 (0.70)
5	SLEEP	18	651	Q1 (5.60)
6	TRIALS	15	65	Q4 (2.50)
7	JOURNAL OF TRADITIONAL CHINESE MEDICINE	12	120	Q3 (2.60)
8	JOURNAL OF ACUPUNCTURE AND TUINA SCIENCE	10	33	Q4 (0.50)
9	JOURNAL OF SLEEP RESEARCH	10	107	Q2 (4.40)
10	NATURE AND SCIENCE OF SLEEP	9	55	Q3 (3.40)
11	SLEEP MEDICINE	9	412	Q2 (4.80)

JCR-c, Joumal Ctation Reports category (2022); IF, impact factor (2022); *The journal was removed from the SCI Catalog (2022) and adopted the 2021 edition.

Table 4 presents the citation rankings for articles on acupuncture for sleep disorders. All but one systematic review and one meta-analysis were clinical studies, and 80% of the studies focused on insomnia. The publication titled "Acupuncture Increases Nocturnal Melatonin Secretion and Reduces Insomnia and Anxiety: A Preliminary Report" from 2004 garnered the highest number of citations, amounting to 138, thus presenting initial evidence regarding the efficacy of acupuncture in ameliorating sleep disorders, particularly anxiety-induced insomnia. The article "Acupuncture Versus Cognitive Behavioral Therapy for Insomnia in Cancer Survivors: A Randomized Clinical Trial" published in the Journal of the National Cancer Institute in 2019 was ranked 7th, a highly cited article in recent years. The article compared acupuncture with cognitive-behavioral therapy and demonstrated that both were effective in improving insomnia among cancer survivors. Acupuncture was found to be more suitable for concurrent pain management. These findings suggest that acupuncture has been increasingly advocated for the management of both primary and secondary sleep disorders.

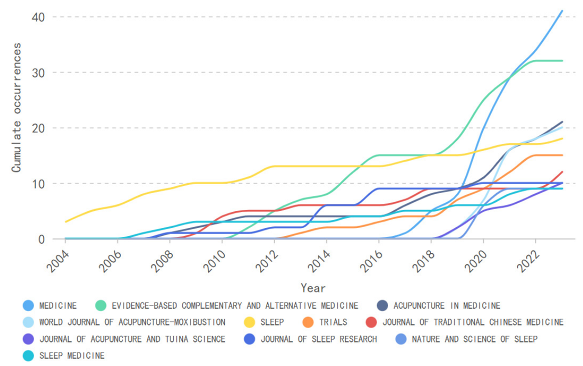

FIGURE 5
Trends of publications in the top 10 sources.

3.6.2 Reference analysis for citation bursts

Citation burst refers to a surge in citations to a particular publication within a specific timeframe (31). Figure 7 shows the 20 publications on acupuncture for sleep disorders that have experienced the highest citation bursts over the past two decades. In the figure, the light blue line represents the pre-publication period of the article, the dark blue line signifies the post-publication period, and the red line denotes the duration of the citation burst. For instance, the article "Efficacy and safety of acupuncture treatment on primary insomnia: a randomized controlled trial" published in 2017 attained the highest citation burst value of 11.37. Furthermore, the ongoing citation bursts in six articles, such as "The Efficacy of Acupuncture for Treating Depression-Related Insomnia Compared with a Control Group: A Systematic Review and Meta-Analysis" suggests that research on acupuncture for secondary insomnia remains prevalent.

3.6.3 Analysis of the most frequently used keywords

Figure 8A illustrates the ten most commonly used keywords and their frequency in studies on acupuncture for sleep disorders. "Sleep," "electroacupuncture," and "acupuncture" ranked in the top 3, representing the major research fields. "Insomnia" was the dominant category of acupuncture for sleep disorders. Additionally, keywords like "quality," "validation," and "efficacy" imply that the effectiveness of acupuncture for sleep disorders remains a hot topic at present.

Keyword clustering relies on co-occurrence analysis and employs statistical techniques to condense the co-occurrence network into a limited number of clusters, wherein keywords sharing common themes are grouped (32). In general, silhouette values above 0.7 provide reliable clustering results (33). Figure 8B visually presents the keyword clustering of acupuncture for sleep disorders. The lower the label number, the greater the number of keywords encompassed within the clustering. The modularity value for this graph is 0.5048, while the silhouette value is 0.7845,

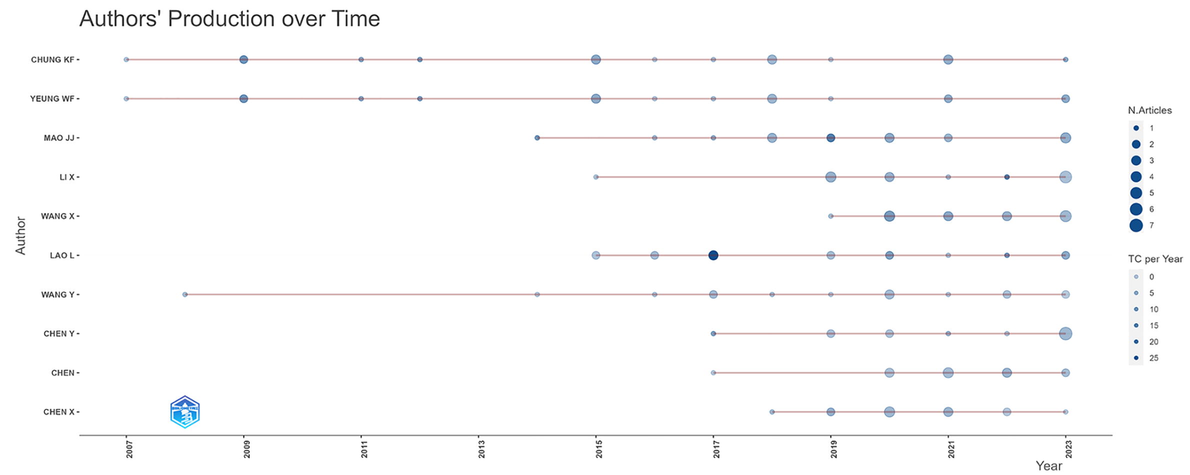

FIGURE 6
Authors production over time.

indicating a well-formed cluster. The 644 keywords within the specified domains were divided into 11 clusters, specifically labeled as "validation," "restless legs syndrome," "randomized clinical trial," "stroke," "manual acupuncture," "delta eeg," "breast neoplasm," "sleep disturbance," "quality of life," "children," and "randomized controlled trial."

Figure 8C shows a three-field plot depicting the authors, keywords, and sources with the highest relevance within the domain. The height of each rectangle in the plot is proportional to the relevance. It is evident that the most locally cited journal in this field, SLEEP, and the top-ranked author, Ka-Fai Chung, focus on the topics of "insomnia," "electroacupuncture," "randomized controlled trial," and "depression".

3.6.4 Analysis of keywords citation bursts

Figure 8D lists the top 10 keywords with the highest citation bursts. The temporal sensitivity of the keywords has resulted in a noticeable absence of significant burst intensity depicted in this graph. However, certain keywords, such as "stimulation" (2004-2015), "double blind" (2006-2016), and "acupressure" (2007-2014) have consistently attracted attention over an extended period. In contrast, "major depressive disorder" (2018-2020), "management" (2017-2019), and "prevalence" (2016-2018) have experienced a surge in attention over the past five years. This trend indicates that the epidemiology, presentation, and management of sleep disorders are expected to remain prominent research topics in the field of acupuncture for sleep disorders.

TABLE 4 Top 10 articles in total citations.

Rank	Title	Total Citations	Annual citations	DOI
1	Acupuncture increases nocturnal melatonin secretion and reduces insomnia and anxiety: a preliminary report	138	6.57	10.1176/appi.neuropsych.16.1.19
2	Efficacy and safety of acupuncture treatment on primary insomnia: a randomized controlled trial	129	16.13	10.1016/j.sleep.2017.02.012
3	Acupuncture for treatment of insomnia: a systematic review of randomized controlled trials	107	6.69	10.1089/acm.2009.0041
4	Acupuncture for insomnia	106	8.15	10.1002/14651858.CD005472.pub3
5	Electroacupuncture for fatigue, sleep, and psychological distress in breast cancer patients with aromatase inhibitor-related arthralgia: a randomized trial	102	9.27	10.1002/cncr.28917
6	Electroacupuncture for primary insomnia: a randomized controlled trial	102	6.38	10.1093/sleep/32.8.1039
7	Acupuncture Versus Cognitive Behavioral Therapy for Insomnia in Cancer Survivors: A Randomized Clinical Trial	89	14.83	10.1093/jnci/djz050
8	Electroacupuncture for residual insomnia associated with major depressive disorder: a randomized controlled trial	88	6.29	10.5665/SLEEP.1056
9	Acupuncture and reflexology for insomnia: a feasibility study	86	5.38	10.1136/aim.2009.000760
10	Acupressure and Transcutaneous Electrical Acupoint Stimulation in improving fatigue, sleep quality and depression in hemodialysis patients	76	3.67	10.1142/S0192415X04002065

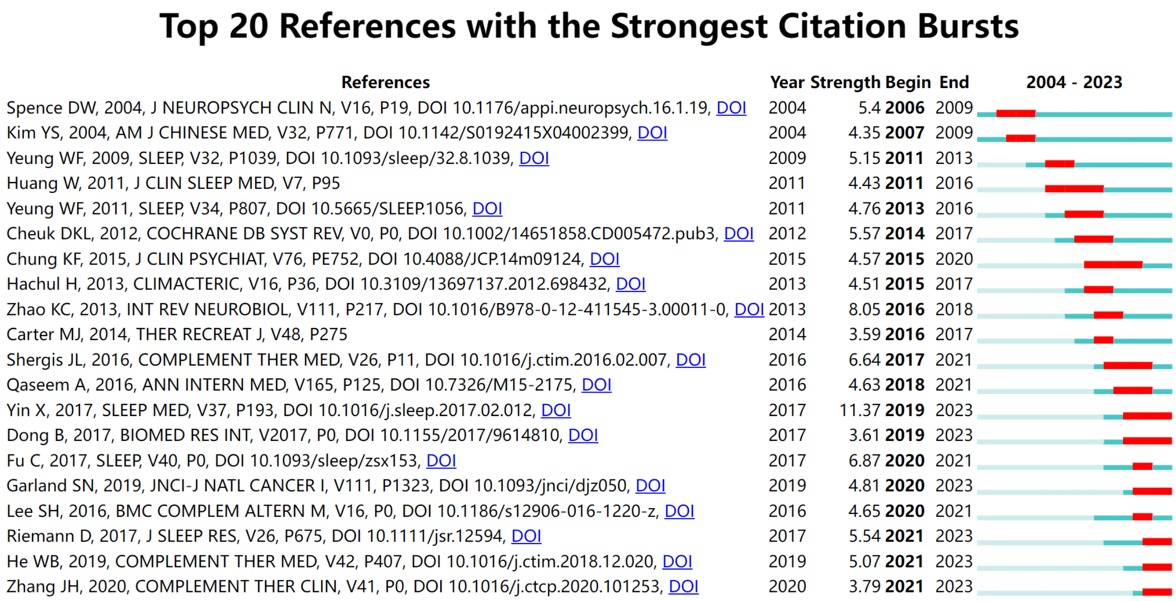

FIGURE 7
Top 19 publications with the highest citation bursts.

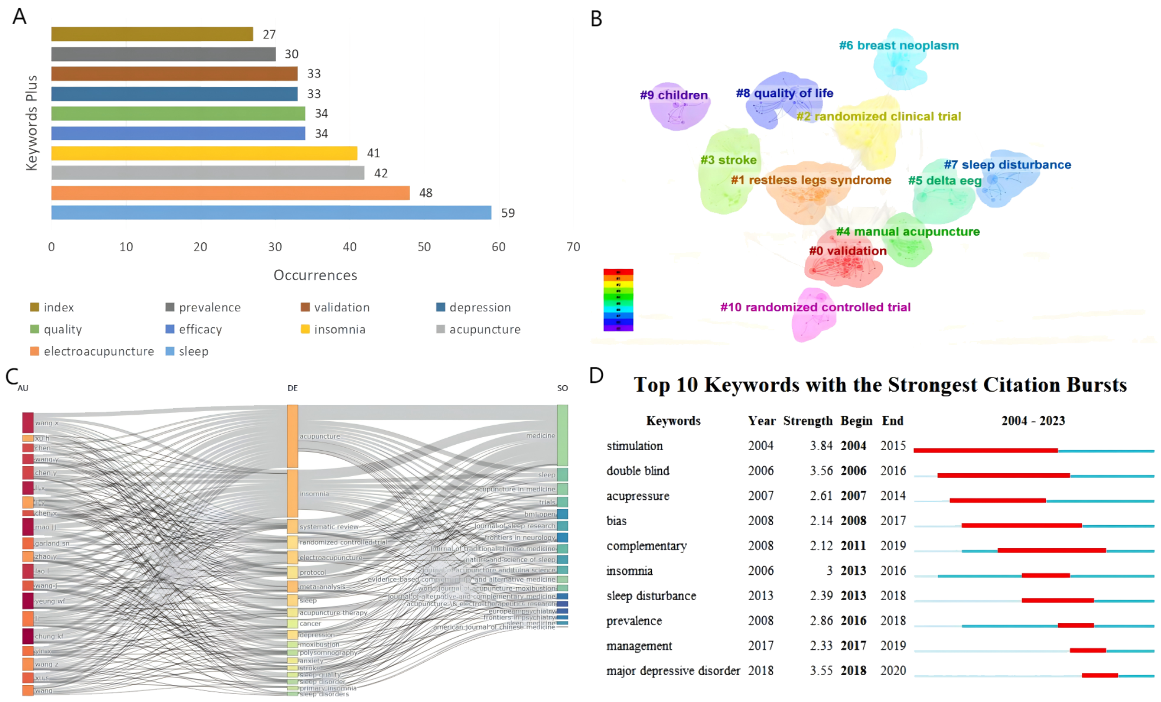

FIGURE 8
(A) Top 10 most frequent keywords; **(B)** Clustering of keywords; **(C)** Three-factor map of authors, keywords, and sources; **(D)** Top 10 keywords with the strongest citation bursts.

4 Discussion

4.1 Global trends in acupuncture for sleep disorders

This study quantitatively analyzed the historical and present state of the development of acupuncture for sleep disorders over the past two decades. Within the last five years, there has been a notable increase in publications within this field compared to the preceding period. However, the average number of citations per year and per article has exhibited a contrasting trend, indicating a deficiency in high-quality and innovative publications regarding acupuncture for sleep disorders. A study of acupuncture for insomnia from 1999-2018 also confirmed a slow growth of pertinent literature until 2018 (22). Twenty-seven countries in Asia, Europe, North America, and Oceania have participated in studies of acupuncture for sleep disorders. China emerged as the primary contributor, but more than 90% of these contributions resulted from domestic collaborations, with an average article citation rate of 10.3, indicating a lack of significant international impact. The University of Hong Kong, Shanghai University of Traditional Chinese Medicine, and Guangzhou University of Chinese Medicine were the major research institutes. In contrast, the U.S. engaged in several high-quality international collaborations, particularly with Canada and South Korea, resulting in an average article citation rate of 16.6. This achievement can be attributed to the contributions made by various institutions such as the University of Pennsylvania, Stanford University, and the Memorial Sloan Kettering Cancer Center. Furthermore, the U.S. government has provided more healthcare support, with a per capita healthcare expenditure of $10,784 in 2021 alone, which may contribute to the abundance of noteworthy medical outcomes observed in the U.S. (34, 35). The primary influential sources within this field consist of scholarly journals that concentrate on complementary medicine and clinical neurology. Among these publications, MEDICINE emerged as the most active journal on acupuncture for sleep disorders. Additionally, the esteemed journal SLEEP has published high-level clinical randomized controlled trials of acupuncture for the treatment of perimenopausal insomnia, primary insomnia, and residual insomnia associated with major depression disorder (36–38). The quantification of publications can reflect an author's engagement and impact within a specific scientific domain. Ka-Fai Chung from the University of Hong Kong has been the most prolific researcher, working on acupuncture for sleep disorders since 2007, with 18 related publications. In 2017, Shifen Xu from the Shanghai University of Traditional Chinese Medicine and Lixing Lao from the University of Hong Kong jointly conducted a clinical study to investigate the effectiveness and safety of acupuncture for primary insomnia. This study has been cited more than a hundred times to date (39).

4.2 Hot and emerging frontiers in acupuncture for sleep disorders

Citation analysis, citation bursting, keyword analysis, and keyword bursting are widely employed bibliometric techniques that offer insights into the evolution of research within a particular discipline and enable the anticipation of future research trends and focal points (40). Based on the available data, investigations about acupuncture for sleep disorders have primarily concentrated on five key domains: secondary insomnia, restless leg syndrome, electroacupuncture, effectiveness, and mechanisms.

4.2.1 Secondary insomnia

Insomnia, characterized by frequent difficulties in initiating and maintaining sleep, and dissatisfaction with the sleep quality, is the most common sleep disorder (41). More than 30% of the global adult population has experienced insomnia, and approximately 40% of these individuals have developed chronic insomnia disorder (≥3 months) (41, 42). Among these cases, insomnia cases caused by somatic diseases, mental disorders, substance abuse, and environmental changes are referred to as "secondary insomnia" or "co-morbid insomnia" (43). It is sometimes difficult to establish a causal relationship between these disorders and insomnia, such as chronic pain syndromes and depression, making the diagnosis and treatment of secondary insomnia difficult (44, 45). Table 4 shows that the top 10 most cited articles focused on the clinical effects of acupuncture for insomnia. When considering the findings from citation bursts, it becomes apparent that recent research has increasingly explored the role of acupuncture in addressing insomnia associated with conditions such as cancer, stroke, and perimenopause. This underscores acupuncture's ongoing potential as an alternative therapeutic option (36, 46, 47).

4.2.2 Restless legs syndrome

Restless legs syndrome, a prevalent sleep-related movement disorder, manifests as intense discomfort in the legs at rest, characterized by sensations of tingling, burning, and tightness, with a prevalence of 18%-23% in older adults (48). This disorder may arise either spontaneously or as a consequence of iron deficiency anemia, pregnancy, diabetes, or other contributing factors (49). Dopamine agonists, namely pramipexole, ropinirole, and rotigotine, have received approval from both the U.S. Food and Drug Administration and the European Medicines Agency as primary treatment options for restless legs syndrome. However, these medications still exhibit varying levels of adverse effects and potentiation (50). In recent years, non-pharmacological interventions such as exercise, acupuncture, and repetitive transcranial magnetic stimulation have gained recognition for their potential role in managing this condition. Several clinical randomized controlled trials have provided evidence that acupuncture effectively alleviates leg discomfort and reduces nocturnal activity in restless leg syndrome without causing side effects (14, 51, 52). In the context of keyword clustering, the keywords represented by restless leg syndrome were the second largest cluster, indicating the progressive use of acupuncture for diverse sleep disorders beyond insomnia.

4.2.3 Electroacupuncture

Acupuncture encompasses a range of techniques, such as manual acupuncture, electroacupuncture, warming needle moxibustion, auricular acupuncture, and acupoint injections (53). According to the citation bursts of keywords, "acupressure" has received constant attention over an extended period of time (2007-2014). Acupressure, a non-invasive therapeutic method, is used to achieve therapeutic effects by applying pressure to specific acupoints on the body to regulate qi and blood in the meridians (54). Due to its simplicity in acquisition, acupressure frequently serves as an initial therapeutic approach for sleep disorders, aiming to circumvent the potential detrimental consequences associated with pharmacological interventions. As the global recognition of acupuncture has grown, the prevailing method for addressing sleep disorders has shifted from acupressure to electroacupuncture, as evidenced by the frequency of keyword occurrences. Electroacupuncture is a technique in which low-frequency pulsed currents close to the bioelectricity of the human body are applied to the needles to prevent and treat diseases after the needles are inserted into the acupoints and produce a “deqi” sensation (55). According to previous studies, electroacupuncture can be used to treat various sleep disorders, including primary and secondary insomnia, circadian rhythm sleep-wake disorders, and restless legs syndrome, by manipulating the frequency, intensity, and acupoints (14, 56, 57).

4.2.4 Effectiveness

While cognitive-behavioral therapy is the primary non-pharmacological treatment option acknowledged for sleep disorders, its clinical prevalence is limited due to the need for doctor-patient collaboration and the time-intensive nature of the therapy (58). Consequently, as a complementary alternative therapy, acupuncture has gained considerable usage in the treatment of sleep disorders. However, it remains unclear whether existing evidence is sufficient to support acupuncture for all types of sleep disorders. In the context of insomnia treatment through acupuncture, multiple meta-analyses have demonstrated that the existing evidence is inadequate to establish or dismiss the efficacy of acupuncture for insomnia (19, 59). This insufficiency arises due to the susceptibility of relevant clinical trials to publication bias, owing to the considerable discrepancies in defining insomnia, participant attributes, and study methodologies. “Quality,” “validation,” and “efficacy” were among the top 10 keywords, confirming that clinical trials of acupuncture for sleep disorders are still not standardized. Furthermore, “validation” represented the primary major cluster in the keyword clustering, suggesting that the effectiveness and safety of acupuncture for sleep disorders are still under continuous scrutiny.

4.2.5 Mechanisms

Clinical evidence indicates that acupuncture has been effective in enhancing both the quality and duration of sleep. However, the precise mechanism underlying this effect remains unclear (56). Drawing on previous research, we present a summary of the potential mechanisms through which acupuncture may alleviate sleep disorders. (1) The principle of warming needle moxibustion to improve insomnia is directly related to gene regulation. This acupuncture technique involves inserting moxa sticks into the handles of acupuncture needles after needling the acupoints to dredge collaterals and strengthen the immune system through warm stimulation. A study found that warming needle moxibustion enhanced the expression of microRNA-101a and suppressed the expression of paired-box 8 in the hippocampus of rat models with insomnia (60). In addition, warming needle moxibustion upregulated the transcript levels of brain-derived neurotrophic factor (BDNF), recombinant early growth response protein 1, and b-cell translocation gene 2, protecting the brain from insomnia-related damage (61). (2) The gut microbiota is closely related to sleep, and acupuncture may treat insomnia by modulating host immune responses through gut flora such as Lactobacillus (62, 63). (3) The hypothalamic-pituitary-adrenal axis plays a crucial role in regulating the stress response and serves as a significant component of the neuroendocrine system. Research has demonstrated that electroacupuncture enhances the expression of D1 and D2 receptors in the hypothalamus, reduces the levels of corticotropin-releasing hormone, adrenocorticotropic hormone, and cortisol, mitigates stress-induced changes in neurotransmitters, and ameliorates acute stress-induced insomnia (64). (4) Patients with chronic insomnia exhibit neuronal cell damage in the cerebral cortex, including degeneration, denaturation, and apoptosis. Research has demonstrated that electroacupuncture can modulate apoptosis in insomniac rats by increasing the expression of B-cell lymphoma-2, reducing the expression of Bax, Bcl-xL/Bcl-2-associated death promoter, and caspase-3. This therapeutic approach also targets the PI3K/AKT pathway and the CAMP/CREB pathway to regulate apoptosis and exerts a beneficial effect on monoamine neurotransmitters (65). Furthermore, proteomics data indicate that acupuncture improves sleep by modulating the expression of four neural-related proteins, Prolargin, NMDA receptor synaptonuclear-signaling and neuronal migration factor, Transmembrane protein 41B, and Microtubule-associated protein 1B (66). (5) Electroacupuncture has been shown to enhance memory deficits resulting from sleep deprivation. This effect is attributed to the activation of the BDNF/TrkB/Erk signaling pathway, which promotes the survival of hippocampal neurons and facilitates synaptic plasticity. Furthermore, electroacupuncture has the potential to partially restore dopamine levels in the hippocampus by activating calcium/calmodulin protein-dependent protein kinase II, synaptophysin I, and tyrosine hydroxylase (16, 67). (6) For secondary sleep disorders, 10-Hz electroacupuncture stimulation of the Fengchi (GB20) has been found to suppress focal epilepsy and its associated sleep disorders. This suppression may be related to the involvement of opioid receptors in the central nucleus of the amygdala (68). Shenmen (HT7) is the most commonly used acupoint for sleep disorders and has been widely used to treat neuropsychological disorders such as amnesia, epilepsy, and insomnia (69). Acupuncture at HT7 alleviated caffeine-dependent sleep deprivation by modulating neuronal activity in the basal forebrain arousal region and BDNF-mediated endoplasmic reticulum stress in the medial septum (17, 70). In summary, acupuncture improves sleep disorders by orchestrating a multifaceted mechanism involving various pathways and targets, encompassing the nervous system, endocrine system, and intestinal flora.

5 Limitations

This study is subject to several limitations. Firstly, the data were exclusively obtained from WoSCC, which, while encompassing a substantial portion of high-quality publications in the field, may still have overlooked certain sources. Secondly, due to the complexity of sleep disorder classification and to avoid the inclusion of irrelevant literature, we used a title search but may have missed a few articles. Thirdly, the names of institutions or sources may have changed over time, given the temporal nature of the study. Lastly, it is important to note that academic publications often lag behind clinical reality, thus the findings of this study solely reflect the current research trends in academia, which was the initial purpose of this bibliometric analysis.

6 Conclusion

The study conducted a bibliometric analysis of 432publications in the WoSCC on acupuncture for sleep disorders from 2004 to 2023. As acupuncture techniques continue to gain global recognition, more and more scholars are dedicating themselves to the field. In addition to insomnia, acupuncture is increasingly being used to treat a variety of sleep disorders, with electroacupuncture becoming the new superior technique. However, the effectiveness, safety, and practicability of acupuncture for sleep disorders remain uncertain due to the inadequate quality of prior research. Acupuncture can modulate various targets and pathways within the organism, yet the precise underlying mechanism necessitates further investigation. Nonetheless, we believe that developing standardized protocols for subsequent clinical trials and exploring the mechanisms of acupuncture for sleep disorders will contribute to a broader understanding of the field.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding authors.

Author contributions

YH: Methodology, Writing – original draft, Writing – review & editing. XY: Data curation, Writing – original draft. JZ: Software, Writing – original draft. RH: Methodology, Writing – original draft. YC: Data curation, Writing – original draft. LW: Writing – original draft. BC: Software, Writing – original draft. KZ: Data curation, Writing – original draft. KH: Conceptualization, Writing – review & editing. RM: Funding acquisition, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1338455/full#supplementary-material

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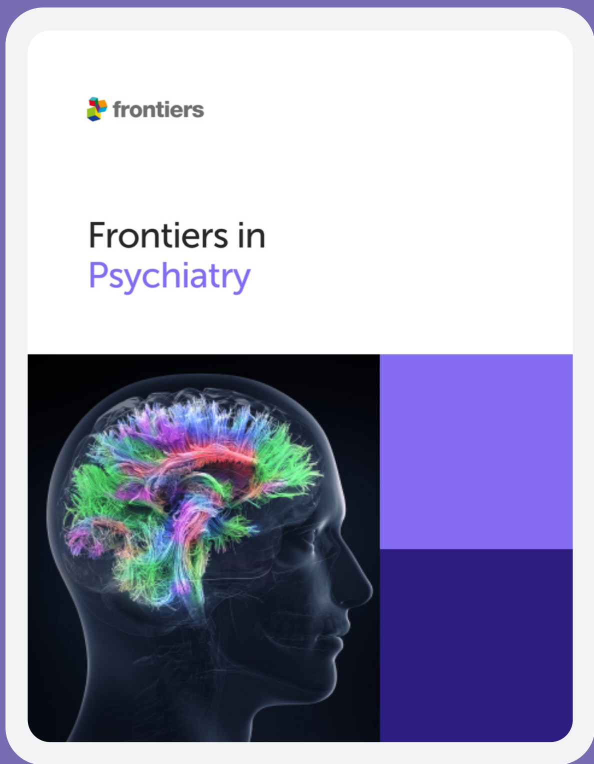

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