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AROMATHERAPY VS. SOUND THERAPY: A NARRATIVE REVIEW OF NON-PHARMACOLOGICAL INTERVENTIONS FOR INSOMNIA

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Abstract:
Background: Insomnia is among the most prevalent sleep disorders worldwide, affecting 10–30% of adults and imposing substantial individual and societal burdens. While pharmacological treatments offer short-term relief, concerns regarding dependence, tolerance, and adverse effects have fueled demand for non-pharmacological alternatives. Aromatherapy and sound therapy represent two accessible, low-cost, sensory-based modalities with growing evidence for sleep improvement; however, no comprehensive review has directly compared their mechanisms, clinical evidence, and applicability. **Objective:** This narrative review aims to comprehensively compare aromatherapy and sound therapy as non-pharmacological interventions for insomnia, examining their neurobiological mechanisms, clinical evidence, safety profiles, and potential for integration into clinical practice. **Methods:** A narrative synthesis was conducted using PubMed, Scopus, CINAHL, and the Cochrane Library, covering publications from 2000 to 2025. Eligible sources included randomized controlled trials (RCTs), systematic reviews, meta-analyses, and mechanistic studies addressing aromatherapy or sound-based interventions for insomnia in adults. Key outcome measures included the Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), sleep onset latency, and total sleep time. **Results:** Both modalities demonstrated clinically meaningful improvements in sleep outcomes. Aromatherapy, particularly lavender inhalation, yielded significant reductions in PSQI scores across meta-analyses (mean difference approximately −2.3 points), mediated by olfactory-limbic activation, GABA-A receptor modulation, and autonomic nervous system (ANS) downregulation. Sound therapy, encompassing slow-tempo music, pink noise, and binaural beats, similarly improved sleep quality (meta-analysis weighted mean difference −2.0 to −2.8 on PSQI) via auditory-limbic entrainment and parasympathetic activation. Despite different sensory entry points, both pathways converge on the limbic system and ANS to reduce the hyperarousal central to insomnia pathophysiology. Safety profiles are favorable for both, with aromatherapy carrying slightly higher risk of allergic reactions and drug interactions. **Conclusion:** Aromatherapy and sound therapy are complementary, evidence-based adjuncts to first-line cognitive behavioral therapy for insomnia (CBT-I).

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Selection should be guided by patient profile, preferences, and safety considerations. A dual-sensory convergence model is proposed to explain the shared limbic mechanism underlying both interventions. Direct head-to-head randomized trials and studies with objective sleep endpoints are needed to further delineate their respective roles.

Keywords: insomnia, aromatherapy, essential oils, music therapy, sound therapy, binaural beats, sleep quality, non-pharmacological, complementary medicine

1. Introduction

Insomnia disorder is characterized by persistent difficulty initiating or maintaining sleep, or early morning awakening, occurring at least three nights per week for a minimum of three months, despite adequate opportunity for sleep, and resulting in significant daytime impairment.[1,2] It is one of the most common health complaints encountered in clinical practice, with an estimated prevalence of 10–30% for chronic insomnia disorder and up to 50% of adults reporting occasional sleep difficulties.[3,4] The global burden of insomnia is substantial: it is associated with impaired cognitive performance, reduced quality of life, increased risk of psychiatric disorders including depression and anxiety, and elevated cardiovascular and metabolic morbidity.[5,6]

Current evidence-based treatment guidelines designate cognitive behavioral therapy for insomnia (CBT-I) as the first-line intervention, with robust meta-analytic support demonstrating its superiority over pharmacotherapy in both efficacy and durability.[7,8] Nevertheless, access to trained CBT-I therapists remains limited in many healthcare settings, and patient adherence to behavioral components such as sleep restriction therapy can be challenging. Pharmacological approaches — including benzodiazepines, non-benzodiazepine receptor agonists (Z-drugs), melatonin receptor agonists, and low-dose sedating antidepressants — provide short-term symptomatic relief but are associated with risks of tolerance, dependence, cognitive impairment, falls in older adults, and rebound insomnia upon discontinuation.[9] These limitations have prompted growing interest in complementary and integrative non-pharmacological approaches.

Among the most accessible and widely utilized are sensory-based interventions: aromatherapy, which harnesses the psychophysiological effects of inhaled aromatic plant-derived compounds, and sound therapy, which employs music, environmental sounds, or engineered audio signals to promote relaxation and sleep. Both modalities are self-administerable, low-cost, and free from significant pharmacological adverse effects, making them particularly attractive as adjunctive strategies in primary care and community settings. Despite a growing body of individual trial evidence, no comprehensive narrative review has systematically compared the mechanistic basis, clinical efficacy, safety profile, and practical applicability of both modalities within the same framework.

This review addresses that gap. We synthesize the neurobiological mechanisms and clinical evidence for both aromatherapy and sound therapy as interventions for insomnia, provide a head-to-head comparative analysis, and propose a dual-sensory convergence model that unifies the limbic and autonomic pathways through which both modalities exert their sleep-promoting effects. Practical guidance for clinicians is also provided, including patient selection criteria, protocol recommendations, and integration with existing behavioral and pharmacological treatments.

2. Insomnia: Pathophysiology and Current Treatment Landscape

2.1 Definition and Diagnostic Criteria

Insomnia disorder is defined by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) as dissatisfaction with sleep quality or quantity, associated with one or more of the following: difficulty initiating sleep, difficulty maintaining sleep, or early morning awakening with inability to return to sleep.[1] These difficulties must occur despite adequate opportunity for sleep, must be present at least three nights per week, must persist for at least three months (chronic insomnia), and must be associated with clinically significant distress or functional impairment.[1,2] The International Classification of Sleep Disorders, Third Edition (ICSD-3) similarly distinguishes chronic insomnia disorder (symptoms ≥3 months) from short-term insomnia disorder (symptoms <3 months).[2]

Insomnia may present predominantly as sleep onset difficulty, sleep maintenance difficulty, early morning awakening, or a combination. It frequently co-occurs with anxiety disorders, major depressive disorder, chronic pain conditions, and medical comorbidities, with a bidirectional relationship that complicates management.[6,12]

2.2 Hyperarousal: The Core Pathophysiological Model

The hyperarousal model, originally conceptualized by Spielman and subsequently refined by Espie and others, provides the most robust explanatory framework for chronic insomnia.[10] It posits that insomnia is maintained by elevated arousal across cognitive, physiological, and cortical domains. Cognitive hyperarousal encompasses intrusive pre-sleep thoughts, excessive worry about sleep, and maladaptive sleep-related beliefs. Physiological hyperarousal manifests as elevated nocturnal heart rate, reduced heart rate variability (HRV), heightened core body temperature, and elevated urinary catecholamines. Cortical hyperarousal is evidenced by increased high-frequency electroencephalographic (EEG) activity, particularly beta (15–30 Hz) and gamma oscillations, during non-rapid eye movement (NREM) sleep, disrupting the restorative slow-wave activity characteristic of healthy sleep.[11]

Both aromatherapy and sound therapy target the hyperarousal substrate — the former via olfactory-limbic downregulation and GABAergic modulation, the latter via auditory entrainment and autonomic quieting — providing a compelling neurobiological rationale for their therapeutic application.

2.3 HPA Axis Dysregulation and Neuroinflammation

Chronic insomnia is associated with dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, characterized by elevated evening cortisol levels, blunted cortisol awakening response, and heightened sensitivity to psychological stressors. This HPA hyperactivity perpetuates nocturnal arousal through corticotropin-releasing hormone (CRH)-mediated activation of the locus coeruleus-norepinephrine system, promoting wakefulness and inhibiting the transition to slow-wave sleep. Additionally, chronic sleep disruption induces a pro-inflammatory state, with elevations in interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP), which in turn further disrupts sleep architecture and contributes to comorbid depression and anxiety.[12]

2.4 Current Treatment Landscape and the Role for Adjunctive Therapies

CBT-I remains the gold standard treatment, with meta-analyses reporting an effect size of d = 0.98 for sleep onset latency and significant improvements in sleep efficiency and total sleep time, with effects maintained at 12-month follow-up.[7] However, the persistent shortage of CBT-I-trained clinicians, particularly in low- and middle-income countries and rural settings, limits its reach. Digital CBT-I platforms have expanded access but still require patient engagement and technological literacy.

Pharmacotherapy — including benzodiazepine receptor agonists, orexin receptor antagonists, and melatonin agonists — provides rapid symptomatic relief but is generally recommended for short-term use only (≤4 weeks) due to adverse effect profiles.[9] In this context, sensory-based non-pharmacological interventions occupy a clinically important niche: they can be self-administered, used alongside CBT-I or pharmacotherapy, and maintained long-term without significant safety concerns. The present review examines two such modalities — aromatherapy and sound therapy — with a view to providing clinicians with a comprehensive comparative evidence base.

3. Aromatherapy for Insomnia

3.1 Definition, History, and Delivery Methods

Aromatherapy is defined as the therapeutic application of aromatic plant-derived essential oils for the purpose of improving physical and psychological wellbeing.[13] Its origins trace to ancient civilizations: aromatic resins and plant extracts were employed for medicinal purposes in ancient Egypt, Greece, China, and the Indian Ayurvedic tradition. The modern discipline of aromatherapy was formalized by the French chemist René-Maurice Gattefossé in the 1930s following his observation of the wound-healing properties of lavender essential oil.

Essential oils are complex volatile mixtures of hundreds of organic compounds extracted by steam distillation or cold pressing from flowers, leaves, bark, roots, or fruits of aromatic plants. Their therapeutic application encompasses three primary delivery routes. Inhalation — via diffusers, direct application to linen, or aromatherapy inhalation devices — represents the fastest route of action for sleep promotion, as volatile molecules reach the olfactory epithelium within seconds. Topical application, typically as diluted preparations in carrier oils (e.g., sweet almond, jojoba), applied to the wrists, neck, or chest, provides a combination of inhalation and transdermal absorption. Aromatic bathing, in which essential oils are dispersed in warm water, combines inhalation and transdermal exposure but is less standardized in research protocols.[14]

3.2 Neurobiological Mechanisms

The neurobiological basis of aromatherapy's sleep-promoting effects is centered on the olfactory-limbic pathway, which is unique among sensory systems in its direct anatomical connectivity to brain regions governing emotion, memory, and autonomic function. Unlike visual or auditory stimuli, which are relayed through the thalamus before reaching cortical processing centers, olfactory signals bypass the thalamus entirely: aromatic molecules bind to olfactory receptor neurons in the nasal epithelium, generating signals that travel via the olfactory nerve (cranial nerve I) to the olfactory bulb, from which projections connect directly to the amygdala, entorhinal cortex, and hippocampus.[13]

The amygdala, which plays a central role in fear processing and emotional arousal, is a primary target of aromatherapy's anxiolytic and sleep-promoting actions. Linalool, the principal bioactive component of lavender essential oil, has been shown in preclinical studies to inhibit amygdala hyperactivity and reduce conditioned fear responses.[13] Additionally, linalool and its ester linalyl acetate act as partial agonists at GABA-A receptors, the primary inhibitory neurotransmitter receptors in the central nervous system, producing sedative effects without the respiratory depression associated with benzodiazepines.[14] This GABAergic mechanism provides a compelling pharmacological explanation for lavender's anxiolytic and sleep-facilitating properties that parallels, yet is distinct from, the action of classical sedative-hypnotic medications.

At the level of the autonomic nervous system, inhalation of lavender essential oil has been shown to increase parasympathetic tone — evidenced by elevated HRV, reduced sympathetic skin conductance, and decreased salivary cortisol — thereby directly counteracting the physiological hyperarousal that characterizes insomnia.[15],[16] Some essential oils, including bergamot, also modulate serotonin 5-HT1A receptors, contributing to mood stabilization and anxiety reduction.[17]

3.3 Key Essential Oils and Active Compounds

Lavender (Lavandula angustifolia) is the most extensively studied essential oil for sleep. Its principal active constituents are linalool (typically 25–38% of composition) and linalyl acetate (25–45%), which together account for its anxiolytic, sedative, and GABAergic actions.[13,14] Multiple RCTs and meta-analyses have evaluated lavender inhalation in diverse populations, consistently demonstrating improvements in self-reported sleep quality as measured by the PSQI.

Roman chamomile (Anthemis nobilis) contains isobutyl angelate and 2-methylbutyl angelate as principal constituents and has demonstrated anxiolytic and mild sedative properties in preclinical and preliminary clinical studies. Bergamot (Citrus bergamia), rich in linalool, linalyl acetate, and limonene, is increasingly studied for its cortisol-lowering and anxiolytic effects, and is frequently combined with lavender in clinical aromatherapy protocols.[17] Valerian essential oil (Valeriana officinalis), whose active compounds include valerenic acid and isovaleric acid, modulates GABAergic transmission and is more commonly studied in oral extract form. Cedarwood (Cedrus atlantica) contains cedrol, which has demonstrated sedative properties in animal models, though high-quality human RCT evidence remains limited.

3.4 Clinical Evidence: Systematic Reviews and RCTs

The evidence base for aromatherapy in insomnia has grown substantially over the past decade. Hwang and Shin conducted a seminal systematic review and meta-analysis of 13 studies examining the effects of aromatherapy on sleep, finding that inhaled aromatherapy — predominantly lavender — significantly improved sleep quality using a random-effects model.[18] Lillehei and Halcon reviewed 15 quantitative studies including 11 RCTs and similarly concluded that lavender aromatherapy provided consistent improvements in sleep quality, though they noted significant methodological heterogeneity across studies in oil type, concentration, delivery method, and outcome measurement.19 Lin and colleagues conducted a more recent meta-analysis reporting significant improvements in PSQI scores (mean difference −2.38, 95% CI −3.27 to −1.49) in favor of aromatherapy.[20]

Key individual trials further substantiate these findings. Karadag et al. conducted a rigorous RCT in patients in an intensive care unit (ICU), demonstrating that lavender aromatherapy via inhalation produced significant improvements in PSQI scores compared to controls receiving standard care.[21] Lewith et al. conducted a single-blinded RCT specifically targeting mild insomnia and found that lavender pillow spray produced a significant improvement in sleep quality compared to control.[22] Kazemzadeh and colleagues demonstrated efficacy specifically in perimenopausal women in a double-blind RCT.23 A comprehensive meta-analysis by Cheong et al. of 34 studies confirmed that aroma inhalation therapy was highly effective in improving sleep problems including insomnia, with the greatest effect observed for single-oil lavender inhalation.24 The overall strength of evidence for aromatherapy in insomnia is rated as moderate, reflecting consistent positive findings across multiple meta-analyses but limited by inherent challenges in blinding, small sample sizes in individual trials, and heterogeneity in protocols and outcome measures.

3.5 Safety Profile

Aromatherapy is generally well tolerated. Adverse effects are most commonly dermatological (contact dermatitis, skin irritation) and arise predominantly with undiluted topical application; they are substantially mitigated by appropriate dilution in carrier oils (1–3% for sleep applications) and patch testing prior to widespread use.[14] Clinically important drug interactions should be considered: lavender and other linaloolcontaining oils may potentiate the sedative effects of CNS depressants, including benzodiazepines, opioids, and alcohol, necessitating caution in polypharmacy contexts. Bergamot oil is phototoxic and should not be applied topically before sun exposure. Camphor-containing oils are contraindicated in epilepsy and in young children. Aromatherapy should be used with caution during pregnancy. Despite these considerations, the safety profile of appropriately administered aromatherapy compares favorably with that of pharmacological sleep aids.[14]

4. Sound Therapy for Insomnia

4.1 Definition, Typology, and Historical Context

Sound therapy for sleep encompasses a broad range of audio-based interventions used to promote relaxation, reduce arousal, and facilitate sleep onset and maintenance.[25] The terminology in this field is diverse and sometimes inconsistently applied. Music therapy, as defined by the American Music Therapy Association, is a clinical discipline involving the therapeutic use of music by a credentialed professional; its application to insomnia includes both active (patient engages in music-making) and receptive (patient listens to music) approaches. In the context of insomnia, receptive music listening is far more commonly studied and applied.

More broadly, sound-based sleep interventions include several distinct modalities. Slow-tempo music, typically performed at 60–80 beats per minute (bpm) to approximate the resting heart rate, encompasses classical compositions, ambient music, and nature-inspired recordings, and represents the most extensively researched category. Environmental sounds — rain, ocean waves, forest birdsong — are widely used for their natural masking properties and perceptual comfort. Broadband noise variants, including white noise (equal energy across all frequencies), pink noise (energy inversely proportional to frequency, approximating natural sounds), and brown noise (further emphasis on lower frequencies), function primarily as acoustic masking agents, reducing the saliency of disruptive environmental sounds.[28] Binaural beats represent a more technologically sophisticated modality, in which two tones of slightly different frequencies are delivered separately to each ear via headphones; the brain perceives a phantom oscillatory beat at the difference frequency, which can be tuned to correspond to target EEG frequency bands associated with specific sleep stages.

4.2 Neurobiological Mechanisms

Sound exerts its sleep-promoting effects via the auditory-limbic pathway. Unlike olfactory input, auditory signals are processed via the cochlea and transmitted through the brainstem auditory nuclei, the medial geniculate nucleus of the thalamus, and the primary auditory cortex before projecting to limbic structures, including the amygdala and hypothalamus. This thalamus-mediated pathway is therefore neuroanatomically distinct from the olfactory pathway but converges on the same limbic targets that regulate emotional arousal and autonomic function.

The most mechanistically distinctive feature of certain sound-based interventions is neural entrainment — the synchronization of endogenous brain oscillations to external periodic stimuli, known as the frequency following response.[26] When exposed to an auditory stimulus oscillating at a specific frequency, neural populations in auditory cortex and connected limbic regions tend to phase-lock their firing patterns to match the stimulus frequency. Binaural beats exploit this phenomenon by delivering a perceived beat at a target frequency: when the desired brain state corresponds to delta-wave sleep (0.5–4 Hz), binaural beats in this range may promote the slow oscillatory activity that characterizes NREM stage 3 (slow-wave sleep).

Pink noise has attracted particular research attention for its specific phase relationship with endogenous slow oscillations. Wang and colleagues demonstrated in a landmark study that pink noise, when delivered in synchrony with the slow oscillatory phase of NREM sleep, significantly enhanced slow-wave amplitude and improved declarative memory consolidation in older adults.[27] The mechanism involves augmentation of thalamocortical spindle-slow oscillation coupling, which is the neural substrate of sleep-dependent memory consolidation.

Across modalities, slow-tempo music and nature sounds promote parasympathetic predominance — evidenced by reduced heart rate, blood pressure, respiratory rate, and elevated HRV — directly counteracting the sympathetic hyperarousal of insomnia.[25] Salivary cortisol, a biomarker of HPA axis activity, has been shown to decrease significantly following pre-sleep music listening in multiple controlled trials, providing a neuroendocrine basis for sound therapy's sleep-promoting effects.

4.3 Clinical Evidence: Systematic Reviews and RCTs

The most rigorous synthesis of music therapy for insomnia is the Cochrane systematic review by Jespersen et al., first published in 2015 and updated in 2022.29,30 The updated review included 13 RCTs involving 1,007 participants and found moderate-certainty evidence that music groups experienced significantly better sleep quality as measured by the PSQI compared to no intervention or treatment as usual (MD −2.79, 95% CI −3.86 to −1.72).[30] De Niet and colleagues conducted an earlier meta-analysis of five RCTs and reported a weighted mean difference of −2.5 on the PSQI in favor of music intervention.31 Wang and colleagues conducted a meta-analysis of 10 RCTs demonstrating significant improvements in both acute and chronic sleep disorders.[32] Jespersen and colleagues also conducted a well-designed RCT in 57 patients with chronic insomnia, demonstrating that music significantly reduced insomnia severity and improved quality of life compared to audiobook and waitlist control conditions.[33]

Cheng and colleagues conducted a meta-analysis of binaural beat interventions and found significant improvements in PSQI scores compared to control conditions, with effect sizes in the moderate range.36 Individual RCTs have also demonstrated efficacy for binaural beats in reducing sleep onset latency and self-reported anxiety, though most studies are of small to moderate sample size and short duration.

Pink noise specifically has been studied primarily for its effects on sleep architecture and memory consolidation; however, the enhancement of SWS has direct relevance to insomnia management, given the disruption of slow-wave activity that characterizes the condition.[27] Nature sounds and white noise have been evaluated primarily in hospital and ICU settings as environmental masking agents, with evidence suggesting reductions in nocturnal arousal and improvements in patient-reported sleep quality.[28]

4.4 Safety Profile

Sound therapy has a highly favorable safety profile. No serious adverse events have been reported in RCTs to date. The principal safety consideration is hearing safety: prolonged exposure to sounds above 60–65 decibels (dB) carries risk of acoustic trauma; clinicians should advise patients to maintain listening volumes within safe limits (≤60 dB).[25] Habituation — the gradual diminution of the therapeutic response with repeated exposure to the same audio stimulus — has been reported anecdotally and may be mitigated by rotating between different music pieces or sound types. Individual variability in sound preference is clinically significant: a minority of individuals report increased arousal or distress in response to specific sounds. Binaural beats are theoretically contraindicated in epilepsy due to the potential for auditory stimulation to provoke seizures, though this risk has not been confirmed in controlled human studies.

5. Comparative Analysis: Aromatherapy vs. Sound Therapy

5.1 Key Contribution of This Review

This section provides the first comprehensive head-to-head comparison of aromatherapy and sound therapy for insomnia, synthesizing mechanistic, clinical, safety, and feasibility dimensions within a unified framework.

5.2 Head-to-Head Comparison

Table 1 provides a structured comparison of aromatherapy and sound therapy across eleven clinically relevant domains. Despite arising from distinct sensory systems, the two modalities demonstrate striking mechanistic parallels, converging on shared limbic and autonomic targets that are central to the hyperarousal model of insomnia.

Table 1: Head-to-head comparison of aromatherapy and sound therapy for insomnia

Domain	Aromatherapy	Sound Therapy
Sensory entry	Olfactory pathway	Auditory pathway
Primary target	Amygdala, GABA-A receptors, ANS	Limbic system, cortical entrainment, ANS
Mechanism	Linalool/linalyl acetate → GABA-A agonism; cortisol suppression	Neural entrainment; parasympathetic activation; masking
Onset	Minutes (inhalation)	Immediate
Key agents	Lavender, chamomile, bergamot	Slow music, pink noise, binaural beats (delta)

Primary benefit	Sleep quality, anxiety reduction	Sleep onset latency, anxiety
Evidence level	Moderate–strong (multiple meta-analyses)	Moderate (growing RCT base)
Safety concern	Allergy, drug interaction (CNS depressants)	Hearing safety, habituation
Accessibility	Low cost, home-use, no device needed	Low cost, app/device-based
Blinding	Difficult (odor detectable)	Possible (control sound feasible)
Combined use	Complementary with sound therapy	Complementary with aromatherapy

5.3 The Dual-Sensory Convergence Model

We propose a dual-sensory convergence model to explain the shared therapeutic mechanisms of aromatherapy and sound therapy for insomnia. The olfactory pathway (activated by aromatherapy) and the auditory pathway (engaged by sound therapy) constitute anatomically distinct sensory entry points. The olfactory pathway projects directly to the amygdala without thalamic relay, providing rapid limbic access.[13] The auditory pathway traverses the thalamus before reaching limbic structures, with a slightly longer latency but offering the additional mechanism of thalamocortical entrainment.[26]

Despite these differences, both pathways converge on the same downstream targets: amygdala downregulation, HPA axis suppression (cortisol reduction), and autonomic nervous system rebalancing toward parasympathetic dominance.[16,25] These shared effector mechanisms directly counteract the three principal components of the insomnia hyperarousal state — cognitive arousal (via amygdala-prefrontal modulation), physiological arousal (via ANS quieting and cortisol suppression), and cortical arousal (via slow-wave promotion in the case of pink noise and binaural beats).[10,27]

5.4 Comparative Efficacy

Across meta-analyses, both aromatherapy and sound therapy produce clinically meaningful improvements in PSQI scores of approximately 2.0–2.8 points, which exceeds the commonly cited minimal clinically important difference of 1.5–2.0 points for this instrument.18,20,30,31 Direct statistical comparison of effect sizes between modalities is precluded by methodological heterogeneity; however, available data suggest that aromatherapy may have a slight advantage for overall sleep quality as captured by the PSQI composite score, while sound therapy — particularly slow-tempo music and binaural beats — may be more effective for reducing sleep onset latency specifically. For anxiety co-morbidity, both modalities demonstrate anxiolytic effects; aromatherapy via direct GABAergic and serotonergic mechanisms, and sound therapy via parasympathetic activation and cortisol suppression.[17,25]

5.5 Safety and Feasibility Comparison

Sound therapy carries a simpler safety profile: there are no allergy concerns, no risk of drug interactions, and no contraindications in most patient populations beyond hearing safety precautions and caution in epilepsy for binaural beats. Aromatherapy requires more individualized safety assessment, particularly in patients with allergic diathesis, those on CNS-active medications, and in specific populations.[14] From a feasibility standpoint, both modalities are low-cost and self-administerable without clinical supervision, which is a significant advantage over CBT-I in resource-limited settings.

5.6 Potential for Combined Use

The dual-sensory convergence model suggests a theoretical basis for synergistic benefit when aromatherapy and sound therapy are used concurrently. By simultaneously engaging olfactory and auditory limbic pathways, a combined intervention may produce greater aggregate downregulation of the hyperarousal state than either modality alone. Preliminary evidence supports this hypothesis: Cruz and colleagues studied a combined aromatherapy and music intervention in postoperative patients and observed improvements in sleep quality that were greater than those reported for either modality in isolation.[39] Formal head-to-head RCTs specifically evaluating combined versus single-modality protocols for insomnia disorder are lacking and represent a priority for future investigation.

6. Special Populations

6.1 Older Adults

Insomnia is disproportionately prevalent in older adults, affecting 40–50% of those over 60 years, and is often compounded by age-related changes in sleep architecture and polypharmacy.[44,45] Pharmacological hypnotics pose heightened risks in this population, including falls, cognitive impairment, and paradoxical agitation with benzodiazepines, making non-pharmacological alternatives particularly valuable. Both aromatherapy and sound therapy have demonstrated efficacy in older adult populations in individual RCTs.[21,34] However, age-related sensory changes — diminished olfactory acuity and hearing loss — may affect the effectiveness of respective interventions and necessitate protocol adjustments.

6.2 Hospitalized and Intensive Care Unit Patients

Sleep disruption is nearly universal in hospitalized patients, particularly those in the ICU, where environmental noise, artificial lighting, procedural interruptions, and psychological distress converge to severely fragment sleep. Karadag and colleagues demonstrated significant PSQI improvement in ICU patients receiving lavender aromatherapy via inhalation compared to standard care.[21] Sound therapy in the form of earplugs combined with relaxing music has similarly demonstrated improvements in sleep quality in ICU patients.[40,41] Both modalities can be practically implemented in hospital settings without interfering with clinical monitoring.

6.3 Cancer Patients

Insomnia occurs in approximately 30–60% of cancer patients, driven by disease-related factors, treatment-related effects, and psychological burden. Both aromatherapy massage and music therapy have established evidence bases in oncology care, with demonstrated benefits for anxiety, pain perception, mood, and sleep quality.[42] Aromatherapy massage — combining the tactile benefit of massage with inhaled aromatic compounds — may be particularly appropriate in cancer patients, given the potential for addressing multiple symptom domains simultaneously.

6.4 Perimenopausal and Menopausal Women

Insomnia affects 40–60% of women during the menopausal transition, driven by vasomotor symptoms, mood disturbance, and hormonal fluctuation. Kazemzadeh and colleagues conducted a double-blind RCT demonstrating that lavender aromatherapy significantly improved sleep quality as measured by the PSQI in menopausal women.[23] Lillehei and colleagues subsequently confirmed the benefits of inhaled lavender for self-reported sleep issues.[43] Additionally, mindfulness-based relaxation interventions that integrate sound elements have demonstrated benefit in postmenopausal women.[47] Evidence for sound therapy specifically in perimenopausal insomnia remains limited and represents a research gap.

7. Clinical Application and Practical Guidance

7.1 Patient Selection

The selection of aromatherapy versus sound therapy should be individualized based on patient characteristics, preferences, contraindications, and the specific clinical presentation of insomnia. Aromatherapy may be preferentially considered for patients with anxiety-dominant insomnia, those with a preference for sensory or tactile interventions, and menopausal or older women in whom lavender-specific evidence is strongest.[18,23] It should be approached with caution in patients with allergic dermatitis, asthma, or known essential oil sensitivities, and in those on multiple CNS-active medications.[14]

Sound therapy is preferable for patients who experience discomfort from strong scents, those with nasal congestion or anosmia, patients in shared living environments, and individuals comfortable with digital tools and smartphone applications.[25] A combined approach is reasonable in patients who have partially responded to a single modality and as an adjunct to CBT-I.[7,39]

7.2 Recommended Protocols

For aromatherapy, the most evidence-based protocol involves lavender essential oil (Lavandula angustifolia) inhalation via a bedside diffuser, delivering 2–4 drops for 30–60 minutes beginning 30 minutes before lights out.[18,26] For topical application, a 1–2%

dilution in a carrier oil applied to wrists, temples, or chest is appropriate. A minimum trial duration of four weeks is recommended before assessing response.

For sound therapy, a practical starting protocol is 45–60 minutes of slow-tempo instrumental music or preferred nature sounds at a volume of 40–60 dB, initiated 30–45 minutes before the desired sleep time.[29,30] Patients preferring binaural beats should use headphones and select delta-frequency (0.5–4 Hz) recordings. Pink noise may be delivered via a bedside speaker as a continuous loop throughout the sleep period.[27,28]

7.3 Integration with CBT-I

Both modalities are most appropriately positioned as adjunctive therapies within a CBT-I framework, not as standalone treatments for moderate-to-severe insomnia disorder.[7,8] Aromatherapy is particularly well integrated with the stimulus control component of CBT-I: the establishment of a consistent pre-sleep olfactory cue creates a conditioned sleep-wake association that reinforces the behavioral goals of stimulus control. Sound therapy aligns naturally with the relaxation component of CBT-I, potentially substituting for or augmenting progressive muscle relaxation techniques.

7.4 Feasibility in Primary Care and Community Clinic Settings

Both aromatherapy and sound therapy are highly feasible for implementation in primary care settings. Neither modality requires specialized equipment beyond a diffuser or smartphone, and the cost of both is minimal. Clinicians can introduce these interventions during a standard consultation and schedule follow-up assessment at four to eight weeks using the PSQI48 or ISI.[49] Where response is inadequate after eight weeks of consistent adherence, referral for formal CBT-I or specialist sleep medicine assessment is appropriate.[50]

8. Limitations and Research Gaps

8.1 Methodological Limitations in Existing Literature

The evidence base for both aromatherapy and sound therapy is subject to several important methodological limitations. There is substantial heterogeneity in intervention protocols across trials: for aromatherapy, this encompasses variation in essential oil type, chemical composition, delivery method, concentration, duration, and timing.[18,19] For sound therapy, variation in music genre, tempo, volume, duration, delivery platform, and control condition introduces comparable heterogeneity.[29,30] The predominance of self-reported outcome measures — particularly the PSQI and ISI — across both literatures limits mechanistic interpretation and introduces susceptibility to response bias. Blinding is a particularly challenging methodological issue for aromatherapy research: participants cannot be blinded to the presence of an odor.[19,24]

8.2 Absence of Direct Head-to-Head Trials

To our knowledge, no published RCT has directly compared aromatherapy and sound therapy as interventions for insomnia disorder. The comparative analysis presented in this review, therefore, represents an indirect comparison and is subject to the limitations inherent in cross-study comparisons, including differences in patient populations, control conditions, and follow-up duration. A well-designed head-to-head RCT, or a factorial design allowing evaluation of both modalities alone and in combination, is needed to establish their relative efficacy and to test the synergy hypothesis implied by the dual-sensory convergence model.[39]

8.3 Future Research Priorities

Several directions for future research are identified. First, standardized intervention protocols and consensus guidelines for both modalities are needed to facilitate between-study comparison. Second, incorporation of objective sleep endpoints (actigraphy as a minimum, polysomnography for mechanistic studies) would strengthen the evidence base.[27,28] Third, longer-duration follow-up (≥12 weeks) is needed to assess the durability of treatment effects. Fourth, studies in under-represented populations — including adolescents, low- and middle-income country populations, and individuals with psychiatric comorbidities — are needed to broaden generalizability. Finally, formal evaluation of combined aromatherapy and sound therapy protocols represents a priority given the preliminary evidence for synergistic benefit.[39]

9. Conclusion

Insomnia imposes a profound burden on individual health and societal productivity, and the limitations of pharmacological management have generated an urgent need for evidence-based non-pharmacological alternatives. This narrative review has comprehensively evaluated aromatherapy and sound therapy as two accessible, low-cost, and mechanistically well-characterized sensory-based interventions for insomnia, and provides the first direct comparative analysis of these modalities in the scientific literature.

Both aromatherapy — particularly lavender essential oil administered via inhalation — and sound therapy — encompassing slow-tempo music, pink noise, and binaural beats — demonstrate clinically meaningful improvements in sleep quality, with meta-analytic effect sizes of moderate magnitude that are consistent across diverse patient populations.[18,20,30,31] Their neurobiological mechanisms, while arising from distinct sensory entry points, converge on the limbic system, HPA axis, and autonomic nervous system — the core substrates of insomnia's hyperarousal pathophysiology. We propose a dual-sensory convergence model as a unifying framework for understanding and comparing these interventions.

Aromatherapy offers a slight advantage in overall sleep quality and has direct pharmacological mechanisms (GABAergic and serotonergic modulation) that may confer anxiolytic benefits beyond sedation.[13,17] Sound therapy is supported by a simpler safety profile, greater scalability via digital delivery platforms, and specific evidence for sleep architecture enhancement, particularly slow-wave sleep augmentation with pink noise.[27,30] The choice between modalities should be individualized based on patient preference, contraindication profile, and insomnia subtype.

Both modalities are appropriately positioned as adjunctive therapies within a CBT-I framework, not as replacements for evidence-based first-line treatment.[7] Their integration into primary care and community clinic practice is feasible and aligned with the growing emphasis on lifestyle-based, non-pharmacological approaches to chronic disease management. Direct head-to-head randomized trials, studies incorporating objective sleep endpoints, and longer-term follow-up data are needed to further establish the comparative evidence base and to optimize clinical protocols. Until such data are available, aromatherapy and sound therapy represent safe, accessible, and evidence-informed options that clinicians can confidently offer to patients seeking non-pharmacological support for insomnia.

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References are listed in Vancouver style, numbered in order of first citation in the text. References marked [VERIFY] require final confirmation of volume/page/PMID in PubMed before submission.

Conflict of Interest Statement
The author declares no conflicts of interest.

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