Asian Nursing Research xxx (xxxx) xxx

Contents lists available at ScienceDirect

Asian Nursing Research

journal homepage: www.asian-nursingresearch.com

Review Article

Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials

Shu-Ya Yang,[1] Shou-Jen Lan,[1, 2, 3] Yea-Yin Yen,[4] Yen-Ping Hsieh,[5] Pei-Tseng Kung,[1, 2, 3] Shao-Huan Lan[6, *]

[1] *Department of Healthcare Administration, Asia University, Taichung, Taiwan*
[2] *Department of Medical Research, China Medical University Hospital, Taichung, Taiwan*
[3] *China Medical University, Taichung, Taiwan*
[4] *Department of Oral Hygiene, Kaohsiung Medical University, Kaohsiung, Taiwan*
[5] *Department of Long Term Care, National Quemoy University, Jinning, Taiwan*
[6] *School of Pharmaceutical Sciences and Medical Technology, Putian University, Putian, China*

ARTICLE INFO

Article history:
Received 3 June 2019
Received in revised form
17 January 2020
Accepted 17 January 2020

Keywords:
exercise
meta-analysis
pregnant women
sleep
sleep initiation and maintenance disorders

SUMMARY

Purpose: Sleep quality was considered a priority concern facing pregnant women. Conventional wisdom argues that good sleep quality benefits pregnant women and their fetuses. The aim of this study is to assess the effects of a specific exercise program on the sleep quality in pregnant women. Methods: Searches were executed in seven databases since their inceptions until February 28, 2019, for randomized controlled trials evaluating the effects of an exercise program on the sleep quality and insomnia in pregnant women. A random-effects model was applied for meta-analysis, and odds ratio, mean differences (MDs), and 95% confidence intervals (CIs) are shown as parts of outcomes. Results: Seven studies were included for meta-analysis. Compared with their not-exercising counterparts, analyses showed that regularly exercising women had significantly enhanced sleep quality, with an odds ratio of 6.21 (95% CI, 2.02−19.11; $p = 0.001$; $I^2 = 80.2\%$), with a standardized MD of −0.93 (95% CI, −1.19 to −0.67; $p < 0.001$; $I^2 = 30.0\%$). However, exercising women showed no significant insomnia improvement, with an standardized MD of −2.85 (95% CI, −7.67 to 1.98; $p = 0.250$; $I^2 = 97.0\%$), relative to their not-exercising counterparts. Conclusion: This research indicated that exercise has a positive impact on the sleep quality of pregnant women. Despite the aforementioned positive impact on sleep quality, the present study did not find evidence to support that exercise may also improve insomnia for pregnant women.

Introduction

Sleep disturbance is quite common in pregnant women. About 76% of pregnant women experienced poor sleep quality throughout all trimesters, and 57.3% of pregnant women experience subthreshold insomnia throughout all trimesters [1]. Longitudinal studies indicated that sleep quality decreased from the second to third trimester [2]. Many pregnant women experience frequent poor sleep quality, nighttime awakening, insomnia, insufficient nighttime sleep, and significant daytime sleepiness during their pregnancy [1].

Sleep disturbances have been correlated with the increased risk of adverse pregnancy outcomes including emergency cesarean sections [3,4], preterm births [4], development of depressive symptoms [5–7], glucose intolerance [8,9], and gestational hypertension [3,10]. Based on these associations, the authors believe that the improvement in sleep could presumably result in better pregnancy outcomes. Furthermore, an insomnia drug therapy has several side effects: preterm birth, preterm deliveries, cesarean deliveries, low birth weight, and even delivery of small-for-gestational-age infants [11].

Exercise has been suggested as one of the several non-pharmacological alternatives to enhance sleep quality [12]. Exercise

Shu-Ya Yang: https://orcid.org/0000-0002-6867-8139; Shou-Jen Lan: https://orcid.org/0000-0002-8395-2052; Yea-Yin Yen: https://orcid.org/0000-0003-1476-3511; Yen-Ping Hsieh: https://orcid.org/0000-0002-5636-9929; Pei-Tseng Kung: https://orcid.org/0000-0001-5323-7210; Shao-Huan Lan: https://orcid.org/0000-0002-8663-3161

* Correspondence to: Shao-Huan, Lan, PhD, School of Pharmaceutical Sciences and Medical Technology, Putian University, 1133 Xueyuan Road, Chengxiang District, Putian, Fujian Province, 351100, PR China.
E-mail address: shawnlan0713@gmail.com

https://doi.org/10.1016/j.anr.2020.01.003
p1976-1317 e2093-7482/

has been considered to enhance sleep quality and improve insomnia and anxiety [13–16]. Women with uncomplicated pregnancies should be encouraged to engage in aerobic and strength-conditioning exercises during pregnancy [17]. For healthy pregnant women, the guidelines recommend at least 150 minutes per week of moderate-intensity aerobic activity [18]. Some studies have shown that water exercise and relaxation exercise can improve the sleep quality of pregnant women [19,20], but one study has shown that tai chi/yoga does not improve the sleep disturbances of pregnant women [21]. When reviewing individual studies, the effect of physical activity or exercise on sleep quality and insomnia during pregnancy is inconclusive. Therefore, the authors conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to assess and validate the effects of exercise programs on quality of sleep and insomnia.

Methods

This study used Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols 2015 statements in constructing the structure of this review [22].

Search strategies

Electronic literature searches were conducted in seven databases MEDLINE, PubMed, Cumulative Index to Nursing and Allied Health Literature, Cochrane, Excerpta Medica database (Embase), Chinese National Knowledge Infrastructure, and Airiti Library since their inceptions through February 28, 2019. Corresponding Chinese terms were used for searching in Chinese databases (Chinese National Knowledge Infrastructure and Airiti Library). The search terms used were "pregnan*" or "gestation" or "prenatal" and "sleep" or "insomnia" and "exercise" or "sport" or "physical activity" or "yoga" or "tai chi." Manual searches were also performed on retrieved articles for additional references.

Inclusion/exclusion criteria and study selection

A PICOS (Participants, Intervention, Comparison, Outcomes) tool, composed of participant, intervention, comparison, outcomes, and study setting, was used as selection criteria to develop an effective strategy [23]. As per the design, participants were pregnant women, and the intervention was exercise regardless of its types or forms (e.g., aerobic exercise, stretching and relaxation, yoga, or tai chi) versus nonactive intervention (e.g., education or usual care) as a comparison. Quality of sleep or insomnia was the outcome, and for the study setting, only RCTs were assessed.

The following studies were excluded: (1) prospective cohort studies, (2) numerical data not provided or specified on specific tools, and (3) studies with participants reported to have acute complications during the courses of exercises, such as vaginal bleeding, amniotic fluid leakage, or regular painful contractions.

Data extraction

To ensure the objectivity of literature screening, two reviewers (S.-Y.Y. and S.-H.L.) independently screened titles, abstracts, and full-text journal articles. Citations considered potentially relevant to literature with titles or abstracts containing insufficient information were retrieved and further assessed, via applying the PICOS tool, by two independent reviewers (S.-Y.Y. and S.-H.L.) to determine eligibility for inclusion. In cases of disagreement over eligibility for inclusion between the two independent reviewers (S.-Y.Y. and S.-H.L.), a consensus was achieved by discussing and consulting with a third reviewer (S.-J.L.). Two reviewers (S.-Y.Y. and S.-H.L.) independently extracted data from the included studies. The following information was extracted: authors, the year of publication, the number of participants, age of the participants, nationality, pregnant body mass index, gestational age, the information about characteristics of exercise programs, and the information about characteristics of the outcome measurement. A consensus was achieved by discussing and consulting with a third reviewer (S.-J.L.).

Quality assessment of selected studies

The methodological quality of the selected RCTs was evaluated against the Cochrane risk of bias tool. Higgins et al. states that "the risk of bias tool covers six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias." In evaluating any RCTs, each item was depicted as having either a low risk of bias, a high risk of bias, or an unclear risk of bias. The risk of bias was independently evaluated by two authors (S.-Y.Y. and S.-J.L.) by applying the Cochrane risk of bias tool [24].

Meta-analytical and statistical methods

The reviewers extracted data in connection with the study characteristics (PICOS criteria) by using the data form. Once verified for their exactness and completeness, the results were then analyzed by applying the Cochrane Collaboration Review Manager (RevMan) software program version 5.4 (Cochrane, London, UK). As for data synthesis of continuous variables, results of the individual studies were calculated as mean difference (MD) or standardized MD (SMD), with 95% confidence intervals (CIs). When the pooled trials used different rating scales, the absolute MD divided by the SMD was applied. For dichotomous variables, results of the individual studies were calculated as odds ratios (ORs), with 95% CIs [25]. The researchers deemed only randomized trials demonstrating clinical homogeneity to be potentially eligible for meta-analysis. As for pooled effects, heterogeneity was tested applying the Breslow–Day test, with $p < .10$ considered statistically significant. The I^2 analysis is a useful statistic to quantify inconsistency: $I^2 = [(Q - df)/Q] \times 100\%$, where Q is the χ^2 statistic and df is its degrees of freedom [23,26]. The χ^2 test was further applied to evaluate and quantify statistical heterogeneity across trials by using the I^2 statistic (small, $I^2 < 25\%$; moderate, I^2 between 26% and 74%; and high, $I^2 \geq 75\%$) [25]. If heterogeneity was observed (the value of heterogeneity being higher than or equal to 25%), the authors then applied a random-effects model. If the value of heterogeneity was lower than 25%, the authors applied a fixed-effects model [27]. To assess the possibility of publication bias, we also applied Egger's regression test, and the Begg adjusted rank correlation test [28,29].

Results

Literature search

A flow chart describing the literature extraction process as well as the criteria for inclusion and exclusion can be seen in Figure 1. As per initial search results, 461 records were identified from relevant databases and their reference lists, with 137 duplicate references being removed. Among the remaining 324 potentially eligible articles, 273 were excluded after screening their titles and abstracts, and in addition, four more non–full-text articles were further removed. During the eligibility screening stage, 40 of 47 full-text articles were excluded for not meeting the inclusion criteria. These remaining seven articles were included for meta-analysis [19–21,30–33].

Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003

Characteristics of the selected studies

Participants

A total of 688 pregnant women were included as participants in seven RCTs. All studies focused on pregnant women without physical complications reported during pregnancy. Participants in one study were pregnant women with depression, whereas another study has involved pregnant women with complaints of insomnia or fatigue. The mean age for participants was around 26.00–32.12 years, with their pregnancy stages covering the first, second, and third trimesters. Of the seven studies included for analyses, three were conducted in China, one in the USA, one in Spain, one in Turkey, and the remaining one in Nigeria (Table 1).

Intervention

Among studies included for meta-analysis, participants of three studies practiced yoga, whereas participants in the other four studies practiced multiple forms of exercise, including aerobic exercise, gymnastics training, tai chi, and relaxation exercise. The duration of exercise was between 4 and 16 weeks, with its frequency ranging from 1 to 3 sessions per week and duration for each session lasting as long as 20–60 minutes. In addition to the regular programmed exercise, participants of four studies also performed self-initiated exercise by themselves at home on a daily basis (Table 2).

Comparison

The control group of one study was allocated to a waitlist childcare transportation and that of five studies was implemented with education and another one was in routine care (Table 1).

Outcome

Four studies [19,20,31,32] reported sleep quality by applying the Pittsburgh Sleep Quality Index (PSQI), one study [28] reported sleep quality by applying the Self-Rating Scale of Sleep, and the other two studies [21,30] adopted the Verran and Snyder-Holpern Sleep Scale and the Insomnia Severity Index scale to report participants' insomnia condition. Six studies [19,20,30–33] reported that the quality of sleep or insomnia conditions in the exercise group was better than that of the counterpart group. One study [21] reported no difference in insomnia conditions among participants in both the exercise and the no-exercise control group. The characteristics of the included articles are summarized in Table 2.

Risk of bias assessment

Risk of bias assessment is illustrated in Figure 2. The methodological quality of all the included studies was judged to be "moderate" based on the distribution for each item assessed for risk of bias. Publication bias was calculated as Begg and Egger tests (Begg test, $p = .042$; Egger test, $p = .029$).

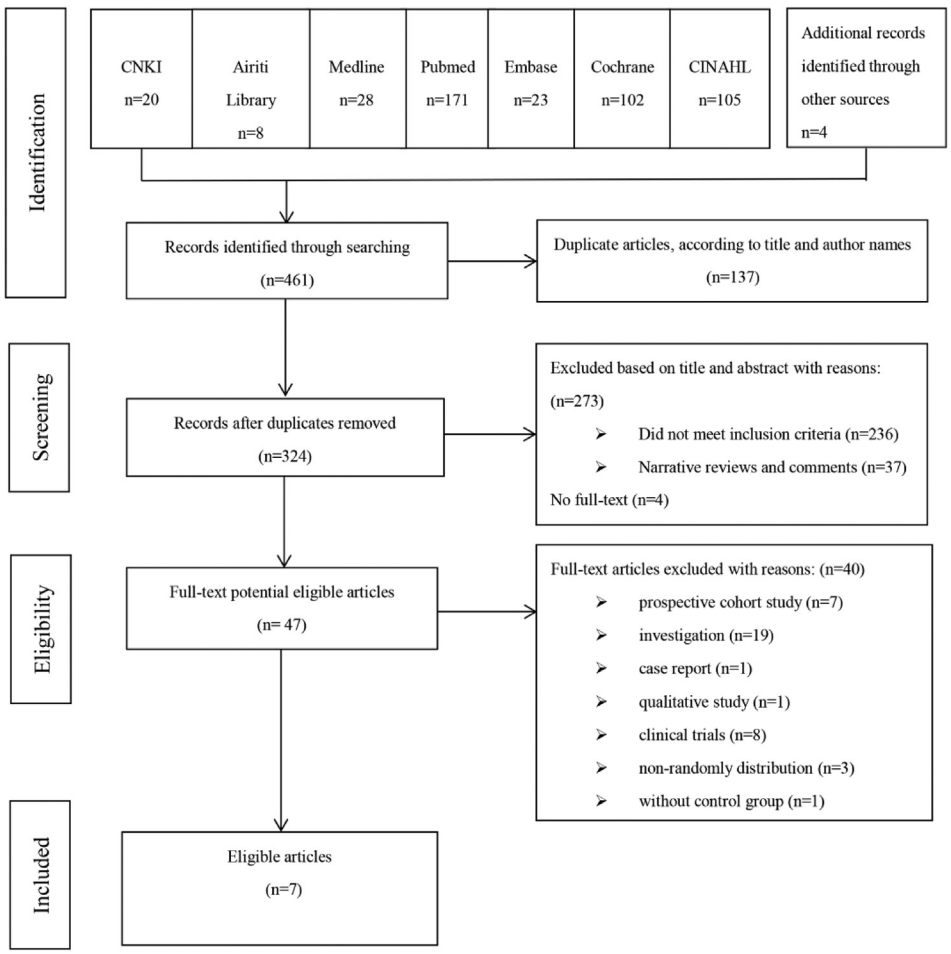


Figure 1. Flow chart describing literature extraction process. *Note*. CINAHL = Cumulative Index to Nursing and Allied Health Literature; CNKI = Chinese National Knowledge Infrastructure.

Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003

Table 1 *Main Characteristics of the Included Studies in the Meta-analysis (N = 7).*

Author (year)	Site of the study, country	Type of the sample	Age (mean ± SD)	Pregnant BMI (mean ± SD)		Gestational age	Type of exercise	N	Duration (weeks/study)
				Pre-test	Post-test				
Tella et al.(2011) [30]	Nigeria	Pregnant women with complaint of insomnia and fatigue	IG: 31.8 ± 7.7 CG: 31.0 ± 7.1	37.8 ± 3.5 36.7 ± 3.4	–– ––	Third trimester Third trimester	Aerobic exercise CG: sleeping education	16 14	6 6
Li (2011) [31]	China	Uncomplicated pregnancy	IG: 27.8 ± 6.3 CG: 27.8 ± 6.3	Normal Normal	3.8% abnormal 11.3% abnormal	20 weeks	Yoga CG: routine care	80 80	16 16
Field et al.(2013) [21]	USA	Clinically depressed pregnant woman	IG: 24.4 ± 4.7	––	––	Second and third trimester	Yoga/tai chi	37	12
		Uncomplicated pregnancy with no medical illness	CG: 26.0 ± 5.6	––	––	Second and third trimester	CG (waitlist)	38	12
Rodriguez-Blanque et al.(2018) [19]	Spain	Pregnant women	IG: 32.12 ± 4.43 CG: 30.58 ± 4.75	23.89 24.01	27.76 ± 4.03 29.03 ± 4.45	20 weeks 20 weeks	Aerobic exercise in water CG: sleep education	67 67	16 16
Liu (2018) [32]	China	Uncomplicated pregnancy	IG: 27 ± 5.13 CG: 26 ± 4.3	21.5 ± 3.2 23.1 ± 2.5	–– ––	25 weeks	Gymnastics training CG: education	50 50	11 11
Ozkan and Rathfisch (2018) [20]	Turkey	Normal pregnancy	IG: 27.93 ± 4.56 CG: 27.79 ± 3.90	22.10 (pregravid) 21.94 (pregravid)	–– ––	Third trimester Third trimester	Relaxation exercise CG: education	42 42	4 4
Shu et al. (2018) [33]	China	Uncomplicated pregnancy	IG: 29.29 ± 4.80	––	––	First to third trimester	Mindfulness yoga	55	4
			CG: 29.16 ± 4.46	––	–––	First to third trimester	CG: education	50	4

Note. BMI = body mass index; CG = control group; IG = intervention group; SD = standard deviation.

Summary of the results

Four studies reported the sleep quality of participants by using the PSQI, with the results of dichotomous variables revealing that the participants in the exercise group showed an obvious sleep quality improvement (OR, 6.21; 95% CI, 2.20–19.11; p = .001; I^2 = 82.0%). Two studies reporting the sleep quality of participants, with the results of continuous variables revealing that the participants in the exercise group demonstrated an obvious sleep quality improvement (SMD, −0.93; 95% CI, −1.19 to −0.67; p < .001; I^2 = 30.0%) (Figure3).

Two studies reported participants' insomnia condition by using the Verran and Snyder-Holpern Sleep Scale and PSQI, with the results of continuous variables revealing no significant difference among the participants in either the exercise group or the no-exercise counterpart group (SMD, −2.85; 95% CI, −7.67 to 1.98; p = .250; I^2 = 97.0%) (Figure 3).

Of the two studies that conducted integrated analyses on the participants who practiced aerobic exercise, the results of the dichotomous variables showed that the participants in the exercise group also had significant improvement in sleep quality (OR, 4.26; 95% CI, 2.23–8.11; p < .001; I^2 = 16.0%) (Figure 3).

Discussion

A previous meta-analysis examining the effects of aerobic exercise was found to have improved the sleep quality of middle-aged women [34]. Similarly, findings derived from our meta-analysis also showed that programmed aerobic exercise can improve the sleep quality of pregnant women. This study has found that the effectiveness of aerobic exercise, when compared with overall exercises, on sleep improvement was least effective. However, opposite results were also discovered when research participants were middle-aged pregnant women [34]. Whether or not exercises of lower intensity such as yoga, tai chi, and relaxation exercise are more effective in improving sleep quality of pregnant women is an interesting topic and warrants further studies to explore and clarify their effectiveness.

Because of different statistical value representations (continuous variables and dichotomous variables) and distinct outcomes used, three articles exploring the effectiveness of practicing yoga on improving the sleep quality and insomnia conditions in pregnant women were included in the meta-analysis. The results of our review cannot conclusively determine the effectiveness of practicing yoga on improving the sleep quality or insomnia conditions in pregnant women. Conventional wisdom has nevertheless endorsed yoga and considered it beneficial in indirectly facilitating a better sleep, as well as a viable intervention in reducing pain, discomfort, and depression in pregnant women [31,33,35,36]. Relaxation exercise was found to ameliorate the sleep quality for inpatient patients during hospitalization [37]. As in our meta-analysis, only one small study (n = 82), addressed the effects of relaxation exercise on sleep quality. The results derived from our analyses could neither substantiate nor repudiate the proposition that relaxation exercise can actually improve the sleep quality of pregnant women. Accordingly, more relevant studies are warranted and encouraged to validate the presumed beneficial effects of yoga and relaxation exercise on improving the sleep quality and insomnia conditions in pregnant women.

According to the meta-analysis, exercise from the second trimester can effectively improve sleep (only one study started exercise from the first trimester) [19–21,30–33]. However, the effect of exercise type and intensity on improving pregnant women's sleep is still not clear in the analysis. Further studies on the impact of exercise type and intensity on sleep in pregnant women at different trimesters are recommended. The results of this study

Table 2 *Characteristics of Exercise Programs and Outcomes Assessment of the Studies Included in the Meta-analysis (N = 7).*

Author (year)	Type of exercise	Exercise content	Exercise intensity	Exercise frequency (sessions/week)	Session length (min)	Duration (weeks/study)	Basal score		Poster scale		Tool/result
							Sleep quality mean ± SD or good sleep quality (%)	Insomnia mean ± SD	Sleep quality mean ± SD or good sleep quality (%)	Insomnia mean ± SD	
Tella et al. (2011) [30]	Aerobic exercise	Walk, stair climbing, mild jogging, ball throwing, sitting on a chair	Moderate	1	20	6		18.4 ± 7.9		2.9 ± 0.4	ISI/the IG reported significant reduction in the insomnia level ($p < .001$)
	CG							15.8 ± 7.0		9.5 ± 1.7 $p < .001$	
Li (2011) [31]	Yoga	Bulletin board yoga training; self-practice at home every day	Low	2	60	16	88.7%		81.2%		PSQI/the IG reported significantly better sleep quality ($p < .05$)
	CG						85.0% $p > .05$		65.0% $p < .05$		
Field et al. (2013) [21]	Yoga/tai chi	Yoga and tai chi combined	Low	1	20	12		56.6 ± 20.1		53.5 ± 19.5	VSH/the IG reported lower sleep disturbances ($p = .05$)
	CG							54.4 ± 19.7		62.1 ± 18.4 $p = .05$	
Rodriguez-Blanque et al. (2018) [19]	Aerobic exercise	Aerobic exercise, force, resistance exercise, stretching, relaxation exercise in water	Moderate (Borg scale higher than 14)	3	60	16	6.51 ± 3.74/ 55.71%		6.84 ± 2.86/ 34.32%		PSQI/the IG reported significantly better sleep quality ($p < .05$)
	CG						6.81 ± 3.72/ 56.72% $p > .05$		10.10 ± 3.12/ 7.46% $p < .05$		
Liu (2018) [32]	Gymnastic training	Lifting the anus (Kegel exercise), foot movement, sitting cross-legged, waist twisting exercise, and self-practice at home 1 h every day	Moderate (mild shortness of breath, mild sweat)	2	60	11	82.0%		74.0%		PSQI/the IG reported significantly better sleep quality ($p = .007$)
	CG						76.0% $p = .617$		48.0% $p = .007$		
Ozkan and Rathfisch (2018) [20]	Relaxation exercise	Relaxation exercise: 30-min relaxation exercise, 30-min relaxation music, and self-practice at home 1 h every day with CD before sleep	Low	1	60	4	40.5%		83.3%		PSQI/the IG reported significantly better sleep quality ($p = .001$)

(*continued on next page*)

Table 2 (*continued*)

Author (year)	Type of exercise	Exercise content	Exercise intensity	Exercise frequency (sessions/week)	Session length (min)	Duration (weeks/study)	Basal score: Sleep quality mean ± SD or good sleep quality (%)	Basal score: Insomnia mean ± SD	Poster scale: Sleep quality mean ± SD or good sleep quality (%)	Poster scale: Insomnia mean ± SD	Tool/result
	CG						38.1% $p = 1.000$		9.5% $p = .001$		
Shu et al. (2018) [33]	Mindfulness yoga	Guide breathing to body, meditation, yoga for posture, mindfulness walking; and self-practice at home 20mins every morning and evening	Low	1	60	4	28.44 ± 5.71		25.29 ± 4.34		SRSS/the IG reported significantly better sleep quality ($p < .001$)
	CG						28.00 ± 4.40 $p = .663$		28.58 ± 4.24 $p < .001$		

Note. CG = control group; IG = intervention group; ISI = Insomnia Severity Index; PSQI = Pittsburgh Sleep Quality Index; SD = standard deviation; SRSS = Self-Rating Scale of Sleep; VSH = Verran and Snyder-Holpern.

showed that exercise intervention is an assistive way to improve pregnant women's quality of sleep. Moreover, according to the meta-analysis, three studies pointed out that pregnant woman can do yoga, relaxation exercise, and gymnastic exercise at home by themselves. If the researchers can design more exercises that are suitable and safe for pregnant women to do at home, it can improve the pregnant women's quality of sleep more conveniently and effectively.

Exercise has long been claimed to have a positive impact on sleep quality in many RCT-based studies [12]. Putative mechanisms suggested that generally exercise has a positive impact on physiological functions, including depression, anxiety, immune function, body restoration, circadian phase shifting, cytokine concentration, adenosine release, and thermoregulation [15].

Diabetes, obesity, and hypertension are generally considered contraindications for pregnant women to practice aerobic exercise [17]. Furthermore, pregnant women with comorbidities tend to have more sleep problems than healthy ones [38,39]. As, unfortunately, there are no related studies conducted to determine whether and how exercise benefits pregnant women with comorbidities, interested researchers are encouraged to delve more broadly and deeply into studies designed to explore and determine the exact types or forms of exercise that may improve the sleep quality in women with other clinical conditions.

One previous meta-analysis study addressing relationships between exercise and insomnia in middle-aged women has found that exercise has a nonsignificant decrease in insomnia severity in pregnant women [34]. Similarly, findings from our meta-analysis also showed that programmed exercise during pregnancy has a nonsignificant decrease in insomnia severity in pregnant women. Insomnia is a very complex medical condition subjected to influences from a multitude of factors, e.g., comorbid status, medical therapies, negative life events, family status, social relationship problems, and employment conditions, among other factors. Exercise during pregnancy alone may not be enough to neutralize or counterbalance other negative factors contributing to insomnia [40–42]. In this meta-analysis, only two studies included pregnancy exercise, one study combined yoga and tai chi as pregnancy exercise, and the other practiced aerobic exercise. More studies are warranted in the future, for example, studies adopting new approaches to measure the effectiveness of exercise on insomnia, potential confounding factors, and specific quantitative assessment such as polysomnography.

Of the seven studies included, only one research study has addressed the issues of exercise intensity and warning signs for pregnant women to discontinue exercise. Pregnant women are advised to adhere to those exercise guidelines strictly to ensure their safety during the courses of exercising. The American College of Obstetrics and Gynecology recommends that all women with uncomplicated pregnancies should, after consulting with their providers, routinely engage them in aerobic and strength-conditioning exercise. An exercise program of moderate intensity aimed at achieving optimal effectiveness should be for at least 20–30 minutes per day on most days, if not every day of the week [17]. Safe exercise includes stationary cycling, low-impact aerobics, swimming, walking, yoga, and Pilates during pregnancy [17,18]. After consultation with and evaluation by an obstetrician, racquet sports, strength training, and running or jogging may be safe for pregnant women who practiced these exercises regularly before pregnancy [17,18]. For moderate-intensity exercise, perceived exertion should be rated, 13–14 ("somewhat hard" but not reaching the "hard" scale) on the Borg Scale of Perceived Exertion. Applying the "talk test" is another effective way to evaluate exertion. As long as a woman can have a conversation while exercising, there is no overexerting exercise [17].

Tella et al.(2011)[27]	Li (2011)[28]	Field et al. (2013)[25]	Rodriguez-Blanque et al. (2018)	Liu (2018)[29]	Ozkan et al. (2018)[30]	Shu et al. (2018)[31]	
⊕	⊕	⊕	⊕	⊕	⊕	⊕	Random sequence generation
?	?	?	⊕	⊕	⊕	⊕	Allocation concealment
?	⊖	?	⊖	⊕	⊖	⊖	Blinding of participants and personnel
?	?	?	⊕	⊕	?	⊕	Blinding of outcome assessment
?	?	⊕	⊕	?	⊕	⊕	Incomplete outcome data
⊕	⊕	⊕	⊕	⊕	⊕	⊕	Selective reporting
⊖	⊕	⊕	⊕	⊕	⊕	⊖	Other bias

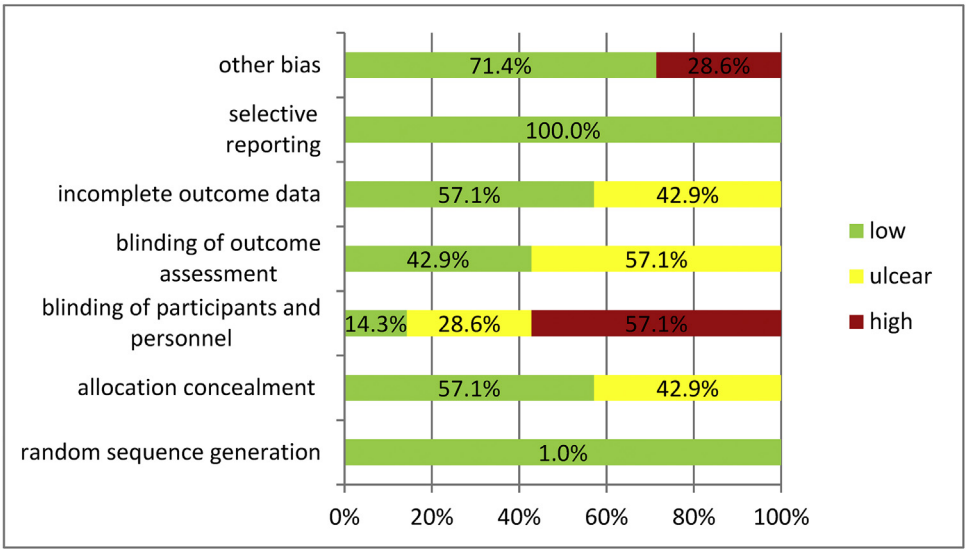
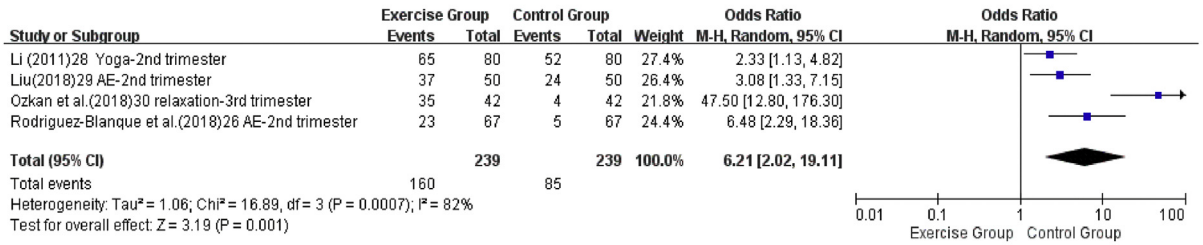


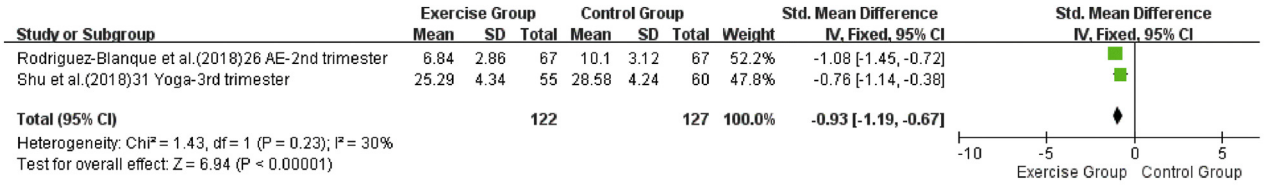
Figure 2. Assessment of risk of bias of the included RCTs. Note. RCT = randomized controlled trial.

Of all studies included in the meta-analysis, only two articles addressed body weight changes in the pregnancy process. A study by Rodriguez-Blanque et al. [19] has shown that sleep quality was better for the exercising pregnant women with a normal body weight during their pregnancy, yet it was not statistically significant when compared with their obese counterparts in the control group. As most studies did not monitor body weight changes throughout the entire courses of pregnancy, the question of whether or not an abnormal body weight increase during pregnancy may influence sleep quality and insomnia is still unknown. As such, future researchers are recommended to address the factor of body weight increase during pregnancy in their studies, hopefully to explore the relationships between exercise during pregnancy and the degree of sleep quality improvement more clearly.

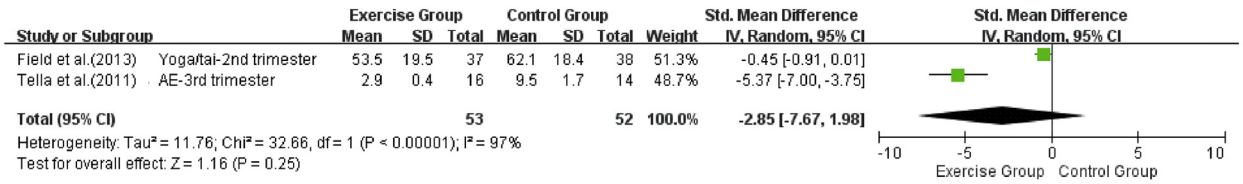
Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003

Sleep Quality





Insomnia



Aerobic Exercise

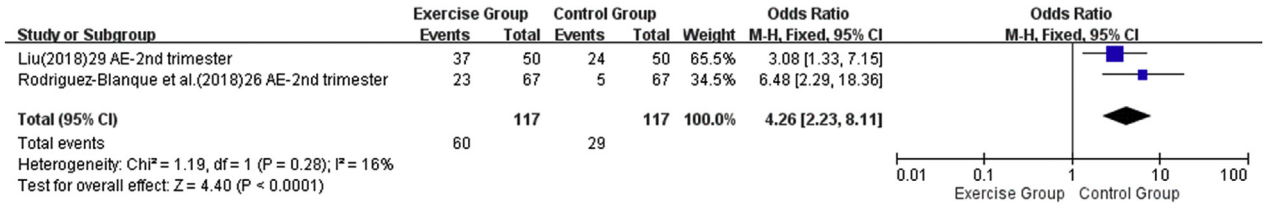


Figure 3. The effects of exercise program on improving sleep quality and insomnia; the effects of aerobic exercise program on improving sleep quality. *Note.* AE = aerobic exercise; CI = confidence interval; df = degrees of freedom; SD = standard deviation.

Conclusions

This systematic review study attempted to assess and validate effects of exercise on pregnant women. Seven studies involving 688 participants were included in our study for systematic review and meta-analysis. The findings from our study showed that exercise of 4–16 weeks in duration significantly improved the sleep quality in pregnant women. Most of the studies included in the reviews and analyses were of low quality in terms of evidence strength owing to a lack of participants or blinding of personnel. Heterogeneity of effects was high across these studies. The high heterogeneity was caused in part by distinct exercise types pregnant women practiced during pregnancy, as shown by the results derived from subgroup analyses. Going forward, better-designed studies involving a greater number of participants are warranted to validate presumed benefits of exercise in pregnant women in the future.

Although publication bias was detected across these studies, the fact that the OR value related to improved sleep quality as a result of

Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003

exercise during pregnancy was as high as 6.21 allows the authors to infer that exercise indeed can contribute to sleep quality improvement in pregnant women. Ideally, the OR value should be lower than 6.21. We therefore expect more future studies, including invalidity studies, to be undertaken in a bid to mitigate publication bias of meta-analyses.

Clinical implications

The findings derived from this meta-analysis and the much broader systematic review confirm with certainty that exercise can be seen as a safe, nonpharmacological approach to improve the sleep quality in pregnant women. Positive findings from this study were nevertheless somewhat offset by the fact that few high-quality studies on this subject were currently available. To make more definitive conclusions regarding the potential effects of exercise in pregnant women and perhaps their actual mechanisms, more clearly defined and rigorously designed large-scale RCTs are warranted in the future.

Conflict of interest

The authors have no conflicts of interest to disclose.

Acknowledgments

The authors wish to express heartfelt gratitude to their family for their support and sacrifice in allowing them sufficient space and time to complete this study. The authors' appreciations also go to Associate Professor Hung-En Liao of Asia University, Taiwan, and Dr. Lin Long-Yau of Chung Shan Medical University Hospital, Taiwan, for their subject matter expertise in women health that offered valuable guidance and recommendations for this research. The authors also thank the fellow PhD students and candidates of Asia University, Taiwan, who have shared with them so many brilliant research ideas and rendered much needed support in conducting this study.

References

1. Mindell JA, Cook RA, Nikolovski J. Sleep patterns and sleep disturbances across pregnancy. Sleep Med. 2015;16(4):483–8. https://doi.org/10.1016/j.sleep.2014.12.006
2. Sedov ID, Cameron EE, Madigan S, Tomfohr-Madsen LM. Sleep quality during pregnancy:Ameta-analysis. Sleep Med Rev. 2018;38:168–76. https://doi.org/10.1016/j.smrv.2017.06.005
3. Sharma SK, Nehra A, Sinha S, Soneja M, Sunesh K, Sreenivas V, et al. Sleep disorders in pregnancy and their association with pregnancy outcomes: a prospective observational study. Sleep Breath. 2016;20(1):87–93. https://doi.org/10.1007/s11325-015-1188-9
4. Li R, Zhang J, Zhou R, Liu J, Dai Z, Liu D, et al. Sleep disturbances during pregnancy are associated with cesarean delivery and preterm birth. J Matern Fetal Neonatal Med. 2017;30(6):733–8. https://doi.org/10.1080/14767058.2016.1183637
5. González-Mesa E, Cuenca-Marin C, Suarez-Arana M, Tripiana-Serrano B, Ibrahim-Díez N, Gonzalez-Cazorla A, et al. Poor sleep quality is associated with perinatal depression. A systematic review of last decade scientific literature and meta-analysis. J Perinat Med. 2019;47(7):689–703. https://doi.org/10.1515/jpm-2019-0214
6. Gao M, Hu J, Yang L, Ding N, Wei X, Li L, et al. Association of sleep quality during pregnancy with stress and depression: a prospective birth cohort study in China. BMC Pregnancy Childbirth. 2019;19:444. https://doi.org/10.1186/s12884-019-2583-1
7. Yu Y, Li M, Pu L, Wang S, Wu J, Ruan L, et al. Sleep wasassociated with depression and anxiety status during pregnancy: a prospective longitudinal study. Arch Womens Ment Health. 2017;20(5):695–701. https://doi.org/10.1007/s00737-017-0754-5
8. Facco FL, Grobman WA, Reid KJ, Parker CB, Hunter SM, Silver RM, et al. Objectively measured short sleep duration and later sleep midpoint in pregnancy are associated with a higher risk of gestational diabetes. Am J Obstet Gynecol. 2017;217(4):447. https://doi.org/10.1016/j.ajog.2017.05.066, 447.e1–447.e13.
9. Zhong C, Chen R, Zhou X, Xu S, Li Q, Cui W, et al. Poor sleep during early pregnancy increases subsequent risk of gestational diabetes mellitus. Sleep Med. 2018;46:20–5. https://doi.org/10.1016/j.sleep.2018.02.014
10. Pengo MF, Rossi GP, Steier J. Obstructive sleep apnea, gestational hypertension and preeclampsia: a review of the literature. Curr Opin Pulm Med. 2014;20(6):588–94. https://doi.org/10.1097/MCP.0000000000000097
11. Okun ML, Ebert R, Saini B. A review of sleep-promoting medications used in pregnancy. Am J Obstet Gynecol. 2015;212(4):428–41. https://doi.org/10.1016/j.ajog.2014.10.1106
12. Kelley GA, Kelley KS. Exercise and sleep: a systematic review of previous meta-analyses. J Evid Based Med. 2017;10(1):26–36. https://doi.org/10.1111/jebm.12236
13. Chang SP, Shih KS, Chi CP, Chang CM, Hwang KL, Chen YH. Association between exercise participation and quality of sleep and life among university students in Taiwan. Asia Pac J Public Health. 2016;28(4):356–67. https://doi.org/10.1177/1010539516645160
14. Wu Y, Yang L, Shen X, Zhai L, Fan C, Zhang D. Effect of leisure-time aerobic exercise and muscle strength activity on sleep duration: results from the 2012 National Health Interview Survey. J Public Health. 2016;24(2):117–24. https://doi.org/10.1007/s10389-015-0705-4
15. Varrasse M, Li J, Gooneratne N. Exercise and sleep in community-dwelling older adults. Curr Sleep Med Rep. 2015;1(4):232–40. https://doi.org/10.1007/s40675-015-0028-6
16. Morita Y, Sasai-Sakuma T, Inoue Y. Effects of acute morning and evening exercise on subjective and objective sleep quality in older individuals with insomnia. Sleep Med. 2017;34:200–8. https://doi.org/10.1016/j.sleep.2017.03.014
17. ACOG. Committee opinion no. 650: physical activity and exercise during pregnancy and the postpartum period. Obstet Gynecol. 2015;126(6):e135–42. https://doi.org/10.1097/AOG.0000000000001214
18. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, et al. The physical activity guidelines for Americans. JAMA. 2018;320(19):2020–8. https://doi.org/10.1001/jama.2018.14854
19. Rodriguez-Blanque R, Sánchez-García JC, Sánchez-López AM, Mur-Villar N, Aguilar-Cordero MJ. The influence of physical activity in water on the sleep quality in pregnant women: a randomised trial. Women Birth. 2018;31(1):e51–8. https://doi.org/10.1016/j.wombi.2017.06.018
20. Özkan SA, Rathfisch G. The effect of relaxation exercises on the sleep quality in pregnant women in the third trimester: a randomized controlled trial. Compl Ther Clin Pract. 2018;32:79–84. https://doi.org/10.1016/j.ctcp.2018.05.008
21. Field T, Diego M, Delgado J, Medina L. Tai chi/yoga reduces prenatal depression, anxiety and sleep disturbances. Compl Ther Clin Pract. 2013;19(1):6–10. https://doi.org/10.1016/j.ctcp.2012.10.001
22. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:1. https://doi.org/10.1186/2046-4053-4-1
23. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557–60. https://doi.org/10.1136/bmj.327.7414.557
24. Higgins JP, Altman DG, Gøtzsche PC, Gotzsche PC, Jüni P, Moher D, et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928. https://doi.org/10.1136/bmj.d5928
25. Demets DL. Methods for combining randomized clinical trials: strengths and limitations. Stat Med. 1987;6(3):341–8. https://doi.org/10.1002/sim.4780060325
26. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21(11):1539–58. https://doi.org/10.1002/sim.1186
27. Crocetti E. Systematic reviews with meta-analysis: why, when, and how? Emerg Adulthood. 2016;4(1):3–18. https://doi.org/10.1177/2167696815617076
28. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629–34. https://doi.org/10.1136/bmj.315.7109.629
29. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics. 1994;50(4):1088–101. https://doi.org/10.2307/2533446, https://www.ncbi.nlm.nih.gov/pubmed/7786990
30. Tella B, Sokunbi OG, Akinlami OF, Afolabi B. Effects of aerobic exercises on the level of insomnia and fatigue in pregnant women. Internet J Gynecol Obstet. 2011;15(1):1–6.
31. Li C. Influence of bulletin boards yoga on pregnant women body mass and the sleep quality. Chin J Health Birth Child Care. 2011;17(4):206–7. https://doi.org/10.3969/j.issn.1007-3434.2011.04.009 [Chinese].
32. Liu H. Effect of prenatal gymnastics on quality and pregnancy outcome in pregnant women [Internet]. Taipei, Taiwan: Airitilibrary; 2018 [cited 2019 Mar 19]. Available from: http://www.airitilibrary.com/Publication/alDetailedMesh?docid=sjsmyxzz201801016 [Chinese].
33. Shu L, Xi M, Wu C, Zhao W, Tan C, Chen D. Effects of mindfulness yoga training on sleeping, anxiety and childbirth fear among pregnant women. Chin Nurs Manag. 2018;18(10):1422–7. https://doi.org/10.3969/j.issn.1672-1756.2018.10.026 [Chinese].
34. Rubio-Arias JÁ, Marín-Cascales E, Ramos-Campo DJ, Hernandez AV, Pérez-López FR. Effect of exercise on the sleep quality and insomnia in middle-aged women: a systematic review and meta-analysis of randomized controlled trials. Maturitas. 2017;100:49–56. https://doi.org/10.1016/j.maturitas.2017.04.003
35. Jiang Q, Wu Z, Zhou L, Dunlop J, Chen P. Effects of yoga intervention during pregnancy: a review for current status. Am J Perinatol. 2015;32(6):503–14. https://doi.org/10.1055/s-0034-1396701

Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003

36. Gong H, Ni C, Shen X, Wu T, Jiang C. Yoga for prenatal depression: a systematic review and meta-analysis. BMC Psychiatr. 2015;15(14):14. https://doi.org/10.1186/s12888-015-0393-1
37. Alparslan GB, Orsal Ö, Unsal A. Assessment of the sleep quality and effects of relaxation exercise on the sleep quality in patients hospitalized in internal medicine services in a university hospital: the effect of relaxation exercises in patients hospitalized. Holist Nurs Pract. 2016;30(3):155–65. https://doi.org/10.1097/hnp.0000000000000147
38. Wilson DL, Walker SP, Fung AM, Pell G, O'Donoghue FJ, Barries M, et al. Sleep-disordered breathing in hypertensive disorders of pregnancy: a BMI-matched study. J Sleep Res. 2018;27(5):e12656. https://doi.org/10.1111/jsr.12656
39. Gay CL, Richoux SE, Beebe KR, Lee KA. Sleep disruption and duration in late pregnancy is associated with excess gestational weight gain among overweight and obese women. Birth. 2017;44(2):173–80. https://doi.org/10.1111/birt.12277
40. Patel D, Steinberg J, Patel P. Insomnia in the elderly: a review. J Clin Sleep Med. 2018;14(6):1017–24. https://doi.org/10.5664/jcsm.7172
41. Cunnington D, Junge MF, Fernando AT. Insomnia: prevalence, consequences and effective treatment. Med J Aust. 2013;199(S8):S36–40. https://doi.org/10.5694/mja13.10718
42. Winkelman JW. Insomnia disorder. N Engl J Med. 2015;373(15):1437–44. https://doi.org/10.1056/NEJMcp1412740

Please cite this article as: Yang S-Y et al., Effects of Exercise on Sleep Quality in Pregnant Women: A Systematic Review and Meta-analysis of Randomized Controlled Trials, Asian Nursing Research, https://doi.org/10.1016/j.anr.2020.01.003