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Sleep disorder management during pregnancy: A systematic review and meta-analysis

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Abstract

Background: Pregnancy is commonly accompanied by sleep disturbances, which can adversely affect both maternal and fetal health. Although a variety of interventions have been proposed, there is no consensus regarding the most effective approach.

Objectives: This systematic review and meta-analysis aimed to evaluate the effectiveness of interventions designed to improve sleep quality and reduce insomnia during pregnancy.

Methods: A comprehensive search of PubMed, MEDLINE, Embase, Web of Science, and CENTRAL databases was performed for studies published between January 2000 and March 2025. Only randomized controlled trials (RCTs) involving pregnant women aged 10–49 years were included. Study selection adhered to PICOS criteria, focusing on interventions targeting sleep quality or insomnia outcomes. Data were pooled using a random-effects model in STATA, and effect sizes were calculated as standardized mean differences (SMD) with 95% confidence intervals (CI), assessing both efficacy and heterogeneity.

Results: Eleven RCTs, encompassing a total of 1,176 participants, met the inclusion criteria. Pooled analysis demonstrated that sleep interventions significantly improved sleep quality compared with controls (SMD=−0.81; 95% CI=−1.09 to −0.52; P<0.001). Among the various interventions evaluated -including complementary medicine, water-based exercise, aerobic exercise, cognitive behavioral therapy, and acupuncture- sleep health behavior education showed the most pronounced and sustained improvement, particularly evident at two months post-intervention.

Conclusion: Sleep health behavior education appears to be the most effective and durable intervention for enhancing sleep quality during pregnancy. While other approaches, such as acupuncture, cognitive behavioral therapy, and exercise, produced benefits, their long-term effects were inconsistent. These findings support the integration of structured behavioral sleep education into prenatal care as a cost-effective, accessible, and sustainable strategy to improve maternal sleep health.

Keywords: Sleep disorder, Pregnancy, Systematic review.

Introduction

A 30-year review reported that sleep disorders affect pregnant women across all trimesters, with prevalence rates of 14%, 20%, and 66% in the first, second, and third trimesters, respectively.[1] Other studies have estimated the overall prevalence of sleep disturbances during pregnancy to range between 78% and 97%.[2,3]

These disturbances have significant implications for both maternal and fetal health. Sleep disruption has been linked to adverse outcomes such as preterm birth, low birth weight, prolonged labor, instrumental delivery, increased cesarean section rates, and postpartum complications, including mood disturbances and daytime fatigue.[4-6] Even short-term sleep disruption lasting more than three days can impair routine activities and diminish maternal quality of life, which is highly dependent on sleep quality.[1]

In response to these impacts, various interventions have been investigated. Behavioral counseling and educational programs have demonstrated effectiveness in improving both sleep quality and psychological well-being during pregnancy.[7-9] Light therapy has been explored for its dual benefits on depressive symptoms and sleep regulation

during and after pregnancy.[10,11] Nodine and Matthews identified sleep apnea, restless legs syndrome, and insomnia as the principal types of pregnancy-related sleep disturbances and recommended relaxation techniques, acupuncture, and pharmacological interventions as effective management strategies.[12]

Emerging technologies, including personal health monitors (PHM) and structured sleep training programs, have also shown benefits that are comparable or even superior to pharmacological interventions in enhancing sleep and mood.[13] Conversely, some mindfulness-based programs have demonstrated only partial improvement, with approximately half of participants reporting no change in sleep quality.[14] Hoegholt et al., compared standard sleep hygiene with and without music therapy, finding both approaches effective, though the addition of music did not confer significant additional benefit.[15]

Objectives

Despite the wide range of interventions studied, results remain inconsistent, and no consensus exists regarding the most effective approach for managing sleep disturbances in pregnancy. Furthermore, no prior systematic analysis has clearly prioritized these interventions. Considering the critical role of midwives in maternal care and the importance of evidence-based recommendations, this study presents a systematic review and meta-analysis to evaluate the comparative effectiveness of both medical and non-medical sleep interventions during pregnancy.

Methods

Study design

This systematic review and meta-analysis was conducted following Cochrane methods for systematic reviews of interventions[12] and reported according to PRISMA guidelines.[16] Inclusion criteria were defined based on PICOS guidelines, targeting randomized controlled trials (RCTs) that evaluated interventions for sleep disorders, including sleep quality and insomnia, in pregnant women. Studies addressing prevalence alone were excluded. Grey literature was assessed using predefined criteria via resources such as dissertations and conference abstracts available in SIGLE (System for Information on Grey Literature in Europe), the NLM Gateway, and Dialog (Thomson) through the university database.

The PICOS framework guided inclusion criteria: population (pregnant women), interventions (any approach targeting sleep quality or insomnia), comparators, outcomes (sleep quality and insomnia), and study design (RCTs).[17] All English-language RCTs published between January 2000 and March 2025 were included. Given that interventions often involved multiple follow-ups, studies reporting outcomes at one, two, or three months post-intervention were considered.

Effect sizes were calculated using standardized mean differences (SMD) to accommodate varying measurement scales across studies. Both sleep quality and insomnia were evaluated as outcomes, since insomnia typically impairs sleep quality and results in non-restorative sleep and fatigue. Consequently, studies reporting either or both outcomes were included.

Information sources and keywords

We searched Google Scholar, Embase, PubMed, MEDLINE, Web of Science, CENTRAL, PsycINFO, and AMED for relevant keywords. Ongoing trials from registries, including CENTRAL, as well as grey literature databases such as Dialog (Thomson) and SIGLE, were also assessed.[18] Keywords related to sleep disorders, sleep quality, pregnancy, and clinical trials were employed in structured search strategies across all databases.

Literature search and study selection

All identified records were imported into EndNote, where duplicates and irrelevant articles were removed. Two authors (ER and ZB) independently screened titles and abstracts for eligibility based on the Cochrane inclusion criteria. Discrepancies were resolved through consensus and consultation with a third author. The Cochrane Risk of Bias 2 (RoB2) tool was used to assess study quality and ensure reliability of findings. Data extraction followed a predefined collection form, and corresponding authors were contacted for missing or unclear information. Studies were then categorized according to intervention type and outcomes.

The initial search yielded 1,775 publications (PubMed, MEDLINE, Embase: 280; Google Scholar: 1,350; Cochrane: 50; grey literature: 95). After removing 705 duplicates, two authors independently reviewed titles and abstracts, excluding 1,015 articles. Full texts of 55 articles were assessed by three authors. Ultimately, 10 RCTs were included in the meta-analysis, with exclusion of incomplete or non-randomized studies (28 observational studies, 7 non-randomized or quasi-experimental trials without a control group, and 10 studies conducted outside pregnancy) [Figure-1].

Data collection

Data were extracted into Table-1 and Table-2, including study characteristics (authors, year, country, design, methodology), participant demographics (age, sex, race), health status, sample size, attrition rates, data collection

instruments, intervention type, comparator groups, duration and follow-up periods, measurement stages, outcomes, results, and conclusions.

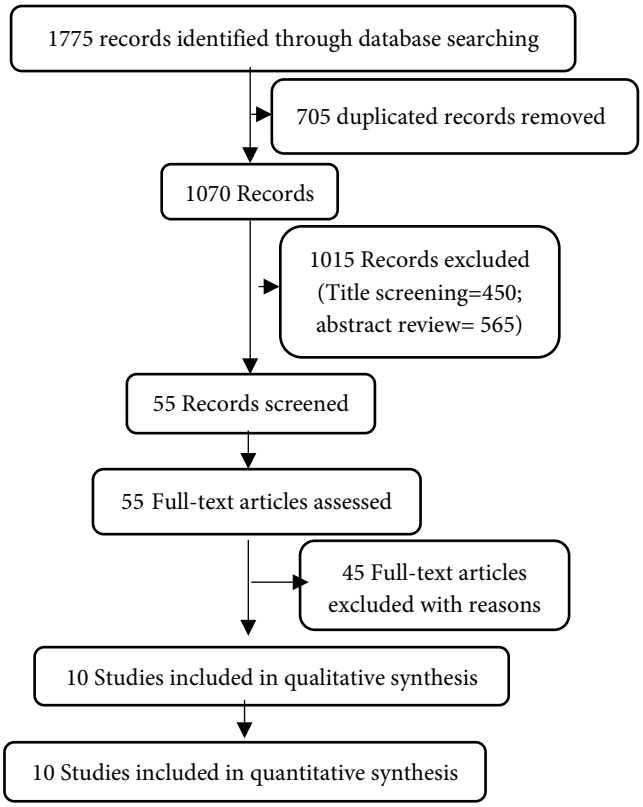

Figure-1. Preferred reporting items for systematic reviews and meta-analyses study selection flow diagram

Results

Data extraction and synthesis

Two researchers (ER and NDN) independently extracted information from the 10 included articles, with all three authors reviewing agreements and discrepancies to minimize bias and errors.[19] Data were extracted focusing on the effectiveness of interventions.[20,21] Duplicate and multiple publications were included once, with relevant findings reported when necessary.[19]

Both systematic synthesis and meta-analysis were employed to summarize study outcomes, following recommendations for reporting systematic reviews.[20] Ten articles were included in the systematic synthesis [Tables 1 and 2] and analyzed quantitatively via meta-analysis. Mean (SD) scores for sleep quality and quality of life in pregnant women with sleep disorders were reported.

The standardized mean difference (SMD) was used as the effect size to accommodate multiple measurement tools across studies. SMD, equivalent to the Hedges' g (adjusted for small sample bias), is similar to Cohen's d and enhances generalizability of results, particularly for studies with small sample sizes.[22,23] The primary outcomes were sleep quality and insomnia, which are closely related: insomnia generally impairs sleep quality, resulting in non-restorative sleep and fatigue. Consequently, studies reporting either or both outcomes were included.

Assessment of research quality, bias, and heterogeneity

Study quality was evaluated using the GRADE framework, as reported in Table-3.[24] Risk of bias was assessed across five domains following Cochrane guidelines.[25] Heterogeneity among study results was assessed using Cochran's Q test at a significance level of <0.01.[26,27] Given the low statistical power in meta-analyses with small sample sizes, I^2 statistics were also calculated, with 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively.[23]

Summary measures

Meta-analysis outcomes were reported using SMDs and presented via forest plots with 95% confidence intervals.

Systematic synthesis

Systematic synthesis provided a qualitative summary of findings. Tables 1 and 2 summarize the characteristics of the included studies. One article included two distinct clinical trials; both were reported separately, resulting in 11 trials across 10 articles.

Study settings and participants

From the initial 1,775 articles identified, 10 studies (11 RCTs) were included. The total number of pregnant women across the 11 studies was 1,176 (IQR: 84–134; Mean: 106.9; SD: 46.58; Median: 100; range: 22–208). Sample sizes varied, and most studies had different numbers at baseline and follow-up [Table-1] (Mean change: 14.34; SD: 10.99; Range: 0–30; IQR: 4.2–26.6). Attrition rates also differed across studies. The mean age of participants ranged from 28 to 35 years (SD: 3.69–6.65), and mean gestational age ranged from 13.8 to 34.5 weeks (SD: 0–6.35). Five RCTs (45.5%) were conducted in the USA, three (27.2%) in Iran, and one (9.1%) each in Brazil, Taiwan, and Spain. All 11 studies were randomized clinical trials with intervention and control groups.

Seven RCTs were from developed countries: USA,[26,29,32,33] Brazil,[28] and Spain,[30] four were from developing countries: Iran,[7,8,31] and Taiwan.[34]

Research settings included hospitals,[29,31,33] health clinics,[30] health centers,[7,8,28] and combined hospital and health center settings.[32]

Interventions

Interventions aimed at improving sleep quality and reducing insomnia included complementary medicine (lettuce seeds),[31] water-based exercise,[30] aerobic

exercise,[34] health behavior education,[7,8,29] cognitive behavioral therapy,[32,35] and acupuncture.[28]

Duration of interventions and outcome measurement

Intervention durations ranged from two weeks,[31] one month,[7,8,31,32] six weeks,[33,35] three months,[34] to four months.[30,32] Outcomes were measured before intervention and at one, two, and three months post-intervention. Ten studies had one-month follow-ups,[7,8,29–34] three studies had two-month follow-ups,[7,8,32] and four studies had three-month follow-ups.[27,29,33,34] Two three-month follow-ups were excluded because they occurred postpartum.[29,33]

Sleep assessment tools included the Pittsburgh Sleep Quality Index (PSQI)[8,30,31,34] in five studies, the Insomnia Severity Index (ISI)[32,33,35] in two studies, PSQI and ISI in one study,[35] the General Sleep Disturbance Scale (GSDS),[29] and the International Classification of Sleep Disorders (ICSD).[28] Table-2 summarizes the systematic synthesis, highlighting improvements in sleep outcomes following interventions.

Risk of Bias and Quality of Evidence

Figure 2 presents risk-of-bias assessments. High risk of attrition bias was observed, whereas other domains - blinding of outcome assessment, allocation concealment, participant and personnel blinding, random sequence generation, and selective reporting- were appropriately addressed. Most studies employed between-group analyses; a few used within-group analyses [Table-2].

Overall study quality was rated as moderate across all follow-up periods based on GRADE assessment [Table-3].

Meta-analysis

Two meta-analyses were conducted for follow-ups at one and two months (Figures 3a and 3b). A three-month follow-up meta-analysis was not performed due to insufficient data (minimum required: three studies).

One-month follow-up

Ten studies including 993 participants were analyzed for one-month outcomes. Interventions showed statistically significant improvements in sleep quality and insomnia, except for two interventions. The Sleep Hygiene Intervention Package for Parents (SHIPP) and health behavior education significantly improved sleep quality. Significant heterogeneity was observed among studies [Figure-3.a]. Meta-regression analyses incorporating age, gestational age, and attrition bias revealed that age was a significant contributor to heterogeneity (coefficient: –0.498), indicating that older participants had lower sleep disorder scores.

Two-month follow-up

Three studies (207 participants) with two-month follow-ups were analyzed. Health behavior education demonstrated statistically significant improvements in sleep outcomes in two studies. Homogeneity was observed between studies (SMD: –0.81; 95% CI: –1.09 to –0.52) [Figure-3b].

Principal findings

This review conducted a systematic qualitative and quantitative analysis of the included studies. A systematic review of nine RCTs indicated an improvement in women's sleep quality and a reduction in insomnia following the interventions at follow-up stages. However, two RCTs found no statistically significant difference between the intervention and control groups [Tables -1 and -2].[29,34]

Tables 1 and 2 display the characteristics of the included articles. Based on the reviewers' quality assessment, most articles (n=7) were of moderate quality, while three were high quality. The overall quality of evidence, evaluated using the Cochrane GRADE tool, is illustrated in Table-3. The evidence for outcomes at one month (Cohen's d: 0.99; 95% CI: 0.26 to 2.25), two months (Cohen's d: -0.79; 95% CI: -1.08 to -0.51), and three months (Cohen's d: -0.50; 95% CI: -0.74 to -0.26) post-intervention was graded as moderate.

Two RCTs reported three-month follow-ups, but a meta-analysis was not conducted for this time point due to the low number of studies, which would preclude an accurate pooled estimate. High heterogeneity was observed in the results of the one- and two-month follow-ups. This lack of homogeneity may be attributed to variations in social, economic, cultural, and psychological factors, different intervention types, and the racial diversity of participants across the different countries represented (Tables -1 and -2).

Despite this heterogeneity, the meta-analysis of 11 studies for the one- and two-month follow-ups showed a statistically significant difference in the pooled effect, based on the standardized mean difference (SMD) two months post-intervention [Figures-3.a and -3.b].

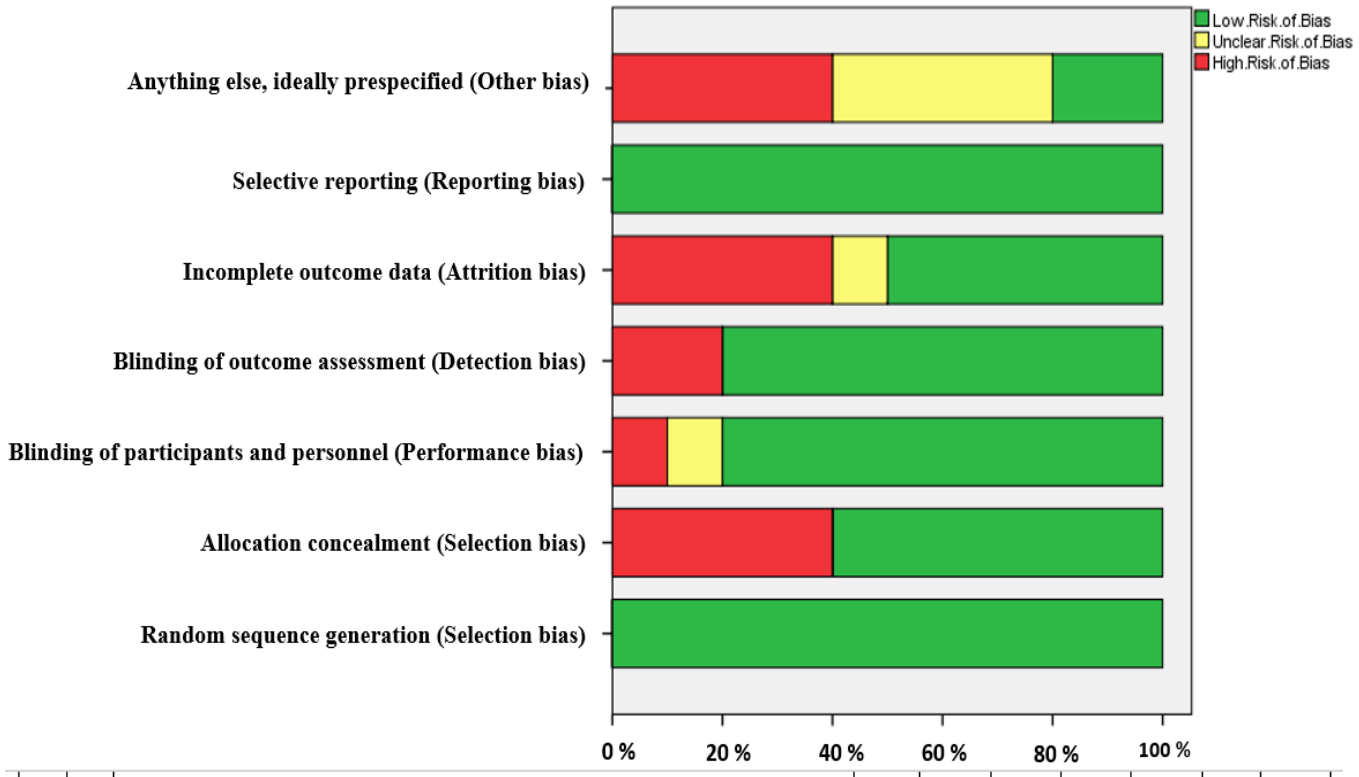

Figure 2. Risk of bias summary

N	Authors, year	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome Assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Anything else, ideally prespecified (Other bias)
1	(Pour et al., 2018)	+	+	+	+	-	+	-
2	(Lee & Gay, 2011)	+	+	+	+	-	+	?
3	(Rodriguez-Blanque, Sánchez-García, Sánchez-López, Mur-Villar, & Aguilar-Cordero, 2018)	+	+	+	+	+	+	-
4	(Manber et al., 2019)	+	+	-	+	-	+	+
5	(E. Rezaei, Behboodi Moghadam, & Hagani, 2015)	+	+	+	-	+	+	-
6	(Shen & Chen, 2021)	+	-	+	+	?	+	?
7	(E. Rezaei, et al. , 2014)	+	-	+	+	+	+	?
8	(Kalmbach et al., 2020)	+	-	+	+	+	+	-
9	(Felder, Epel, Neuhaus, Krystal, & Prather, 2020)	+	+	+	-	+	+	?
10	(da Silva, Nakamura, Cordeiro, & Kulay, 2005)	+	-	?	+	-	+	+

Low risk of bias(+) ; Unclear risk of bias (?); High risk of bias (-)

Figure-2. Risk of Bias assessment of studies included to Meta-analysis

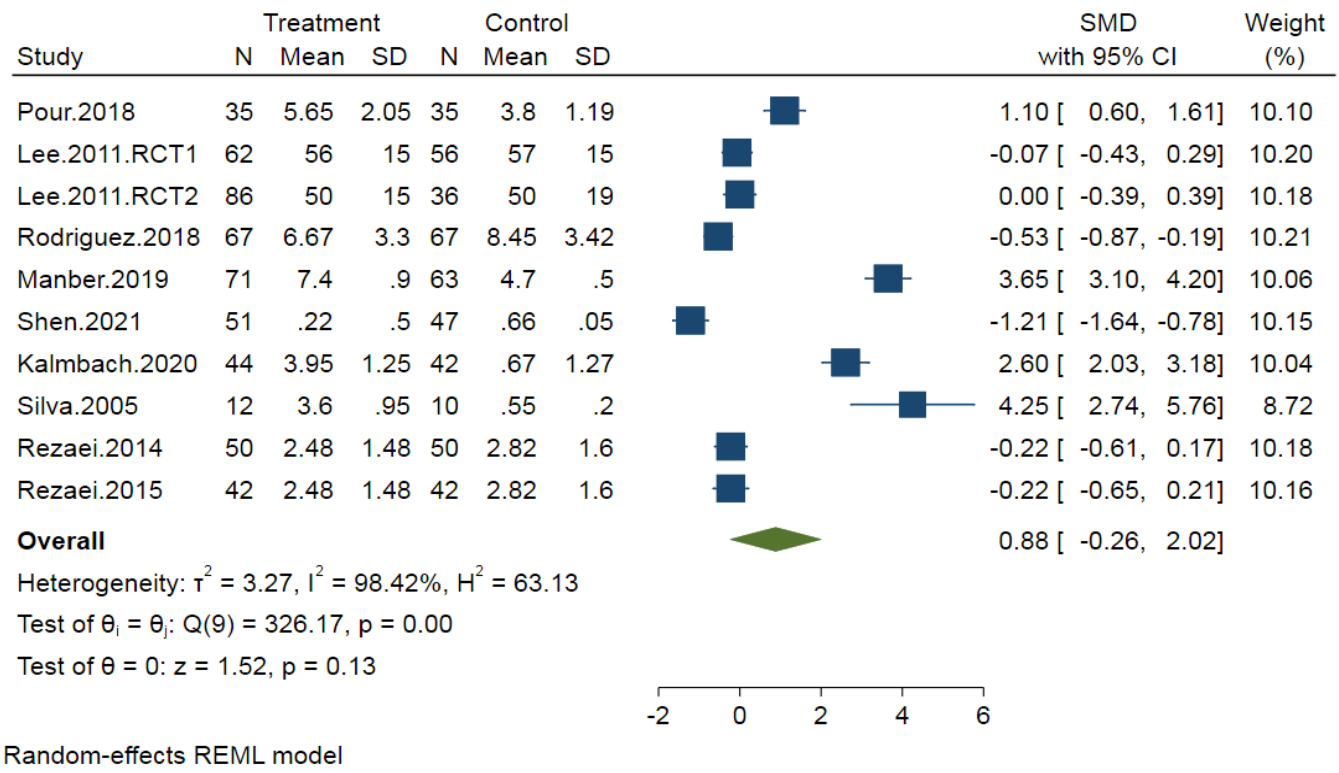

Figure-3.a. Meta-analysis findings for follow-up at 1 month

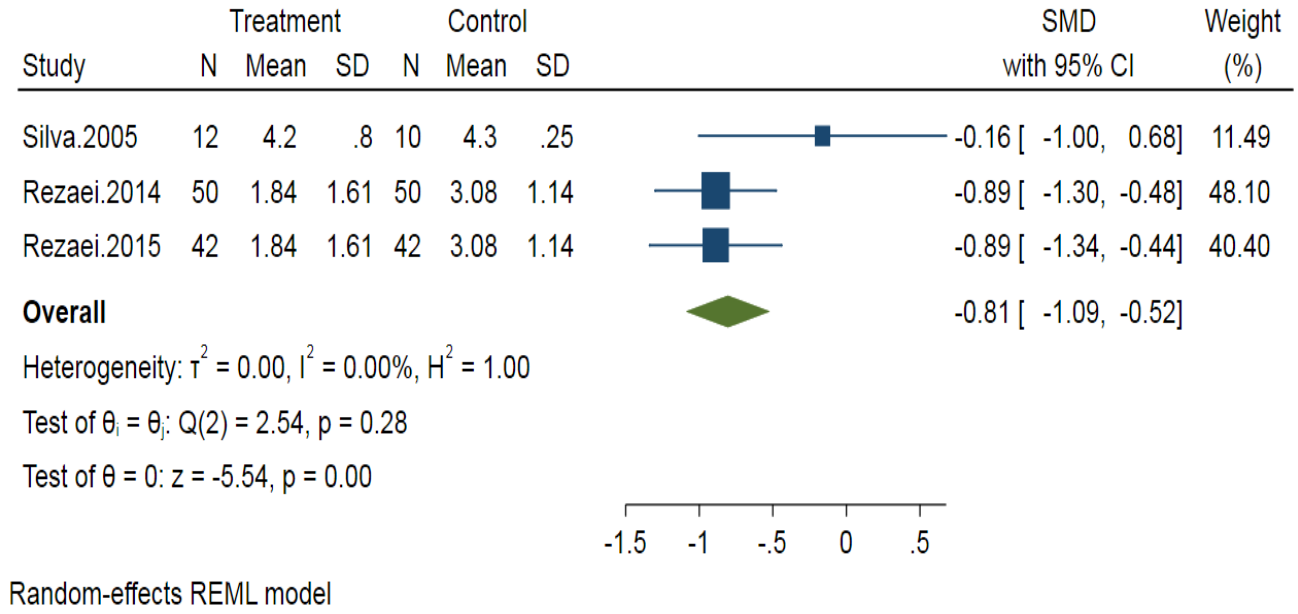

Figure-3.b. Meta-analysis findings for follow-up at 2 months

Table-1. Characters of articles included in this study

Article Authors	Quality of evidence (reviewers' assessment) [a]	Research design	Settings	Participants			Health or medical Conditions investigated	Sampling method	Sample size Total (Intervention (In.); Control (Co))	Research methods or data collection tools
				Age (year) Mean (SD)	Gender	Ethnicity				
da Silva et al., 2005[28]	Moderate	RCT	local area	In.: 26.5 (7.7); Co.: 26.5 (5.6)	Female (Pregnant women)	Brazilian	Insomnia; Sleep apnea, Snoring and BMI	Random Allocation; Day of attendance	30 base line (In. 17; Co. 13). 22 follow up (In 12; Co. 10).	ICSD
Lee and Gay, 2011; RCT1.[29]	Moderate	RCT	hospital	Sample 1: 32.1(4.5)	Female and Male (Pregnant women and their partners)	American	Sleep Disturbance; sleep noise or snoring	Block (Size: 6) Randomization; Convenient sampling.	304 base lines, 240 follow up. -Sample 1: 152 base line (In.: 77, Co.: 75), 118 follow up (In.: 62, Co.: 56)	Wrist Actigraphy; GSDS
Lee and Gay, 2011; RCT2.[29]				Sample 2: 26.7(6.4)					-Sample 2: 152 base line (In.:102, Co.: 50), 122 follow up (In.: 86, Co.:36)	
Rezaei et al., 2014[7]	High	RCT	health-elected city center	In.: 26.72(6.31). Co.: 27 (6.77)	Female (Pregnant women)	Iranian	Sleep quality; Quality of life	Simple Randomization (the table of random numbers); Convenient sampling	112 base lines (In.: 56; Co.: 56); 100 follow up (In.: 50; Co.: 50).	PSQI; WHOQOL-BREF

Rezaei et al., 2015[8]	Moderate	RCT	health-elected city center	In.: 27.26 (5.07); Co.: 27.21 (5.8).	Female (Pregnant women)	Iranian	Depression of women with sleep disorders	Simple Randomization (the table of random numbers); Convenient sampling	96 base lines, 84 follow up (Both of groups: 48 base lines, 42 follow up)	PSQI; BDI
Rodriguez et al., 2018[30]	High	RCT	Health Clinics	In.: 32.12 (4.43); Co.: 30.58 (4.75).	Female (Pregnant women)	Spanish	sleep quality; Respiratory distress, BMI, sleep apnea	Simple Randomization (the table of random numbers); Convenient sampling	140 base lines, 134 follow up (Both of groups: 70 base lines, 67 follow up)	PSQI and self-perception questionnaire
Pour et al., 2018[31]	Moderate	Double-blind RCT	hospitals	In.: 30.2(4.9); Co.: 28.6(5.6).	Female (Pregnant women)	Iranian	Insomnia; Quality and patterns of sleep	Randomization table based on the registration number of the patients (in order of referral)	100 base lines, 70 follow up (Both of groups: 50 base lines, 35 follow up)	PSQI
Manber et al., 2019[32]	Moderate	Randomized, unmasked, 3-site controlled. trial	-University based obstetric clinics -Hospital based obstetric clinics -Medical Center through community advertising	In.: 33.4 (5.2); Co.: 32.66 (4.9)	Female (Pregnant women)	American	Insomnia; Depression	Block (Size: 2, 4, 6) Randomization; Convenient sampling	194 base lines (In. 96; Co. 98). 179 follow up (In 71; Co. 63).	ISI; self reported time awake; EPDS
Kalmbach et al., 2020[33]	Moderate	Single-site RCT	6-hospital healthcare system	In.: 28.91 (4.1). Co.: 29.16 (4.1)	Female (Pregnant women)	American	Insomnia; Sleep apnea, Snoring and BMI	Block (Size: 2, 4, 6) Randomization; Convenient sampling.	91 base lines (In. 46; Co. 45); 79 follow up (In 44; Co. 42).	ISI; PSQI; EPDS

Felder, et al., 2020[27]	High	RCT	Research Electronic Data Capture (REDCap) online survey systems	In.: 33.9 (3.38). Co.: 32.2 (4.0)	Female (Pregnant women)	American	Insomnia; sleep quality; anxiety; depression	Block Randomization; Convenient sampling.	208 base lines (In. 105; Co. 103). 208 follow up (In 105; Co. 103).	Insomnia ISI; PSQI; EPDS Scale; Generalized Anxiety Disorder Scale-7
Shen and Chen, 2021[34]	Moderate	RCT	Prenatal clinic	In.: 33.3 (4.19). Co.: 32.8 (3.83)	Female (Pregnant women)	Taiwanese	sleep quality	Assigned systematically from a random starting point	140 base lines (In. 70; Co. 70); 98 follow up (In 51; Co. 47).	PSQI; MMFAS

Pittsburgh Sleep Quality Index (PSQI); General Sleep Disturbance Scale (GSDS); Beck's Depression Inventory (BDI); Insomnia Severity Index (ISI); Edinburgh Postnatal Depression Scale (EPDS); International Classification of Sleep Disorders (ICSD); World Health Organization Quality of Life (WHOQOL-BREF); Modified Maternal-Fetal Attachment Scale (MMFAS); Randomized clinical trial (RCT); Standard Deviation (SD)

[a]: A Quality of evidence grades: high (we are very confident that the true effect lies close to that of the estimate of the effect), moderate (we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different), low (our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect), and very low (we have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of effect).

Table-2. Other characters of articles included in this study

Study	**Interventions**	**Comparators**	**Intervention duration**	**Follow up duration**	**Outcomes: Sleep quality scores by measurement stages, mean (SD)**				**Results or findings**	**Conclusion by the authors of the study**
					Baseline	**One month**	**Two months**	**Three months**		
da Silva et al., 2005[28]	Acupuncture	Control (conventional treatment alone (sleep hygiene)	once a week over 8- 12 sessions	8 weeks. Interviewing five times during two-week intervals	In.: 6.7 (3.5); Co.: 4.6 (3.00)	In.: 3.0 (2.7); Co.: 3.4 (3.1)	In.: 1.6 (1.7). Co.: 4.6 (3.002)	Not measured	ANOVA P=0.008; (In. 5.1 (SD=3.8) vs Co.:0.0 (SD=3.7) (Two-sample t test: P=0.0028)	Acupuncture alleviates insomnia during pregnancy

Lee and Gay, 2011; RCT1.[29]	SHIPP in two samples (According to education, employment and economic)	Control (receiving pamphlet containing information about how diet can influence sleep and recommendations for healthy eating)	Daily for a month during the third trimester	Samples were assessed four times. The first assessment occurred during the last month of pregnancy, and subsequent assessments were conducted after delivery	Sample 1: 45(15);	Sample 1: Co.: 75(15), In.: 56(15);	Not measured	Sample 1: Co.: 38(16),In.: 41(17);	Repeated Measures Analysis (F Statistic: no significant)	SHIPP evaluated in this study provided little benefit to mothers
Lee and Gay, 2011; RCT2.[29]					Sample 2: 45(17)	Sample 2: Co.: 50(19), In.: 50(15)		Sample 2: Co.: 36(20), In.: 38(16)		
Rezaei et al., 2014[7]	Education of sleep health behavior	Control (conventional prenatal care)	a four-hour session held in weeks 22, 23, 24, and 25 of pregnancy	Follow-up sessions (1 and 2 months after educational intervention)	In.: 8.76 (2.33); Co.:8.38 (2.37)	In.: 7.30 (3.33); Co.:7.8 (2.89)	In.: 6.88 (3.06); Co.:8.21 (2.85)	Not measured	Repeated measures analysis (1 and 2 months after In.: P value 0.009 and 0.034)	Education was effective on the Quality of Life in women with sleep disorders
Rezaei et al., 2015[8]	Sleep Health Behavioral Education	Control (only received routine prenatal care)	a four-hour session held in weeks 22, 23, 24, and 25 of pregnancy	follow-up session at weeks 29 and 33 of pregnancy	In.: 22.47 (10.08); Co.:20.69 (7.65).	In.: 14.78 (10.14); Co.:19.57 (8.9).	In.: 13.33 (9.27); Co.: 18.16 (10.20).	Not measured	Repeated measure analysis showed significant differences at first and second follow-ups	Sleep health behavioral education improves depression in pregnant women who are experiencing insomnia
Rodriguez et al., 2018[30]	SWEP program	Control	three one-hour sessions per week of exercises, from weeks 20 to 37 of pregnancy	Follow up after the intervention in the third trimester, between 36–38	In.:6.51 (3.74). Co.: 6.81 (3.72)	In.:6.84 (2.86); Co.: 10.10 (3.12)	Not measured	Not measured	Statistical differences were significant	SWEP method improved sleep quality in pregnant women

				weeks of gestation						
Pour et al., 2018[31]	Capsules containing 1000mg of lettuce seed	Placebo	Every night for two weeks.	The effects were assessed at the end of two weeks	In.: 12.51(1.9). Co.: 12.34(2.68)	In.:6.86 (4.03). Co.: 8.54(3.87)	Not measure d	Not measured	Linear regression analysis (coefficie:1.83; SE: 0.80; P-value: 0.03)	Lettuce seed could be used as a safe hypnotic treatment for pregnant women
Manber et al., 2019[32]	Cognitive behavioral therapy	Control (Imagery exercise)	five individual therapy sessions provided between 18 and 32 weeks of gestation	follow-up sessions were weekly between 18 and 32	In.: 15.4 (4.3). Co.:15.9 (4.4).	Not measured	In.:8.0 (5.2). Co.: 11.2 (4.9).	Not measured	Statistical differences were significant (P<0.001, d=0.5)	Cognitive behavioral therapy for insomnia is an effective nonpharmacologic treatment for insomnia during pregnancy.
Kalmbach et al., 2020[33]	CBTI	Control (digital sleep education)	Six weekly emails based on the National Institutes of Health guide to healthy sleep in patients entering the third trimester of pregnancy	a week after completing treatment or upon discontinuing treatment, and finally postnatal follow-up: six weeks after childbirth	In.: 9.59 (2.61). Co.: 9.13 (3.06)	In.: 9.29 (4.12). Co.: 6.61 (2.99)	Not measure d	Measured but after delivery (In.: 7.53 (3.47); Co.: 7.00 (3.22))	Repeated measures analysis of covariance (ANCOVA) models (F (1,85) = 16.72, P < 0.001)	Digital CBTI improves sleep quality during pregnancy and after childbirth
Felder, et al., 2020[27]	CBT-I	Control (standard treatment)	6 weekly sessions that were accessed via website or IOS app	Outcome measures at 10 weeks (post intervention) and 18 weeks (follow-up) after randomization	In.:9.52 (2.74). Co.: 9.47 (3.02)	Not measured	Not measure d	Mean Difference of effect Size Between Groups: -0.185	Linear Mixed-Effects Analysis of Change from Baseline to Follow-Up (X^2: 7.5.8; d: -0.34, P:0.006)	CBT was an effective intervention for improving insomnia symptoms during pregnancy

Shen and Chhen, 2021 [34]	non-supervised aerobic exercise	Control (conventional prenatal care)	Three times per week for a period of three months	four and 12-weeks post-intervention	In.: 6.11 (3.47). Co.:5.61 (2.8)	In.: 5.89 (2.97). Co.:6.27 (2.85)	Not measured	In.:7.27 (3.77); Co.: 6.98 (2.95)	χ2 and two-sample t-tests (4 and 12-weeks t: 0.89; P: 0.38 and t: 0.43; P: 0.67)	Findings encouraged pregnant women to regularly perform low-impact aerobic exercise

Sleep Hygiene Intervention Package for Parents (SHIPP); Study of Water Exercise in Pregnancy (SWEP); Digital cognitive behavioral therapy for insomnia (CBTI); Chi square (χ2); Analysis of Variance (ANOVA); Analysis of covariance (ANCOVA).

Table-3. GRADE (Grading of Recommendations Assessment, Development and Evaluation) quality of evidence summary.

Various interventions to improve sleep (Outcome: sleep quality)										
Quality assessment							**Summary of findings**			
Number and type of studies	Risk of bias [23,24]	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Number of participants study event rates (%)		Anticipated effects	
							With usual care	With interventions	Cohen's d (CI 95%)	Risk difference (CI 95%)
One month after interventions										
10 RCT	Moderate	None	Not serious	Not serious	Not serious	⨁⨁⨁◯ Moderate	469 / 571 (82%)	524 / 624 (84%)	0.99 (0.26 to 2.25)	SMD: 0.95 (0.025 to 1.87)
Two months after interventions										
3 RCT	Moderate	None	Not serious	Not serious	None	⨁⨁⨁◯ Moderate	103 / 111 (92 %)	104 / 115 (90 %)	-0.79 (-1.08 to -0.51)	SMD: -0.80 (-1.09 to -0.52)
Three months after interventions										
2 RCT	Moderate	None	Not serious	None	None	⨁⨁⨁◯ Moderate	160 / 197 (81 %)	203 / 247 (82 %)	-0.50 (-0.74 to -0.26)	SMD: -0.49 (-0.73 to -0.24)

GRADE classifies the quality (certainty) of evidence into four levels: High (We are very confident the true effect is close to the estimate), Moderate (The true effect is probably close to the estimate), Low (The true effect may be substantially different), Very Low (The true effect is likely to be very different).

Discussion

Among the evaluated interventions, sleep health behavior education demonstrated the most consistent and sustained improvement in sleep quality, particularly evident at the two-month post-intervention assessment. This finding corroborates the results of Rezaei et al., and Sönmez and Aksoy Derya, who similarly reported significant and enduring enhancements in sleep quality following behavioral educational programs.[7,36] In contrast, other modalities, such as acupuncture and exercise, often yielded more rapid but transient effects, likely due to their limited focus on long-term behavioral or lifestyle modification. Previous meta-analyses, such as that by Bacaro et al., also identified a wide range of effective interventions;[37] however, methodological variability -particularly the inclusion of non-randomized and quasi-experimental studies- may partly explain the observed discrepancies. By exclusively incorporating RCTs, the present analysis provides more robust and methodologically rigorous evidence supporting the prioritization of behavioral education as an integral component of prenatal care.

The current findings confirm that among various interventions designed to improve sleep quality and alleviate insomnia in pregnant women, sleep health behavior education demonstrated the most reliable and prolonged effects, particularly at the two-month follow-up. This sustained impact may stem from its focus on enduring behavioral and lifestyle modifications, which promote adaptive sleep-related habits. Conversely, interventions such as acupuncture, exercise, and cognitive behavioral therapy (CBT) often elicit faster initial benefits that may not persist over time. Variability between the present findings and those reported in earlier studies can likely be attributed to differences in research methodology, sample characteristics, intervention content, or duration. Overall, this study emphasizes the importance of integrating behavioral education-based interventions into prenatal sleep management protocols to foster sustainable improvements in maternal sleep health.

In the present meta-analysis, all interventions -except the SHIPP and health behavior education- did not reach statistical significance. Notably, health behavior education demonstrated a significant effect only at the two-month follow-up, suggesting that such programs require sufficient time to influence sleep-related behaviors among pregnant women. In contrast, complementary medicine, water-based exercise, aerobic exercise, CBT, and acupuncture yielded observable effects within the first month of intervention. These findings indicate that while short-term improvements may occur through various modalities, the long-term maintenance of healthy sleep patterns likely depends on the reinforcement of sustainable behavioral strategies.

The results diverge somewhat from those of Bacaro et al., whose meta-analysis found that several interventions -including CBT for insomnia, pharmacological therapies, acupuncture, mindfulness and yoga practices, relaxation techniques, and herbal remedies- were generally effective in improving sleep outcomes.[37] This discrepancy can largely be explained by methodological distinctions. Specifically, Bacaro and colleagues included both RCTs and non-RCTs in their synthesis, thereby introducing potential heterogeneity in study design and quality. Furthermore, there remains a notable paucity of meta-analyses that comprehensively evaluate non-pharmacological interventions specifically targeting sleep disturbances during pregnancy. By restricting inclusion criteria exclusively to RCTs, the current review enhances the reliability and precision of its effect estimates and offers more definitive insights into the relative efficacy of these interventions.

Previous investigations have predominantly focused on single modalities, such as CBT [38] or structured physical activity programs,[39] without concurrently comparing multiple intervention types to identify the most effective approach. Addressing this critical research gap, the present meta-analysis examined a broad spectrum of interventions published between 2000 and 2025, thereby providing a comprehensive and comparative perspective on non-pharmacological strategies for managing sleep disturbances during pregnancy. Contrary to our findings, Manber et al. reported that CBT significantly improved sleep quality in pregnant women.[32] This divergence likely reflects differences in intervention targets and underlying mechanisms. While CBT primarily addresses cognitive and emotional processes -such as maladaptive beliefs, worry, and sleep-related anxiety- sleep health behavior education encompasses a wider spectrum of determinants, including physical, psychological, social, spiritual, and lifestyle-related domains. This multidimensional focus may account for the greater and more sustained improvements observed in the behavioral education groups in our analysis.

The consistency of the present findings with prior research further underscores the value of health behavior education in prenatal sleep management. For instance, Rezaei et al., reported that behavioral education interventions led to significant improvements not only in sleep quality but also in overall quality of life among

pregnant women.[7] Similarly, Sönmez and Aksoy Derya, found that sleep health education markedly improved sleep outcomes in individuals with restless legs syndrome during pregnancy.[36] Furthermore, Amezcua et al. demonstrated that regular walking contributed positively to sleep quality among pregnant participants.[40] Collectively, these studies reinforce the notion that interventions emphasizing lifestyle modification and sleep-promoting behaviors are particularly beneficial in this population.

Nevertheless, conflicting evidence has also been documented. For example, Lee and Gay, reported no significant improvement following health behavior education.[41] However, the lack of effect in their study likely reflects methodological limitations, including a non-randomized design, short intervention duration (limited to seven days before hospital discharge), and absence of follow-up evaluation. These design constraints may have precluded the detection of meaningful behavioral or physiological changes. In contrast, our meta-analysis underscores the necessity of longer intervention periods and post-intervention monitoring to capture enduring effects. The observed temporal pattern of improvement further supports the hypothesis that behavioral sleep programs require sufficient exposure time for participants to internalize and implement behavioral changes effectively. Therefore, future clinical and research designs should incorporate extended intervention durations and follow-up assessments to better evaluate the durability of sleep-related improvements.

The findings reported by Nodine and Matthews, which indicated that relaxation techniques, acupuncture, and pharmacological therapies were effective for sleep disorders in pregnancy,[12] contrast with our meta-analysis results, which did not find statistically significant benefits for these approaches. This inconsistency may be attributable to the lack of long-term follow-up in many studies included in earlier reviews. While Nodine and Matthews may have identified short-term symptom relief, our analysis emphasizes the critical importance of evaluating sustainability over time. Sleep quality in pregnancy is influenced by a dynamic interplay of hormonal, physiological, and psychological factors that evolve across gestation. Consequently, transient improvements may not necessarily translate into lasting behavioral adaptation or physiological recovery. The absence of longitudinal data in some earlier studies could therefore lead to overestimations of short-term efficacy and underestimation of the necessity for continuous, behaviorally anchored interventions.

Ward et al., observed partial improvements in daytime sleep functioning following an eight-week mindfulness program among pregnant women, yet approximately half of the participants exhibited no significant change in overall sleep quality.[14] Similarly, Hoegholt et al., compared the effects of music listening combined with sleep hygiene education versus sleep hygiene education alone over a four-week period.[15] Both groups demonstrated significant within-group improvements in PSQI and ISI scores; however, the absence of significant between-group differences indicated that music listening did not confer additional benefit beyond standard sleep hygiene training. These results, although supportive of certain non-pharmacological modalities, remain modest in magnitude and align with our meta-analytic conclusion that mindfulness- and music-based interventions exhibit limited or inconsistent effectiveness in this population.

A plausible explanation for the mixed results across mindfulness- and relaxation-based studies lies in the timing and duration of outcome assessments. Both Ward et al. and Hoegholt et al., assessed outcomes immediately following intervention completion, without conducting long-term follow-up. Given the physiological and psychological fluctuations inherent to pregnancy, short-term assessments may fail to capture sustained improvements in sleep regulation. Consequently, the absence of extended follow-up intervals likely limited the detection of persistent treatment effects, thereby contributing to the nonsignificant between-group findings observed in these studies.

Felder et al. also investigated yoga and mindfulness practices and found no significant enhancement in sleep quality among pregnant participants, consistent with our meta-analysis outcomes. Similarly, aerobic and water-based exercise programs were not associated with statistically meaningful effects on sleep during pregnancy. These results suggest that although such interventions promote general maternal well-being, their direct influence on sleep may be limited or contingent upon longer duration, higher intensity, or individualized program design.[35] Conversely, Lee and Gay, reported improvements following relaxation-based interventions, highlighting the variability observed in existing literature.[41] Such inconsistencies may stem from differences in intervention content, session frequency, adherence levels, and participant baseline characteristics. Relaxation techniques may provide immediate alleviation of stress and anxiety -key contributors to sleep disruption- whereas exercise and mindfulness programs often necessitate extended engagement before measurable

benefits emerge. Therefore, intervention-specific mechanisms and contextual factors should be carefully considered when interpreting sleep outcomes across studies.

Taken together, the present findings underscore the necessity for tailored, adequately dosed, and longitudinally evaluated interventions to optimize sleep quality during pregnancy. Standardization of intervention protocols, outcome measures, and follow-up durations will be essential for future research to ensure comparability and reproducibility across studies. Moreover, the integration of multi-component strategies -combining behavioral education with relaxation or physical activity- may enhance effectiveness by targeting both psychological and physiological determinants of sleep disturbance.

Several limitations of this meta-analysis must be acknowledged. First, the inclusion of diverse intervention modalities and varied measurement instruments may have contributed to heterogeneity in effect estimates. To minimize this, SMD were used in statistical analyses. Second, the relatively short follow-up period (maximum of three months) restricted evaluation of long-term intervention effects. Third, the limited number of eligible studies precluded the use of meta-regression to explore potential moderators, such as gestational age, baseline sleep disturbance severity, or intervention intensity. Future research should employ larger, methodologically rigorous RCTs with extended follow-up durations and standardized outcome reporting to strengthen the evidence base and inform evidence-based clinical practice for sleep management in pregnancy.

Conclusion

Among the interventions examined -including complementary medicine, aquatic and aerobic exercise, CBT, and acupuncture- sleep health behavior education demonstrated the greatest effectiveness in improving sleep quality among pregnant women. Its effects were particularly pronounced and sustained up to two months post-intervention. Incorporating structured behavioral sleep education into routine prenatal care may offer a feasible, cost-effective, and sustainable approach to enhance maternal sleep and overall well-being. Health professionals, including midwives, obstetricians, and nurses, can integrate sleep hygiene education, behavioral strategies, and lifestyle counseling into prenatal visits. Moreover, community-based programs and childbirth preparation classes may benefit from embedding these educational components to support expectant mothers in managing sleep disturbances effectively.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PICOS, Participants, Interventions, Comparison, Outcomes, and Study Design; RCT, Randomized Controlled Trial; SMD, Standardized Mean Difference; GRADE, Grading of Recommendations Assessment, Development and Evaluation; RoB2, Risk of Bias 2; PSQI, Pittsburgh Sleep Quality Index; ISI, Insomnia Severity Index; GSDS, General Sleep Disturbance Scale; ICSD, International Classification of Sleep Disorders; ANOVA, Analysis of Variance; ANCOVA, Analysis of Covariance; SHIPP, Sleep Hygiene Intervention Package for Parents; SWEP, Study of Water Exercise in Pregnancy; CBT, Cognitive Behavioral Therapy; CBT-I, Cognitive Behavioral Therapy for Insomnia; REDCap, Research Electronic Data Capture.

Authors' contributions

NDN: Conceptualization, review, and supervision; ZBM: Writing, review, and editing; SG: Literature search and data collection; ER: Methodology, formal analysis, writing, and review. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Faculty of Nursing and Midwifery, Tehran University of Medical Sciences (ID: IR.TUMS.FNM.REC.1399.040).

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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