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Effects of relaxation interventions during pregnancy on maternal mental health, and pregnancy and newborn outcomes: A systematic review and meta-analysis

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Abstract

Background

Stress during pregnancy is detrimental to maternal health, pregnancy and birth outcomes and various preventive relaxation interventions have been developed. This systematic review and meta-analysis aimed to evaluate their effectiveness in terms of maternal mental health, pregnancy and birth outcomes.

Method

The protocol for this review is published on PROSPERO with registration number CRD42020187443. A systematic search of major databases was conducted. Primary outcomes were maternal mental health problems (stress, anxiety, depression), and pregnancy (gestational age, labour duration, delivery mode) and birth outcomes (birth weight, Apgar score, preterm birth). Randomized controlled trials or quasi-experimental studies were eligible. Meta-analyses using a random-effects model was conducted for outcomes with sufficient data. For other outcomes a narrative review was undertaken.

Result

We reviewed 32 studies comprising 3,979 pregnant women aged 18 to 40 years. Relaxation interventions included yoga, music, Benson relaxation, progressive muscle relaxation

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(PMR), deep breathing relaxation (BR), guided imagery, mindfulness and hypnosis. Intervention duration ranged from brief experiment (~10 minutes) to 6 months of daily relaxation. Meta-analyses showed relaxation therapy reduced maternal stress (-4.1 points; 95% Confidence Interval (CI): -7.4, -0.9; 9 trials; 1113 participants), anxiety (-5.04 points; 95% CI: -8.2, -1.9; 10 trials; 1965 participants) and depressive symptoms (-2.3 points; 95% CI: -3.4, -1.3; 7 trials; 733 participants). Relaxation has also increased offspring birth weight (80 g, 95% CI: 1, 157; 8 trials; 1239 participants), explained by PMR (165g, 95% CI: 100, 231; 4 trials; 587 participants) in sub-group analysis. In five trials evaluating maternal physiological responses, relaxation therapy optimized blood pressure, heart rate and respiratory rate. Four trials showed relaxation therapy reduced duration of labour. Apgar score only improved significantly in two of six trials. One of three trials showed a significant increase in birth length, and one of three trials showed a significant increase in gestational age. Two of six trials examining delivery mode showed significantly increased spontaneous vaginal delivery and decreased instrumental delivery or cesarean section following a relaxation intervention.

Discussion

We found consistent evidence for beneficial effects of relaxation interventions in reducing maternal stress, improving mental health, and some evidence for improved maternal physiological outcomes. In addition, we found a positive effect of relaxation interventions on birth weight and inconsistent effects on other pregnancy or birth outcomes. High quality adequately powered trials are needed to examine impacts of relaxation interventions on newborns and offspring health outcomes.

Conclusion

In addition to benefits for mothers, relaxation interventions provided during pregnancy improved birth weight and hold some promise for improving newborn outcomes; therefore, this approach strongly merits further research.

Introduction

Stress, defined as "a state of mental discomfort, unpleasant feeling, worry or tension", when occurring during pregnancy is a major public health problem in low- and middle-income countries (LMICs), associated with adverse maternal health, pregnancy and birth outcomes [1, 2]. Stress occurs when a demand to deal with internal or external cues/stressors exceeds the coping skills and resilience of individuals [3]. Common stressors during pregnancy include physical stressors, such as illness and discomfort, changes in lifestyle, poor social support, unplanned pregnancy, low financial income, role transitions, hormonal and physiological changes, anticipation of labour and delivery, and intimate partner violence during and after pregnancy [4, 5]. Stress can be acute, episodic/transient or chronic, depending on the type and nature of stressors [6].

The human body stores unresolved psychological stress in the musculoskeletal system, mainly in the scalp, neck, back, chest, abdomen and extremities [7]. This can result in sustained contraction of the muscles which interferes with normal physiological functions [7]. The resulting stress response in the body involves psychological (mental, emotional or behavioral) and/or physiological responses (blood pressure, heart rate, respiratory rate and body temperature) [8]. Biologically, stress activates the Hypothalamus-Pituitary-Adrenal (HPA)

axis and the immune system through which it increases circulating glucocorticoids and pro-inflammatory markers [8]. Stress-induced glucocorticoid in the brain interferes with normal neurogenesis and synaptic plasticity leading to impaired functions of the nervous system which can result in mental illness [9–11]. This is recognized as the body-mind connection [12–14] whereby the body and the mind work together to maintain optimal psychological equilibrium and physiological homeostasis.

Stress during pregnancy can negatively impact maternal health and well-being [15] and generally increases the risk of non-communicable diseases such as hypertension, diabetes, cardiovascular problems, anxiety and depression [16]. Nearly one in three women globally [17], and more than half of women in LMICs experience stress during their pregnancy [17–20]. In Ethiopia, pregnant women experience higher levels of psychological stress compared to non-pregnant women and also exhibit lower resilience [18]. Globally, 15 to 25% of women experience high levels of anxiety or depressive symptoms during pregnancy [21, 22], with higher estimates from studies conducted in LMICs [22, 23]. Stress during pregnancy can affect the maternal immune system and increase the risk of infection and inflammatory diseases leading to maternal physical ill-health during and after pregnancy [8]. Antenatal stress and maternal mental disorders can adversely affect normal growth and development of the fetus and result in unfavorable pregnancy, obstetric and birth outcomes [15, 23, 24]. It can also influence the post-natal physical, mental and neurobehavioral health of the offspring, potentially leading to an increased risk of non-communicable diseases including mental illness later in life [24].

Several intervention modalities, including psychotropic medications, relaxation therapy and psychosocial and counseling therapies have been tested to reduce stress and improve the mental health of pregnant women [25]. Treatment of anxiety or depression with psychotropic medications during pregnancy or lactation carries potential risks for the mother and her offspring and has low acceptability [25]. Thus non-pharmacological interventions, such as counseling or relaxation therapies, are preferred for stress management during pregnancy [26, 27]. However, no comprehensive review of evidence is available on the effectiveness of relaxation interventions provided during pregnancy on maternal and neonatal health outcomes. This paper therefore aimed to systematically synthesize evidence on the effects of relaxation interventions on maternal stress and mental health during pregnancy and on pregnancy and birth outcomes.

Methods

Protocol registration

The protocol for this review was registered at PROSPERO International prospective register of systematic reviews and can be accessed at: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020187443.

Article selection

The review process followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guideline [28]. To identify relevant articles, a three-step search strategy was employed. In the first step, key free text and MeSH terms were identified and developed. Then a comprehensive search was conducted in the following major databases: PubMed, EMBASE Classic + EMBASE (Ovid), MEDLINE in-process and non-indexed citations, MEDLINE daily, and MEDLINE (Ovid), Cumulative Index to Nursing & Allied Health Plus (CINAHL via EBSCO) and the Cochrane library. In addition, a manual search was conducted to identify further relevant studies from the reference lists of identified studies. Unpublished and grey literature were excluded.

The search terms were developed with a combination of key words relating to the study population, intervention types and outcome indicators, as follows. ("Pregnant women" OR "pregnancy" OR "prenatal" OR "prenatal care" OR "mother" OR "antenatal" OR "antenatal care" OR "maternal" OR "maternal care") AND ("Relaxation therapy" OR "Mindfulness therapy" OR "Progressive muscle relaxation (PMR) therapy" OR "Music therapy" OR "Exercise therapy" OR "deep breathing relaxation therapy" OR "Meditation therapy" OR "hypnosis therapy" OR "relaxation lighting"), AND ("Stress" OR "distress" OR "anxiety" OR "depression" OR "Birth-weight" OR "birth weight" OR "birth outcome" OR "Apgar", "Apgar score", "Gestation", OR "Gestational age at birth").

Studies were eligible if they employed Randomised Controlled Trial (RCT) or quasi-experimental designs, applied a relaxation intervention during pregnancy or labour, were published in English, and reported one or more of the outcomes of interest specified in our search strategy. Observational studies (case reports, cross-sectional and cohort studies) and editorials or opinion pieces were excluded.

PICO. ***Population*:** apparently healthy pregnant women.

***Intervention/exposure*:** stress reduction relaxation therapy. Any form of relaxation intervention, whether mind-based (tapes, music, meditation) or physical/body-based (massage, stretch or exercise) including progressive muscle relaxation (PMR) and deep breathing exercises, that were applied during pregnancy with the aim of reducing stress and promoting mental health.

***Comparators/controls*:** pregnant women who did not receive a stress-reduction relaxation intervention but who received treatment as usual.

Outcomes: the main outcomes were measures of stress (self-report, physiological or biochemical), mental health problems (anxiety or depressive symptoms), obstetrics/pregnancy outcomes (gestational age, mode of delivery, duration of labour), birth outcomes (birth weight, birth length, Apgar score) and maternal physiology (vital signs).

***Timing of outcome measures*:** studies that measured the outcome during, immediately after, or some weeks or months after the intervention were included.

Study screening process. The literature search was concluded on 26 August 2023. To decide on inclusion, the articles were first screened by title and then by abstract using the eligibility criteria. Full texts of the selected articles were then assessed based on the inclusion and exclusion criteria. Two authors (MA and BD) screened all articles for eligibility. Any queries were discussed with one additional author (AW) to reach a consensus. The screening process and reasons for exclusion are documented.

Methodological quality assessment. Two independent assessors (BD and MA) evaluated the methodological quality of studies in terms of randomization, masking and availability of descriptions for withdrawal and dropout of all participants based on the modified Jadad scoring scale [29] and the modified Delphi List Criteria [30] to assess the overall quality of the studies. Using the Cochrane Collaboration's Assessment checklist [31], the risk of bias was assessed and rated as low, high or unclear for individual elements relating to five domains (selection, performance, attrition, reporting and other). The criterion on blinding was excluded as it is usually impossible to conduct relaxation therapy while blinding the participant or the care providers. S1 Table shows risk of bias assessment for all included studies.

Data extraction

The findings were extracted using a standard data extraction form prepared by the study team. Data were extracted in two phases. In the first phase, citation details (author name, publication year, design, sample size, setting, population, intervention, comparison and outcomes) were extracted. In the second phase, the intervention results by group were extracted.

Strategy for data synthesis

To obtain the pooled effects of the interventions, we conducted meta-analysis on the following outcomes for which there were an adequate number of studies with sufficiently 'similar' outcomes that could be pooled meaningfully: maternal stress, anxiety, depressive symptoms and birth weight (BW). We used the mean difference (MD) with the reported Standard Deviation (SD) of the outcome as a measure of effect size for each of the included studies. For the meta-analysis, the raw mean difference (D), with 95% CI across studies that measured the same outcome (depression with Edinburgh Postnatal Depression Scale (EPDS) or stress with Perceived Stress Scale (PSS), anxiety with State-Trait Anxiety Inventory (S-TAS) and birth weight in grams) was examined and presented. Sub-group analyses were performed to examine the existence of significant differences among studies that used different relaxation methods for any given outcome of interest. We assessed heterogeneity with the Cochrane's Q test and tau-squared (T^2) and measured inconsistency (the percentage of total variation across studies due to heterogeneity) of effects across relaxation interventions using the I^2 statistic. Publication bias was assessed using regression based on Egger's test. For all meta-analyses, random effects model using restricted maximum likelihood estimates (REML) were employed. Statistical significance was defined as $P < 0.05$. Stata version 16 software (College Station, Texas 77845 USA) was used for the meta-analyses and for visualizing the forest plots.

For outcomes where meta-analysis was not possible because of inadequate number of studies and small sample size, a narrative synthesis of the reviewed articles on the effect of the interventions on each outcome of interest was performed and reported. S2 Table shows the preferred reporting items for systematic review and meta-analysis we followed to report the findings.

Results

Search results: Final reviewed studies

A total of 32 studies were included in the systematic review. See Fig 1 for the flow diagram.

Four of the reviewed studies were quasi-experimental [32–35] and one was a non-randomized clinical trial [36]. The remaining 27 studies were RCTs. Among the 27 RCTs, 9 trials reported on maternal perceived stress during pregnancy using PSS [37–45], 13 trials reported on anxiety during pregnancy using the State-Trait Anxiety Inventory (S-TAI) [37, 38, 40, 42, 45–53], 7 trials reported on antenatal and postnatal depression using the Edinburgh Postnatal Depression Scale (EPDS) [32, 38, 44, 48, 49, 51, 54], and 8 trials reported on birth weight in grams or kilograms [33, 51, 55–60]. In addition, two trials reported the effects of antenatal relaxation on postnatal stress, anxiety and depression using the Depression, Anxiety and Stress Scale (DASS) [32, 34], three trials reported symptoms of maternal anxiety during labour and 24 hours postnatal using the Visual Analogue Scale for Anxiety (VAS-A) [54, 55, 61] and one trial reported anxiety using the pregnancy-related anxiety questionnaire [62]. Six trials reported on Apgar score [33, 51, 55–57, 60], three trials reported on gestational age (GA) [51, 58, 60], six trials reported on mode of delivery [33, 50–52, 55, 58], and four trials reported on duration of labour [50, 52, 55, 57].

Study context/settings

Four of the studies were from a lower middle-income countries (India = 3, Egypt = 1), 14 from upper-middle-income countries (China = 1, Thailand = 1, Indonesia = 1, Turkey = 2, Malaysia = 3, Iran = 6), and 14 were from high-income countries (HIC; United States of America = 2, United Kingdom = 1, Germany = 1, Switzerland = 1, Greece = 1, Spain = 3, Taiwan = 5).

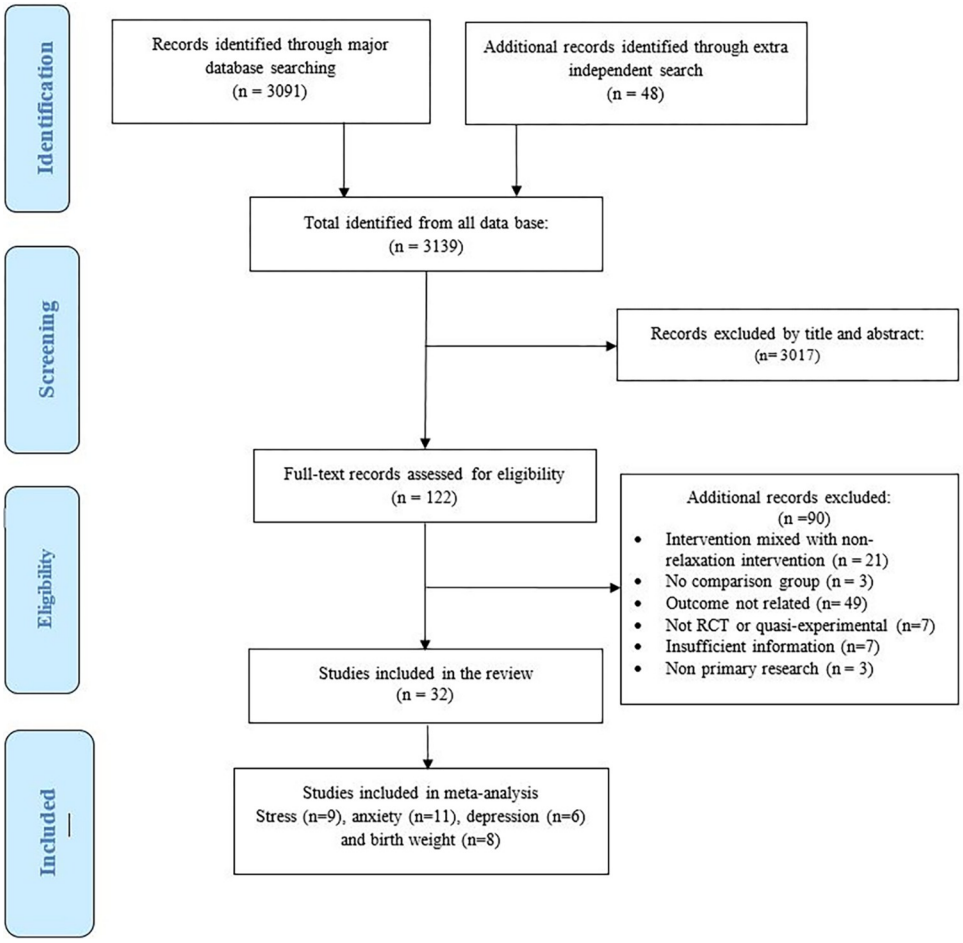

Fig 1. PRISMA flow chart showing literature search results and study selection process.

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Trials examining outcomes of maternal stress, anxiety or depressive symptom were from USA = 2, UK = 1, Switzerland = 1, Greece = 1, Turkey = 2, China = 1, Spain = 2, India = 3, Egypt = 1, Indonesia = 1, Malaysia = 2, Iran = 4 and Taiwan = 5. Trials on birth outcomes were from India = 1, Turkey = 1, Thailand = 1, Malaysia = 1, Spain = 1 and Iran = 3. There were no published studies from sub-Saharan Africa or from other Low-Income Countries (LIC).

Risk of bias within and across studies

Most studies had a low risk of selection, random allocation, concealment or other sources of bias. However, most studies had unclear risks on reporting bias (selective reporting of outcomes). S1 Table shows the risk of bias assessment findings for each of the studies.

Characteristics of relaxation methods

The reviewed articles used one or a combination of the following relaxation methods: yoga = 5, music = 12, PMR/BR = 8, mindfulness = 4, hypnosis = 3, Benson relaxation with music = 1 and Benson relaxation alone = 1. The duration of interventions ranged from as short as a 10-minute brief experimental intervention to 6 months of daily relaxation practice. Table 1 provides a detailed description and summary of information on the included studies.

Table 1. Description and summary of the results of the studies included in the systematic review and meta-analysis.

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
1. Bastani F, et al. 2005	EG:55 CG:55	Iran	RCT	Progressive muscle relaxation (PMR) and breathing exercise for 7 weeks between gestational age of 14 and 28 weeks	Immeditely before and after the 7th week of intervention. Made goup comparison	Stress—percieved stress scale (PSS)	PSS points	24.4 ± 5.8	37.5 ± 5.7*
						State anxiety—state anxiety trait inventory (S-STAI)	S-STAI points	22.7 ± 7.4	38.5 ± 5.7*
						Trait anxiety: (T-STAI)	T-STAI, points	22.7± 7.4	38.5 ±5.7*
2. Bastani F, et al. 2006	EG:55 CG:55	Iran	RCT	Progressive muscle relaxation (PMR) and breathing exercise for 7 weeks between gestational age of 14 and 28 weeks	Immeditely before and after intervention and at birth done for goup comparisons	Birth weight (BW)	grams	3168 ± 42	2883 ± 6*
						Low BW	n (%)	3 (5.8)	14 (26.9)*
						Gestational age	week	38 ± 5.9	38 ± 4.40 ‡
						Preterm birth	n (%)	1 (1.9)	**5 (9.8) ‡**
						Mode of delivery; n (%)	Abnormal	11 (21.2)	25 (48.1)*
							SVD	41 (78.8)	27 (39.7)*
							C/S	8 (15.4)	21 (40.40)*
							Instrumental	3 (5.8)	4 (7.70)*
3. Chuntharapat S, et al. 2008	EG:33 CG:33	Thailand.	RCT	Yoga 1 hour weekly for 6 Weeks at 26–28th, 30th, 32nd, 34th, 36th, and 37th week of gestation	After intervention (at birth) for group comparison	Birth weight	grams	3076.8±311.2	3125.5±287.4‡
						Apgar score, 1st minute	≤7; n (%)	2 (6.1)	5 (15.2) ‡
							8–10; n (%)	31 (93.9)	28 (84.8) ‡
						Apgar score, 5th minutes	≤7; n (%)	0	0 ‡
							8–10; n (%)	33 (100)	33 (100) ‡
						Length of labour, Minute	First stage	520 ± 19	660 ± 27*
							Second stage	27 ± 15	31 ± 14‡
							Total labour	559 ± 20	684 ± 28*
4. Chang MY, et al. 2008	EG: 116 CG: 120	Taiwan	RCT	Music Therapy provided daily for 2 weeks	Pre/post difference for group comparison	Stress: PSS, points	Pretest	17·4 ±4·6	**16·7 ±4·3**
							Posttest	15.3 ± 5.2	**15.8 ± 6.0**
							Pre-post diff.	-2.1	-0.9*
						Anxiety: S-STAI, points	Pretest	37·9 ±9·8	**37·1±10·0**
							Posttest	35.8 ± 10.9	**37.8 ± 12.1**
							Pre-post diff	-2.1	0.7*
						Depression -Edinburg postnatal depression scale (EPDS), points	Pretest	12·1±3·5	**12·2±3·9**
							Posttest	10.3 ± 4.1	**12.1 ± 4.6**
							Pre-post diff.	1.8	0.1*
5. Satyapriya M, et al. 2009	EG:45 CG:45	India	RCT	Yoga daily in the 2nd and 3rd trimester	Pre/post difference for groups comparison	Stress: PSS points, group difference	20th week of pregnancy	15.9 ± 5.0	15.4±5.7‡
							36th week of pregnancy	10.9 ± 4.9	17.3±5.3*
							Pre-post diff	5.0	-1.9*
6. Yang M, et al. 2009	EG:60 CG:60	China	RCT	Music therapy for 30 minutes on 3 consecutive days at admission for expected preterm birth	Pre/post difference for group comparison	Anxiety: STAI points, mean for pre/post and mean and SD for the pre/post difference reported	Pretest	40.7	41.9‡
							Posttest	26.6	41.8*
							Pre-post diff.	-14.1±5.8	-0.1±2.8*
7. Urech C, et al. 2010	EG1: 13 EG2: 13 CG:13	Switzerland	RCT	Progressive Muscle relaxation and Guided imaginary experiment applied for 10 minutes only	Pre/post	State anxiety: S-STAI	Groups did not differ significantly in change of state anxiety from pre to post intervention. Anxiety decreased equally in all three groups from pre- to post-relaxation,F(1,35) = 5.14, p = .030*, d = .38		
8. Liu YH, et al. 2010	EG:30 CG:30	Taiwan	RCT	Music therapy for 1 hour during labour	Posttest for group comparison	Labour anxiety using Visual Analogue Scale (VAS-A), points	Latent phase	6.4 ± 3.0	5.2 ± 2.2‡
							Active phase	8.2 ± 2.3	7.7 ± 2.1‡
							Latent and active phase diff.	-1.8	2.5*

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
9. Simavli S, et al. 2014	EG:67 CG:65	Turkey	RCT	Music therapy during labour	Pre/post for group comparison	Labour anxiety: VAS-A, points	Pretest	2.8±0.4	2.7±0.4‡
							Latent phase	4.3 ± 0.8	5.1 ± 0.9*
							Active phase	8.47 ± 0.7	9.4 ± 0.7*
							Second phase	9.1 ± 0.6	9.8 ± 0.4*
							2 h after delivery	1.7± 0.3	4.2 ± 0.8*
						Birth weight	G	3375 ± 245	3420 ± 239‡
						Apgar 9/10	n (%)	67 (100%)	**61 (93.8%)** +
						Duration of labour, Minutes	Latent phase	162 ± 15	164 ± 15‡
							Active phase	189 ± 28	198 ± 15*
							Second phase	83 ± 13	89 ± 18*
							Third stage	17 ± 50	17 ± 5‡
						Mode of delivery; n (%) $\chi 2$ test, P>0.05	Caesarian section	5 (6.9)	9 (12.2) ‡
							Instrumental	2(2.7)	5 (6.8) ‡
							Spontaneous vaginal delivery	65 (90.2)	60 (81.0) ‡
							Episiotomy	51 (76.1)	52 (80.0) ‡
						Latent phase labour	SBP, mm Hg	106.0±13.1	110.2±9.3*
							DBP, mmHg	66.3±4.9	68.3±3.8*
							Hear rate	76.0±4.8	78.7±5.9*
						Active phase labour	SBP, mm Hg	99.7±12.3	108.3±10.6*
							DBP, mmHg	62.7±5.1	68.3±3.8*
							Hear rate	74.4±4.9	78.7±5.8*
						Second stage labour	SBP, mm Hg	91.6±16.1	101.1±9.1*
							DBP, mmHg	60.6±2.4	59.9±11.5‡
							Hear rate	73.9±3.8	76.5±3.7*
						2 h postpartum period	SBP, mm Hg	94.2±5.0	99.9±15.5*
							DBP, mmHg	59.4±2.4	63.4±10.7*
							Hear rate	72.1±3.9	75.4±10.4*
10. Simavli S, et al. 2014	EG:71 CG:70	Turkey	RCT	Music therapy during labour	Posttest group comparison	Antenatal depression: EPDS	Mean (SD) score	8.0 (2.8)	8.5 (2.6) ‡
							EPDS≥10, n (%)	18 (25.4)	21 (30.0) ‡
							EPDS≥13, n (%)	8 (11.3)	9 (12.9) ‡
						Postnatal depression day 1	Mean (SD) score	7.3±2.4	8.3±2.8*
							EPDS≥10, n (%)	11 (15.5)	22 (31.4)*
							EPDS≥13, n (%)	4 (5.6)	12 (17.1)*
						Postnatal depression: EPDS, day 8	EPDS, points	7.1±2.1	8.6±2.9*
							EPDS≥10, n (%)	9 (12.7)	25 (35.7)*
							EPDS≥13, n (%)	4 (5.6)	13 (18.6)*
						Postnatal Anxiety: VAS-A	VAS-A (1 h)	3.3±0.5	4.9±0.9*
							VAS-A (4 h)	2.7±0.4	4.2±0.8*
							VAS-A (8 h)	2.3±0.3	3.3±0.5*
							VAS-A (16 h)	1.7±0.3	2.8±0.4*
							VAS-A (24 h)	0.9±0.6	2.3±0.3*
11. Tragea C, et al. 2014	EG:31 CG:29	Greece	RCT	Breathing and progressive muscle relaxation 1–2 times a day for 6 weeks	Pre/post difference for group comparison	Stress: PSS, points	Pre-post diff.	−3.7±1.8	−0.5±1.8*
						Anxiety: S-STAI	Pre-post diff.	-3.5±2.8	-2.0±2.9 ‡
						Anxiety: T-STAI	Pre-post diff.	-3.8 (1.4)	-1.6 (2.5) ‡

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
12. Guardino CM, et al. 2014	EG:24 CG:23	USA	RCT	Mindfulness training	Pre/post (immediate posttest and 6 weeks after post test	PSS, points: Significant main effect of time: $p < 0.05$*	Pretest	41.8±6.0	39.9±8.6‡
							Posttest immediate	37.3±5.4	35.8±8.0‡
							Posttest 6 weeks	36.2±5.9	37.4±7.3‡
						Anxiety: S-STAI: Significant main effect of time: $p = 0.001$*	Pretest	45.7±7.6	44.4±11.0‡
							Posttest immediate	39.7±6.3	37.4±11.5‡
							Posttest 6 weeks	38.1±8.8	36.2±10.8‡
13. Newham J, et al. 2014	EG:29 CG:22	UK	RCT	Yoga training and practice applied for 8 weeks	Pre/post difference for group comparison	Anxiety: S-STAI, Points, medians (IQR)	Baseline	28(24–42)	**32 (24–37)**
							End line	27(22–36)	34 (25–38) ‡
						Anxiety: T-STAI, Points, medians (IQR)	Baseline:	34 (29–40)	**35 (33–39)**
							End line:	34 (29–39	34 (30–41) ‡
						Depression: EPDS, Points, medians (IQR)	Baseline:	5 (2–10)	**5 (4–8)**
							End line:	4 (2–7)	6 (3–10)*
						Anxiety: WDEQ	Baseline:	74 (62–87	**77 (60–85)**
							End line:	61 (42–77)	69 (58–78)*
14. Davis K, et al. 2015	EG:23 CG:23	USA	RCT	Yoga for 8 weeks	Pre/post, and midline assessment	Depression: EPDS, points	Baseline	10.1 ± 4.5	**10.6±5.1**
							Midline	8.5 ± 4.9	**8.8 ±6.0**
							End line	6.4 ± 4.0	**7.3 ± 5.1**
							Baseline-end line mean diff.	3.7	3.3‡
						Anxiety: S-STAI), points	Baseline	36.9 ±12.2	**41.7±10.8**
							Midline	41.8±15.2	**39.0±11.4**
							End line	34.8±10.7	**38.8 ±13.7**
							Baseline-end line mean diff.	2.1	2.9‡
						Anxiety: T-STAI, points	Baseline	45.0 ±12.1	**45.4 ±10.2**
							Midline	43.1 ±11.4	**42.4±13.5**
							End line	38.4 ±9.9	**40.4±10.9**
							Baseline-end line mean diff.	6.6	5‡
15. Chang HC, et al. 2015	EG: 145 CG: 151	Taiwan	RCT	Music therapy during 2nd and / or 3rd trimester	Pre/post for pre-post mean difference for group comparison	Stress: PSS, points	Pretest	16.5±4.9	**16.4±4.8**
							Posttest	16.0 ±5.6	**16.4 ±5.3**
							Pre-post diff.	0.5	0‡
						STRESS: Pregnancy Stress Rating Scale (PSRS)	Pretest	53.7±24.1	**49.9±22.3**
							Posttest	54.0±23.6	**54.9±22.7**
							Pre-post diff.	0.3	4.8*
16. Liu YH, et al. 2016	EG:61 CG:60	Taiwan	RCT	Music therapy for 2 weeks	Pre/post	Stress: PSS, points	Pretest:	17.1 ± 5.4	**16.3 ± 5.2**
							Posttest:	17.9 ± 4.1	**19.3 ± 2.5**
							Pre-pots mean diff. for group comparison	-0.8	-3.0*
						Anxiety: S-STAI, points	Pretest	39.7 ± 10.7	**40.2 ± 10.2**
							Posttest	37.3±10.0	**42.1±11.6**
							Pre-pots mean diff. group comparison	2.4	-1.9*

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
17. Muthukrishnan S, et al. 2016	EG:37 CG:37	India	RCT	Mindfulness Meditation for 4 weeks from 13–16 gestational week	5 weeks after enrollment (at 17–18 weeks of gestation)	Stress: PSS, points	Posttest between group comparison	19.1±1.4	32.1±2.40*
						BP: mmHg	SBP	109.22±3.8	124.68±5.6*
							DBP	69.11±2.23	69.11±2.2‡
						Hear rate variability	Beats/min	26.59±2.1	20.65±1.5*
						Respiratory rate	Breath/minute	18.08 ±1.8	19.27±2.1*
						Cold Pressor systolic blood pressure response.		9.68±1.8	13.38±2.23*
						Cold Pressor diastolic blood pressure response.		4.19±0.98	7.54±1.4*
						Mental arithmetic systolic blood pressure response.		8.97±2.21	13.49±3.1*
						Mental arithmetic diastolic blood pressure response.		5.22±1.53	4.38±1.32 +
18. Beevi Z, et al. 2016	EG:28 CG:28	Malaysia	Quasi-experimental	Hypnosis practiced since 16 week of gestation	Pre/post:	Stress: DASS-21, points at 36 weeks of gestation	Posttest mean group difference (raw data not given)	5.8 ±5.4	10.7 ±8.9*
								F (1,44) = 4.70, p = 0.03, partial η^2 = .101*	
						Anxiety: DASS-21, points at 36 weeks of gestation	Posttest mean group difference (raw data not given)	F(1,44) = 10.76,p = 0.01, partial η^2 = 0.20*	
						Depression: DASS-21, points at 36 weeks of gestation	Posttest mean group difference	F(1,16) = 0.958,p = 0.342, partial η^2 = .06. ‡	
19. Beevi Z, et al. 2017	EG: 23 CG: 22	Malaysia	Quasi-experimental	Hypnosis provided at 16, 20, 28, and 36 weeks of their pregnancy and advised to practice every day until labour	Posttest / done at birth	Birth weight, g	3103.5±301.2		3070.9±367.24 ‡
						SVD, n (%)	19 (42.2)		14 (31.1) ‡
						C/S, n (%)	4 (8.9)		8 (17.8) ‡
						Apgar score at 1 minute, %	5	0	4.3‡
							6	0	4.3‡
							8	4.3	18.2‡
							9	95.7	72.7 *
						Apgar score at 5 minute	9	0	4.5‡
							10	100	95.5‡
20. Gonzalezet al. 2017	EG: 204 CG: 205	Spain	RCT	Music therapy for 40 minutes daily for 2 weeks	Posttest for group comparison	Birth weight	Kg	3.4±0.4	3.4±0.5 ‡
						Newborn length	Cm	50.3±1.86	50.6±2.0 ‡
						head circumference	Cm	34.5±1.3	34.6±1.4 ‡
						Apgar score	1 minute,	9.1±0.8)	9.0±0.9 ‡
						Apgar score	5 minute,	9.9±0.3	9.9±0.4 ‡
21. Novelia S, et al. 2018	EG:15 CG:15	Indonesia	Quasi experimental	Yoga 2 times in 2 weeks each lasting 90 minutes	Posttest group comparison:	Anxiety (Anxiety: Hamilton Anxiety Rating Scale), n (%): (t = -9.83, p = 0.01)*	Yes	2 (13.3%)	**15 (100%)**
							No	13 (86.7%)	**0 (0%)**
22. Gonzalez et al. 2018	EG: 204 CG: 205	Spain	RCT	Music therapy for 40 minutes daily for 2 weeks	Posttest group comparison	Onset of labour n (%),p < 0.01*	Spontaneous	140 (68.63)	**111 (54.2)**
							Stimulated	5 (2.5)	**12 (5.9)**
							Induced	59 (28.9)	**82 (40.0)**
						Mode of delivery; n (%), P = 0.58‡	Vaginal	155 (75.9)	**151 (73.7)**
							C/S, n (%)	49 (24.02)	**54 (26.3)**
						Labour duration	First stage, hours	4.36 ±3.7	5.54 ±4.8*
						State-Trait-Anxiety (STA); posttest, group comparison	STA, points	30.6±13.2	43.1 ±15.0*
23. Beevi Z, et al. 2019	EG:28 CG:28	Malaysia	Quasi-experimental	Hypnosis provided at 16, 20, 28, and 36 weeks of their pregnancy and advised to practice every day until labour	2 month postnatal mean (SD) difference for group comparison	Stress: DASS-21	5.5±5.1		3.6±5.1 ‡
						Anxiety: DASS-21	2.9±3.0		38.4± 58.8*
						Depression: DASS-21	1.3± 2.4		6.7± 5.7*
						Depression: EPDS	5.7±2.8		10.6±4.0*

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
24. Pan Win Lan, et al. 2019	EG:39 CG:35	Taiwan	RCT	Mindfulness based Programs: Once every week for 8 weeks	Baseline and 3mo postpartum, mean (SD)	Stress: PSS, points	Pretest	15.4(5.7)	**13.8(6.0)**
							Posttest	11.6 ± 6.1	**14.3 ±5.2**
							Pre-post diff	3.8	0.5*
						Depression: EPDS, points	Pretest	9.5±4.0	**8.7±4.5**
							Posttest	6.5 ± 4.5	**8.8 ±3.4**
							Pre-post diff	3	-0.1*
25. Ahmadi M, et al. 2019	EG:75 CG:75	Iran	RCT	Progressive muscle relaxation/ PMR	Posttest between group comparison	Length at birth	CM	52.1±3.6	48.6±3.4*
						Birth weight	G	3400±0.5	3200±0.6*
						Postpartum depression, day 1	Zung's Self-rating Depression Scale	56.5±0.5	57.1±0.6‡
						Postpartum depression, day 3	Zung's Self-rating Depression Scale	49.7±0.4	59.4±0.7*
						Postpartum depression, day 10	Zung's Self-rating Depression Scale	44±0.4	60.3±0.8*
26. Rajeswari S, et al. 2020	EG: 120 CG: 119	India	RCT	Progressive Muscle Relaxation daily practice from 21/22 weeks of gestation until delivery	Posttest group comparison	Stress: Calvin Hobel scale: P < 0.001*	Minimal; n (%)	0 (0.00)	0 (0.0)
							Mild; n (%)	51 (41.6)	19 (15.2)
							Moderate; n (%)	67 (54.4)	71 (56.8)
							Severe; n (%)	5 (4.00)	35 (28.0)
							Overall stress;	40.5 ±8.6	77.6 ±8.9*
						Anxiety (S-STAI) Fisher exact test: F3 = 17.80, P < 0.001*	Minimal; n (%)	0 (0.0)	0 (0.0)
							Mild; n (%)	22 (17.9)	9 (7.2)
							Moderate; n (%)	97 (78.9)	84 (67.2)
							Severe; n (%)	4(3.2)	32 (25.6)
						Anxiety (T-STAI) Fisher exact test: F3 = 18.60, P < 0.001*	Minimal; n (%)	0 (0.00)	0 (0.0)
							Mild; n (%)	24 (10.0)	10 (8.0)
							Moderate; n (%)	95 (83.0)	83 (66.4)
							Severe; n (%)	4 (3.0)	32 (25.6)
						Overall anxiety: (STAI) Fisher exact test: F3 = 19.80, P < 0.001*	Minimal; n (%)	0 (0.0)	0 (0.0)
							Mild; n (%)	26 (11.0)	11 (8.8)
							Moderate; n (%)	93 (82.0)	82 (65.6)
							Severe; n (%)	4 (32.0)	32 (25.6)
						Postpartum depression	EPDS, points	6.9 ± 2.5	10.5 ±2.7*
						Gestational age, n (%) P = 0.01*	Before 37 weeks	14 (11.5)	25 (20.3)
							After 37 weeks	108 (88.5)	98 (79.7)
						Gestational age (weeks)		38.0±3.6	37.2±4.2*
						Apgar score; n (%); fisher exact test: P = 0.06‡	0-3	0 (0.0)	3 (2.4)
							4–6	2 (1.7)	10 (8.2)
							7–10	120 (98.3)	110 (89.4)
						Apgar score	Score/10	8.3 ±0.2	8.0 ±0.6 ‡
						Birth weight	Kg	2.7 ±0.4	2.6 ±0.5*
						Mode of delivery n (%): P = 0.001*	Normal vaginal	90.0 (74.2)	61.0 (49.6)
							Assisted vaginal	5.0 (4.0)	12.0 (9.8)
							C/S	27 (21.8)	50 (40.60)
						Induced labour P = 0.019*	Yes, n (%)	110(9.0)	23 (20)
							No, n (%)	111 (91.0)	100 (80.0)
						Hypertension P = 0.037*	Yes, n (%)	4 (3.0)	12 (10.0)
							No, n (%)	118 (97)	111 (90)

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
27. Zarenejad M, et al. 2020	EG:30 CG:30	Iran	RCT	Mindfulness: 6 group counseling sessions twice a week, and each session lasted for 60 min	Posttest group comparison	Pregnancy-Related Anxiety: Posttest between group difference P = 0.001*	Pretest,	182.9 ± 74.2	**195.1 ± 42.9**
							Posttest immediate	154.5 ± 61.8	**187.9 ± 41.5**
							Posttest 1 month later	124.9 ± 45.5	**182.5 ± 41.7**
28. Abd Elgwad FMH, et al. 2021	EG:40 CG:40	Egypt	Non-randomized controlled clinical trial	Benson's Relaxation twice daily (separated by 3 hours) for 3 days	Posttest group comparison	Stress: PSS, n (%)	Immediate posttest: P = 0.01*	Yes 25 (62.5)	**40 (100)**
								No 15 (37.5)	**0 (0)**
							Posttest after 3 days: P = 0.01*	Yes 10 (25)	**40 (100)**
								No 30 (75)	**0 (0)**
						Blood pressure: mmHg	SBP: Pretest	158.3±12.2	150.5±18.8*
							SBP immediate posttest	144.1±12.1	145.1±17.1‡
							SBP 3 days posttest	119.3±3.3	145.1±17.1*
							DBP pretest	95.2±11.2	90.8±12.2*
							DBP immediate posttest	87.8±9.5	87.4±9.8‡
							DBP 3 days posttest	77.0±4.6	87.4±9.8*
						Heart rate,	Pretest	92.3±7.2	**97.8±16.3+**
							Immediate posttest	87.4±6.1	93.1±10.0*
							3 days posttest	81.2±3.8	93.1±11.0*
						Respiration rate	Pretest	21.45±2.2	22.8±2.9*
							Immediate posttest	20.7±1.2	22.4±2.7*
							3 days posttest	18.6±1.2	22.4±2.7*
29. Bauer I, et al. 2021	EG1: 12 EG2: 12 CG: 12	Germany	RCT (3-arm, parallel-group)	EG1: Music EG2: Guided imagery (GI) CG: Resting Provided for 20 minute during labour	Pre/post	Indicators	Music group	GI group	**Control group**
						Cardiovascular activity on heart rate, 5 minutes posttest	−2.33±2.9	−1.9±1.8	−2.4±(3.4‡
						Cardiovascular activity on heart rate, 10 minutes posttest	− 2.5±5.6	−1.4±3.0	−2.6±4.3‡
						Heart rate variability	No significant group effect, $F(2,94) = 0.624$, $p = .538$‡		
						Skin conductance 5 minute posttest	0.01±0.1	0.2± 0.7	−0.1± 0.5‡
						Skin conductance 10 minute posttest	−0.04±0.2	−0.7±1.5	−0.1±0.6‡
30. Estrella-Juarez F, et al. 2022	EG1: 104 EG2: 124 CG: 115	Spain	RCT 3-arm parallel group	EG1:Music therapy and EG2: Virtual reality (VR) intervention during labour	Pre/post	Outcomes	Music	VR	**Control**
						First stage of labour, h	4.7±4.1	4.3±3.1	6.3±5.2*
						Spontaneous labour n (%)	50 (48.1)	103 (82.4)	59±51.8*
						Induction labour, n (%)	54 (51.9)	22 (17.6)	55 (48.2)*
						SVD, n (%)	49 (47.1)	73 (58.4)	56 (49.1) ‡
						Instrumental assisted, n (%)	21 (20.2)	32 (25.6)	26 (22.8) ‡
						C/S, n (%)	34 (32.7)	20 (16)	32 (28.1) ‡
						Pretest T-STAI	19.0± 6.9	19.2±7.1	**19.8±7.4**
						Posttest T-STAI	12.6±6.0	12.4±5.9	**19.2±9.0**
						Pre-post mean diff. (within group comparison)	6.4*	6.8*	0.6‡
						Pretest S-STAI	16.3±5.8	16.6±6.8	**16.5±4.8**
						Posttest S-STAI	14.7±3.3	15.2±3.3	**17.6 ±7.2**
						Pre-post diff (between group comparison)	1.6‡	1.3 ‡	−1.1 ‡
						SBP	106.9±8.3	108.3±9.8	115.9±11.4*
						DBP	69.9±7.3	70.4±7.9	75.0±8.9*
						Heart rate	79.2±8.4	79.8±7.9	83.0±10.4*

(*Continued*)

Table 1. (Continued)

Authors, year	Study size	Country	Design	Relaxation, type and duration applied	Time outcome measured	Outcome		Results	
								Relaxation	Control
31. Abarghoee SN, et al. 2022	EG1: 35 EG2: 35 CG:35	Iran	RCT (A parallel, three-armed)	Benson Relaxation Technique (BRT) and Music Therapy (MT)	Pre/post within and between group comparison	Anxiety: S-STAI; Pre-post difference within group comparison	BRT group	MT group	**CG**
							Pre: 50.6±1.3	49.4±1.6	**50.3±1.4**
							Post: 42.3±1.3	43.1±1.2	**48.3±1.7**
							diff: 8.3*	diff: 6.3*	diff: 2.0‡
						Anxiety (S-STAI) pre/post between group comparison	Pre: 50.6±1.3	49.4±1.6	50.3±1.4 ‡
							Post: 42.3±1.3	43.1±1.2	48.3±1.7*
32. Ghorbanneja d S, et al. 2022	EG: 44 CG: 44	Iran	RCT	Jacobson's progressive muscle relaxation	Posttest between group comparison	Birth weight	G	2863.5±176.0	2762.7±202.1*
						Birth length	CM	47.8±2.1	47.5±2.2‡
						HC	CM	34.7±0.2	34.5 0.1‡
						Gestational age	Week	36.3±0.7	36.2±0.8‡
						Apgar score	1st min	9.0±0.4	8.8±0.3‡
						BP: mmHg	SBP	137.6±3.9	147.5±5.0*
							DBP	88.7±3.8	99.2±4.5*
						FBS	**Mg/Dl**	**101.8±6.8**	111.0±9.5*

Abbreviations: ACTH, Adrenocorticotropic hormone; BP, Blood pressure; CG, CM, Centimeter; Control group; C/S: Cesarean section; DASS-21, Depression, anxiety, stress scale- 21 items version; DBP, Diastolic blood pressure; EG, Experimental group; EPDS, Edinburgh postnatal depression scale; FBS, Fasting blood glucose; h, hour; HR, Heart rate; GI, Guided imaginary; IQR, Inter-quartile range; Kg, Kilogram; mg/dL, milligram per deciliter; Mo, Month; PSS, Perceived stress scale; Pre, pretest, post, posttest, diff, difference; RCT, Randomized control trial; SBP, Systolic blood pressure; SD, Standard deviation; S-STAI-S, State-trait anxiety inventory–state version; T-STAI, State-trait anxiety inventory–trait version; SVD, Spontaneous vaginal delivery; VAS, Visual analogue scale; WDEQ, Wijma delivery expectancy questionnaire–modified version.

Note

* $P < 0.05$

+ $p = 0.05$

‡ $P \geq 0.05$

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Intervention outcomes

Maternal mental health. The effects of relaxation interventions on maternal mental health was examined in relation to symptoms of stress, anxiety or depression during the antenatal or postnatal periods.

Maternal stress. Nine trials (one of which reported stress at two time points) reported on the effectiveness of relaxation therapy on maternal stress symptoms using the PSS [37–45] and 2 trials using the DASS scale [32, 34]. Interventions applied were music therapy, meditation, mindfulness-based childbirth and parenting program, yoga, hypnosis, and PMR/BR.

A meta-analysis of the 9 trials (n = 1160 participants) using PSS mean and SD showed that relaxation interventions during pregnancy had a significant effect on reducing maternal perceived stress during pregnancy (overall mean difference (MD): -4.1; 95% CI: -7.4, -0.9)). In a subgroup analysis, only music therapy as a group significantly reduced maternal stress (MD: -.8, 95% CI: -1.53, -0.05), but not other relaxation methods. There was high level of heterogeneity among the studies (I^2 = 97.8%, P<0.01). Output of the meta-analysis on stress is provided in Fig 2.

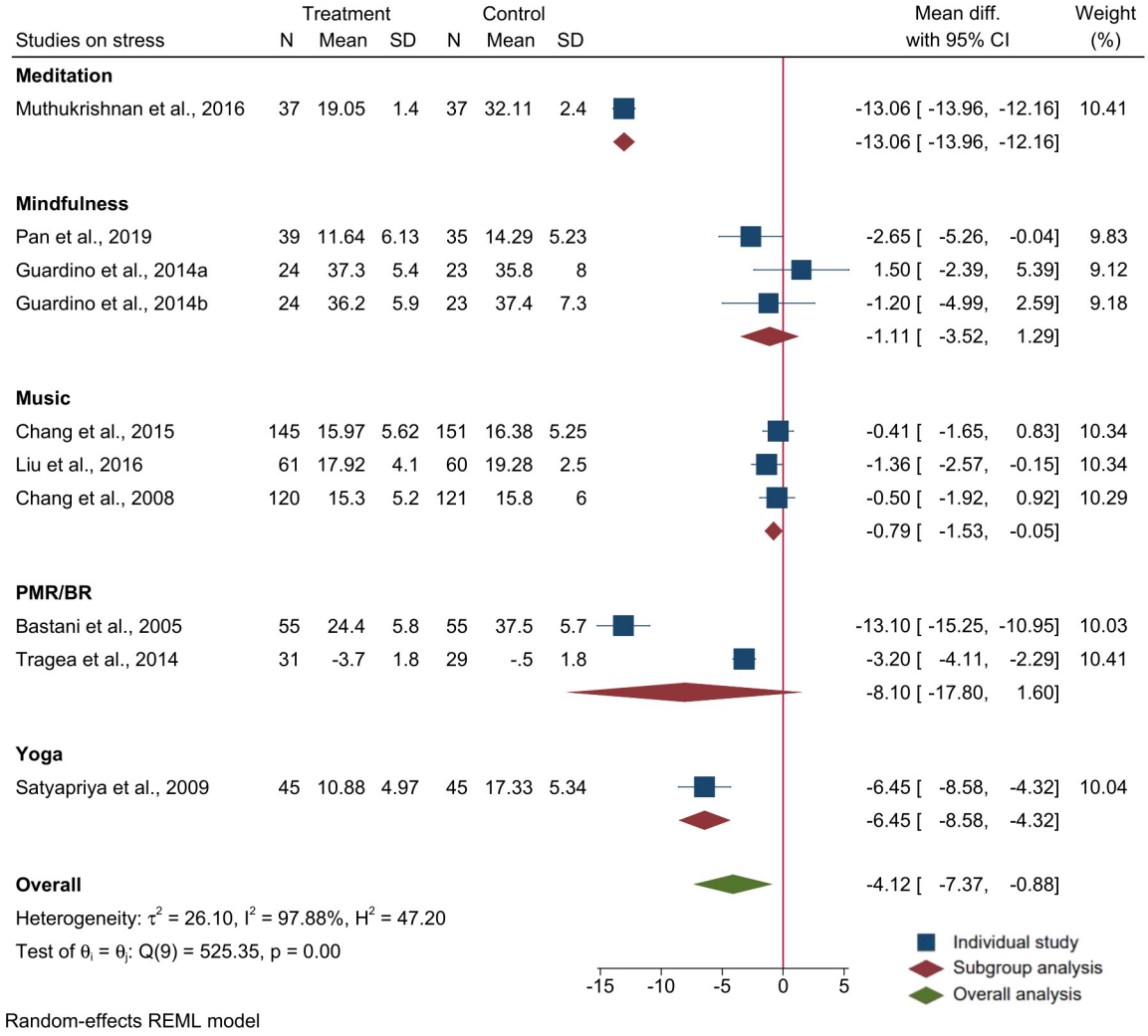

Fig 2. Forest plot and subgroup analysis for raw mean difference of studies on the effects of relaxation interventions on maternal stress measured using the perceived stress scale (PSS).

https://doi.org/10.1371/journal.pone.0278432.g002

Maternal anxiety. Anxiety symptoms were reported in 13 trials [37, 38, 40, 42, 45–53] using the STAI, two trials using the DASS [32, 34], three using the VAS-A scale) [54, 55, 61] and one using pregnancy related anxiety questionnaire [62].

Eleven of the 13 trials reported mean and SD using S-STAI (two of which reported anxiety at two time points). Meta-analysis of the 11 trials (n = 1965 participates) showed that relaxation interventions provided during pregnancy were effective in reducing symptoms of maternal anxiety (overall MD: -5.04; 95% CI: -8.2, -1.9). In a subgroup analysis, only music therapy as a group showed a significant effect in reducing anxiety by 6 points (MD: -5.8; 95% CI: -9.1, -2.4), but not other relaxation methods. The trials were highly heterogeneous (I^2 = 97.1%, $p<0.01$). The output of the meta-analysis on anxiety is provided in Fig 3.

The other 3 trials that were not included in the meta-analysis (because they did not reported mean and SD) were also effective in reducing symptoms of anxiety during pregnancy [34], labour [55, 61], and during the 24 hours [54] and 2 months postnatal [32] periods.

Maternal depressive symptoms. Seven trials examined effects of relaxation interventions provided during pregnancy on maternal depressive symptoms measured using the EPDS [32,

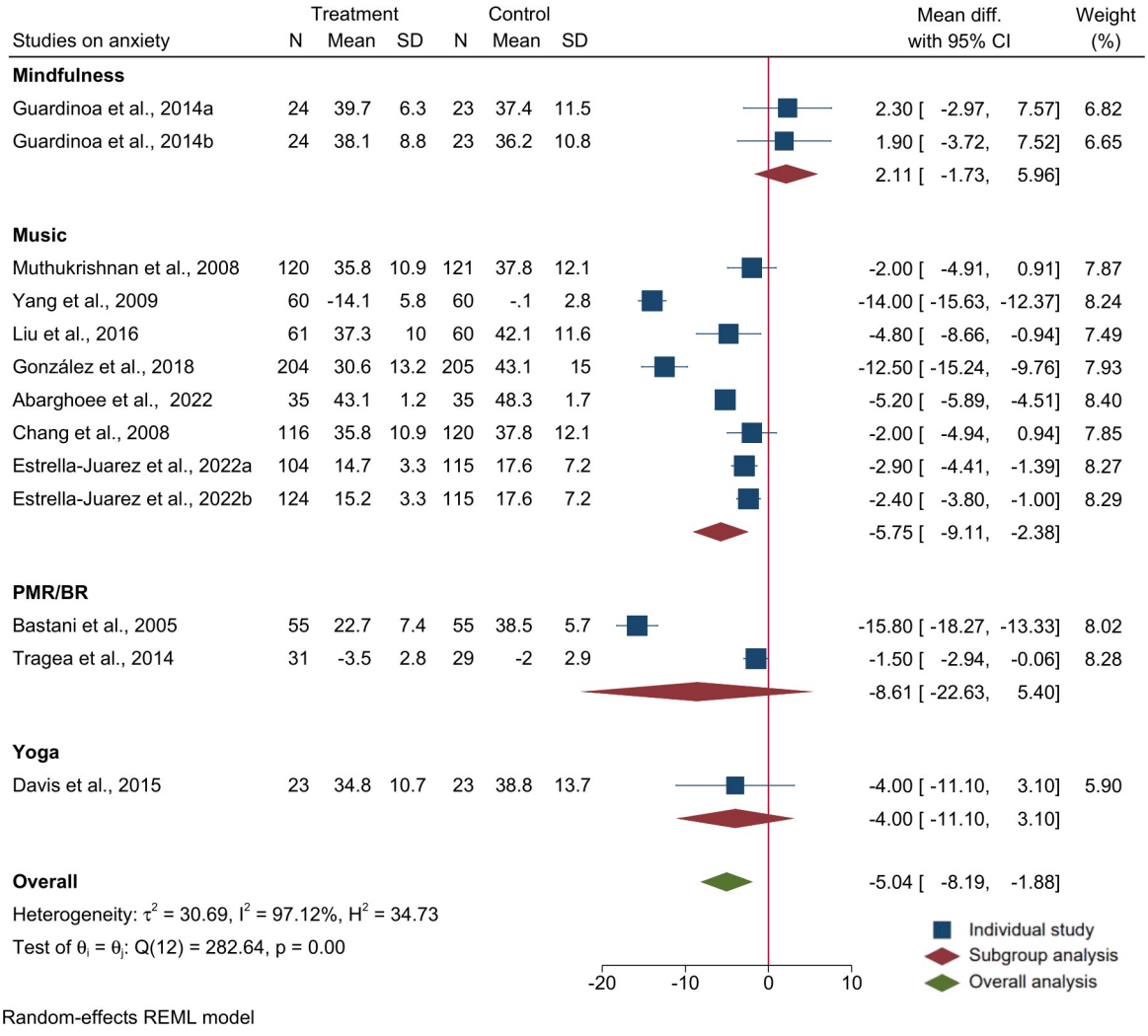

Fig 3. Forest plot and subgroup analysis for raw mean difference of studies on the effects of relaxation interventions on antenatal anxiety score using S-TAI.

https://doi.org/10.1371/journal.pone.0278432.g003

38, 44, 48, 49, 51, 54]. Specific relaxation methods included in this section were yoga, Mindfulness-Based Childbirth and Parenting (MBCP) Music and PMR interventions.

Six of the 7 trials reported mean and SD using EPDS (one of which reported depression at two time points). Meta-analysis of the six trials (n = 933 participants) using EPDS mean and SD showed that relaxation interventions during pregnancy are effective in reducing maternal depressive symptoms (overall MD: -2.3; 95% CI: -3.4, -1.3) in the intervention compared to the control group. In a subgroup analysis, Music therapy as a group showed association with reduced depressive symptoms (MD: -2.2; 95% CI: -3.8, -0.06). The trials were found to be heterogeneous (I^2 = 83.4%, P<0.01). The effects of relaxation interventions in improving depression also persisted to immediate one week postnatal [55] and the two month postnatal [32] period. Output of the meta-analysis on depressive symptoms is provided in Fig 4.

Newborn outcomes. Birth weight (mean, SD) as an outcome was reported in 8 trials [33, 51, 55–60]. The meta-analysis of the 8 trials (n = 1239 participants) indicated that relaxation interventions improved birth weight (overall MD = 80; 95% CI: 1, 157). Subgroup analysis showed that only PMR/BR, but not other relaxation methods, increased birth weight significantly (MD = 165; 95% CI: 100, 231) in the intervention compared to the control group. The subgroup analysis showed significant heterogeneity among the studies (I^2 = 63.0%, P = 0.03). Output of the meta-analysis on birth weight is provided in Fig 5.

Apgar score as outcome was measured in 6 trials [33, 51, 55–57, 60]. A study in Turkey reported 100% of neonates born to mothers in the relaxation group (music therapy) compared to 93.8% of neonates born to mothers in the control group scored 9/10 (p = 0.05) for Apgar

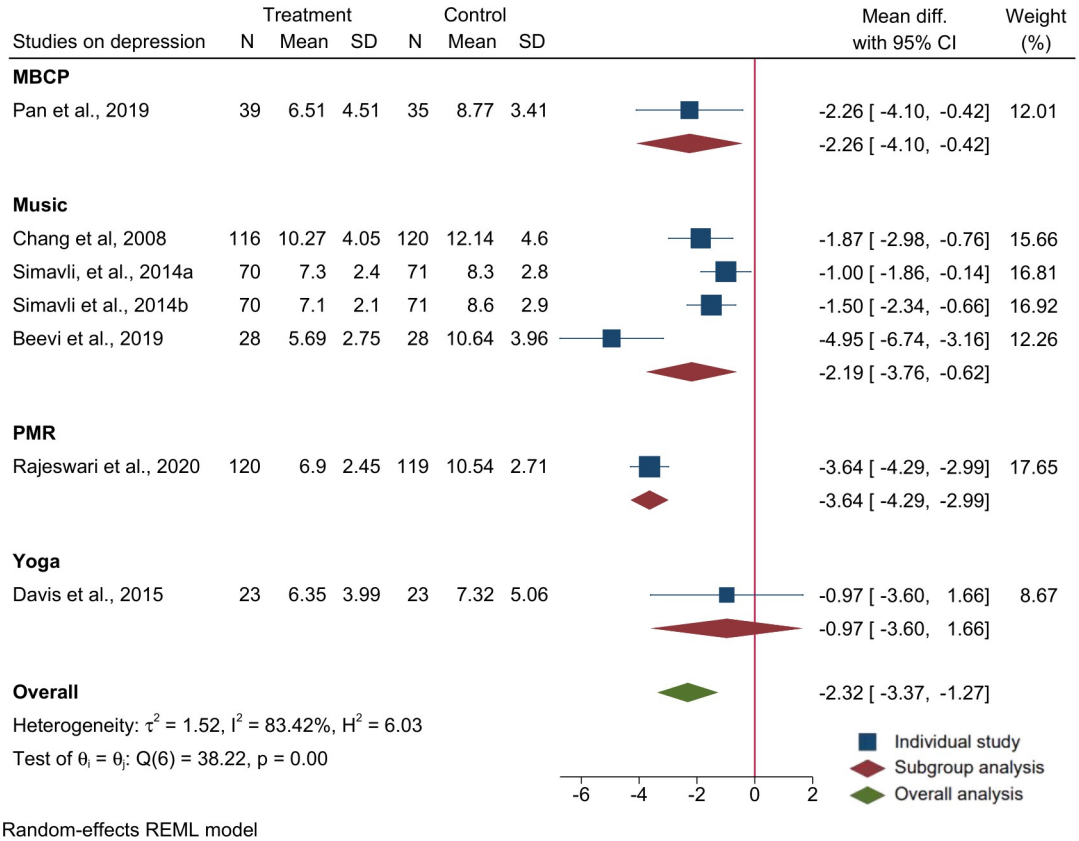

Fig 4. Forest plot and subgroup analysis for raw mean difference of studies on the effects of relaxation interventions on depressive symptoms using EPDS.

https://doi.org/10.1371/journal.pone.0278432.g004

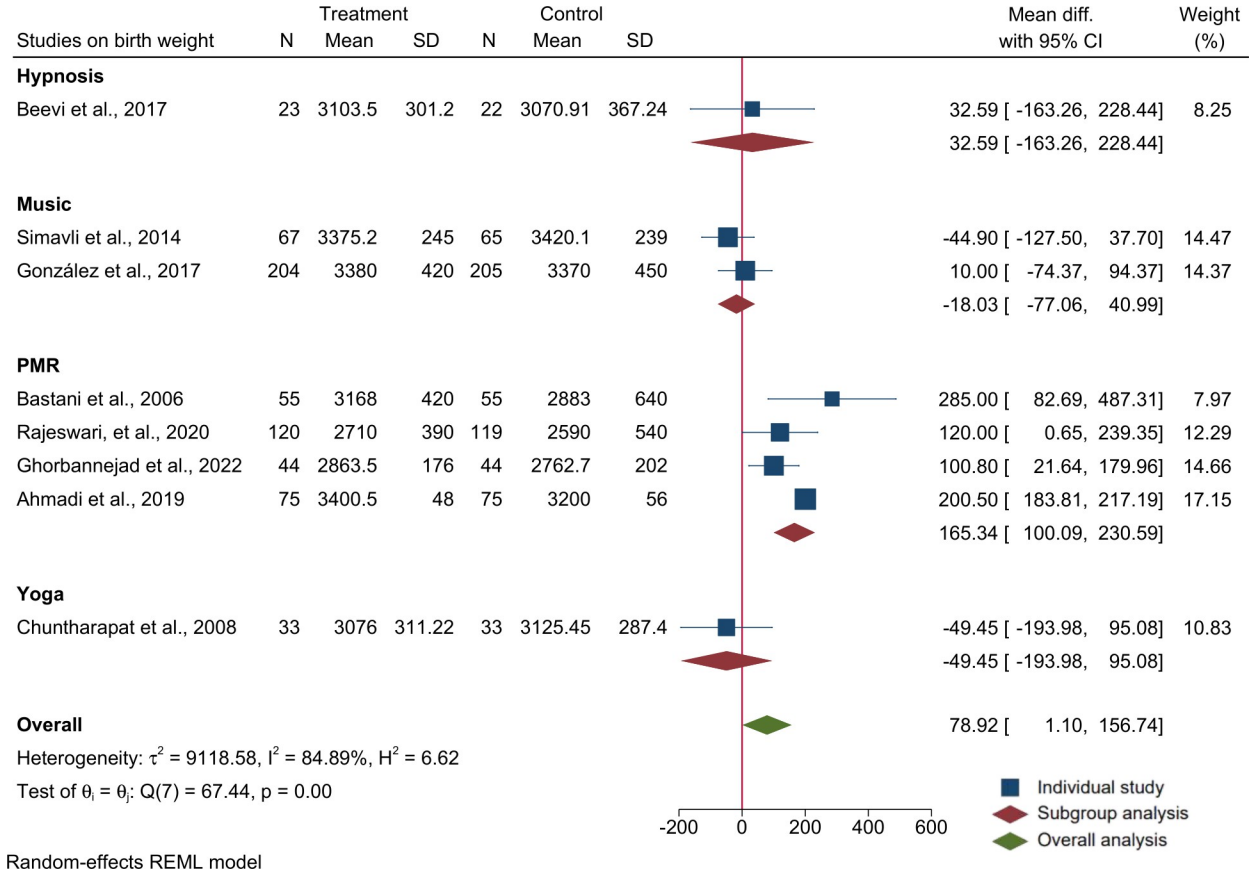

Fig 5. Forest plot and subgroup analysis for raw mean difference of studies on the effects of relaxation interventions on birth weight (g).

https://doi.org/10.1371/journal.pone.0278432.g005

score at 5 minute evaluation [55]. The trial in Malaysia reported a significant difference in Apgar score at 1 minute evaluation where 96% of neonates born to mothers in the relaxation (hypnosis) group scored 9 compared to 73% of neonates born to mothers in the control group [33]. The other trials showed no effect on Apgar score either at 1 or 5 minute evaluation [51, 56, 57].

Gestational age as an outcome was reported in three trials [51, 58, 60]. In India, relaxation significantly increased gestational age at birth (38.0 (±3.6) weeks in the relaxation group vs 37.2 (±4.2) weeks in the control group, $p = 0.04$). The same trial reported that the percentage of preterm births was significantly lower in the relaxation group (11.5%) compared to the control group (20.3%) ($p = 0.01$) [51]. However, studies in Iran reported no significant effect of relaxation therapy on gestational age, but the sample size for this trial was small [58, 60]. Newborn length at birth was reported in three trials; one of which reported increased birth length in the relaxation group (mean difference 3.5 centimetres; 95% CI: 2.4, 4.6) [59]; but not the remaining trials [56, 60].

Obstetric outcomes. Four RCTs assessed the effect of relaxation interventions on obstetric outcomes. In Turkey, women who received music therapy during labour had a significantly shorter mean (SD) duration of labour 189 (28) minutes in the first stage of active labour and 83 (13) minutes in the second stage of labour compared to 198 (15) minutes and 89 (18) minutes respectively in the control group [55]. In the same trial, women in the intervention group (music therapy) had non-significantly decreased rates of Cesarean section (6.8%), instrumental delivery (2.7%), episiotomy (76.1%), and non-significantly increased rate of spontaneous

vaginal delivery (90.2%) compared to 12.2% cesarean section, 6.8% instrumental delivery, 81% episiotomy and 80% spontaneous vaginal delivery in the control group [55]. A study from Iran reported a significantly reduced rate of abnormal delivery in the relaxation (PMR/BR) group (21.2%) compared to 48.1%, p = 0.01, and an increased rate of spontaneous vaginal delivery (78.8%) compared to 39.7%, p = 0.01, in the control group [58]. Similarly, there was a significant improvement in spontaneous vaginal delivery (74.2% in the PMR/BR compared to 49.6% in the control group) and a decreased rate of Caesarian deliveries (21.8% in the PMR/BR compared to 40.6% in the control group) in India [51]. The same trial reported a significantly decreased rate of induced labour in the PMR/BR group compared to women in the control group ($F_2 = 5.50$, p = 0.019) [51].

An RCT in Thailand also reported significantly shorter duration of first stage labour 520 (186) minutes vs. 660 (273) minutes ($p<0.05$) and shorter total duration of labour 559 (203) minutes vs 684 (276) minutes ($p<0.05$) in the yoga group compared to women in the control group [57].

Maternal physiological outcomes. Measurements of maternal physiological outcomes were reported in six studies [36, 43, 52, 55, 60, 63]. Pregnant women in the relaxation group had lower systolic and diastolic blood pressure, heart rate, respiration rate and skin conductance level activity during pregnancy, labour and the postnatal period [36, 43, 52, 55, 60, 63].

Discussion

In this systematic review and meta-analysis, we synthesized existing literature and provided up-to-date evidence on the effects of relaxation interventions during pregnancy on maternal mental health problems (stress, anxiety and depressive symptoms), and pregnancy and birth outcomes. Consistent beneficial impacts of relaxation interventions on mental health and birth weight outcomes were observed in terms of maternal stress, anxiety, depression and birth weight, although study heterogeneity was high. Furthermore, relaxation interventions consistently improved maternal physiological indicators during pregnancy and shortened the length of labour at birth. Findings on birth outcomes such as gestational age, mode of delivery, Apgar score and offspring birth length were mixed and non-conclusive. In subgroup analysis, music therapy has reduced symptoms of stress, anxiety and depression consistently and PMR/BR relaxation improved offspring birth weight. Several mechanisms such as brain stem reflex, arousal, inducing emotions, mental imagery, conjure episodic memory and evaluative conditioning, could be involved in music therapy to improve mental health [64–66]. On the other hand, PMR/BR, through activation of cortical brain activities and by enhancing blood circulation and oxygen saturation, could optimize mental health and physiologic output [67–70].

The meta-analysis indicated that relaxation interventions are effective in reducing stress during pregnancy. One underlying mechanism can be explained by the model of body-mind connection and integration [71] whereby body, mind, brain and behavior are all interlinked and influence one another [72, 73]. Psychological stress leads to sustained contraction of muscle tissues making them tense with increased vasoconstriction, blood pressure, heart rate and decreased circulatory outcomes until the stress is resolved. Physical relaxation methods, such as breathing and muscle relaxation, further contract and then relax the muscle to expel the newly induced stress along with the preexisting pathological stress from the body. Another mechanism is that psychological relaxations such as meditation and music therapies relax the mind, induce emotions, mental imagery, and counter unpleasant feelings and thoughts to improve mental wellbeing.

In addition to their effects on stress, the meta-analysis showed that relaxation interventions are effective in improving symptoms of anxiety and depression. This could be explained by the

fact that anxiety and depression are mainly the consequence of increased and unresolved stress in human life [74, 75]. Increased level of stress activates the HPA axis as well as the sympathetic and parasympathetic nervous system [8, 74, 75] and influences the neuronal circuits responsible for regulating and mediating anxiety and depression in the brain [8, 74, 75]. Thus, by reducing stress, relaxation therapy could break the neurobiological links between stress, anxiety and depression. Another mechanism of relaxation is through its effect on improving neurogenesis, synaptogenesis and increased gray matter density and volume with potential benefit for optimizing neurotransmitters in the brain [76, 77].

In two trials in this review, the positive effects of relaxation in improving anxiety and depression persisted into the postnatal period. This enduring benefit of relaxation could arise because relaxation interventions prevent antenatal anxiety and depression which would otherwise persist into the postnatal period. Alternatively, the relaxation interventions provided during pregnancy may have a prolonged effect on maternal stress management and reduce the risk of anxiety and depression in the postnatal period. Improved maternal well-being during pregnancy helps the mothers to care for herself more optimally during pregnancy while persistence of better maternal mental health into the postnatal period could help mother-infant attachment, child care and exclusive breastfeeding, all of which promote positive growth and development of the offspring [78, 79].

Finally, in the meta-analysis, relaxation interventions showed a positive effect on birth weight of the newborn. This was entirely explained by the effect of progressive muscle relaxation and deep breathing on birth weight [51, 58–60], whereas no effect was seen for music, hypnosis or yoga therapies [33, 55–57]. This contrast could be because deep breathing and muscle relaxation rather than music therapy improve physical relaxation and optimized maternal physiology to improve uterine circulation, benefitting fetal growth and development. However, PMR/BR interventions were also given for longer periods compared to yoga and music therapies which could result in stronger effects compared to the other approaches.

In the narrative synthesis, studies that evaluated physiological responses found relaxation therapies to be effective in improving the physiology of pregnant women by optimizing vital signs such as blood pressure, heart rate, body temperature and respiration. Inconsistent effects of relaxation interventions on pregnancy and birth outcomes such as mode of delivery, gestational age, birth length and Apgar score were observed. The lack of associations in some of the outcomes could be because most of the reviewed studies were primarily powered to examine impacts on maternal mental health but not obstetric and birth outcomes. In addition, only a few trials reported gestational age and birth outcomes, compounded by a relatively small sample size.

In summary, the mechanisms through which relaxation interventions could improve maternal well-being, and pregnancy and birth outcomes could involve an interplay of physical, psychological and physiological mechanisms. Physical responses to relaxation include immediate musculoskeletal relaxation and a decrease in muscle tension; psychological responses include mental calmness, silence and peace; and physiological responses to relaxation include optimized blood pressure, heart rate, respiratory rate and metabolic rate, along with decreased stress hormones and increased blood circulation [80–84]. Through one or a combination of these mechanisms, relaxation interventions could improve the health and well-being of pregnant woman, and this in turn may support fetal growth and development of the offspring.

Strengths and limitations

A strength of this work is that we included trials that applied different forms of relaxation interventions and undertook both descriptive/narrative as well as pooled meta-analysis based

on data availability. However, the findings of the systematic review and meta-analysis also had some limitations. Most trials were primarily powered for maternal mental health, either stress, anxiety or depression, and not for pregnancy or birth outcomes. Because of lack of literature, some of the subgroup analysis involved only a single study. Furthermore, data on the effects of the relaxation interventions on neonatal outcomes other than birth weight were very limited and insufficient to conduct meta-analysis. Finally, most of the studies included in this review are from middle- or HIC and the findings might not be applicable for LIC settings, where both the sources of stress, and the feasibility of interventions, may be different.

Conclusion and recommendation

The results of this review indicate that, in addition to physiological and mental health benefits for mothers, relaxation interventions improved birth weight and hold some promise for improving other newborn outcomes; therefore, this approach strongly merits further research. Future research that is adequately powered on birth and newborn outcomes such as gestational age, birth weight and birth length is crucial. Considering the magnitude of perinatal maternal mental health and psychological problems, the high burden of obstetric complications and the associated global burden of maternal and neonatal morbidity and mortality, the results of this review indicate that a range of complementary interventions may help address these problems. Their relative cost-effectiveness, ease and absence of adverse and teratogenic effects in comparison to pharmacological treatments favours the application of one or a combination of these relaxation therapies in this population group. Relaxation interventions are low-intensity and may be more scalable than individualized psychological interventions in resource-limited settings.

Therefore, we recommend that these relaxation interventions be evaluated for their acceptability, suitability and effectiveness to improve maternal and offspring health outcomes in LICs. Further evaluating the interventions in these settings would also be beneficial to understand whether, in places with severe food insecurity and a high burden of infections, which affect both maternal and infant health, relaxation interventions could mitigate the harmful effects of stressors.

Supporting information

S1 Table. Quality assessment report for risk of bias for included studies in the review based on the Cochrane Collaboration's risk of bias assessment tool.
(DOCX)

S2 Table. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist.
(DOCX)

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References

1. Dunkel Schetter C, Tanner L. Anxiety, depression and stress in pregnancy: implications for mothers, children, research, and practice. Curr Opin Psychiatry. 2012 Mar; 25(2):141–8. https://doi.org/10.1097/YCO.0b013e3283503680 PMID: 22262028
2. Alves AC, Cecatti JG, Souza RT. Resilience and Stress during Pregnancy: A Comprehensive Multidimensional Approach in Maternal and Perinatal Health. Cheng JT, editor. Sci World J. 2021 Aug 13; 2021:1–7. https://doi.org/10.1155/2021/9512854 PMID: 34434079
3. Baqutayan SMS. Stress and Coping Mechanisms: A Historical Overview. Mediterr J Soc Sci [Internet]. 2015 Mar 1 [cited 2023 Aug 17]; Available from: https://www.richtmann.org/journal/index.php/mjss/article/view/5927
4. Fisher J, Cabral De Mello M, Patel V, Rahman A, Tran T, Holton S, et al. Prevalence and determinants of common perinatal mental disorders in women in low- and lower-middle-income countries: a systematic review. Bull World Health Organ. 2012 Feb 1; 90(2):139–149H. https://doi.org/10.2471/BLT.11.091850 PMID: 22423165
5. Saur AM, Dos Santos MA. Risk factors associated with stress symptoms during pregnancy and postpartum: integrative literature review. Women Health. 2021 Aug 9; 61(7):651–67. https://doi.org/10.1080/03630242.2021.1954132 PMID: 34311677
6. McEwen BS. Physiology and Neurobiology of Stress and Adaptation: Central Role of the Brain. Physiol Rev. 2007 Jul; 87(3):873–904. https://doi.org/10.1152/physrev.00041.2006 PMID: 17615391
7. American Psychological Association (APA). Stress effects on the body. https://www.apa.org/topics/stress/body. Accessed: 8/17/2023.
8. Godoy LD, Rossignoli MT, Delfino-Pereira P, Garcia-Cairasco N, De Lima Umeoka EH. A Comprehensive Overview on Stress Neurobiology: Basic Concepts and Clinical Implications. Front Behav Neurosci. 2018 Jul 3; 12:127. https://doi.org/10.3389/fnbeh.2018.00127 PMID: 30034327
9. Vyas A, Mitra R, Shankaranarayana Rao BS, Chattarji S. Chronic Stress Induces Contrasting Patterns of Dendritic Remodeling in Hippocampal and Amygdaloid Neurons. J Neurosci. 2002 Aug 1; 22(15):6810–8. https://doi.org/10.1523/JNEUROSCI.22-15-06810.2002 PMID: 12151561
10. Popoli M, Yan Z, McEwen BS, Sanacora G. The stressed synapse: the impact of stress and glucocorticoids on glutamate transmission. Nat Rev Neurosci. 2012 Jan; 13(1):22–37.
11. Pittenger C, Duman RS. Stress, Depression, and Neuroplasticity: A Convergence of Mechanisms. Neuropsychopharmacology. 2008 Jan; 33(1):88–109. https://doi.org/10.1038/sj.npp.1301574 PMID: 17851537
12. Berrios GE. Historical epistemology of the body-mind interaction in psychiatry. Dialogues Clin Neurosci. 2018 Mar; 20(1):5–13. https://doi.org/10.31887/DCNS.2018.20.1/gberrios PMID: 29946206
13. Brower V. Mind–body research moves towards the mainstream: Mounting evidence for the role of the mind in disease and healing is leading to a greater acceptance of mind–body medicine. EMBO Rep. 2006 Mar; 7(4):358–61.
14. Johnson M. The body in the mind.: The bodily basis of meaning, imagination, and reason. (1987). University of Chicago Press.
15. Coussons-Read ME. Effects of prenatal stress on pregnancy and human development: mechanisms and pathways. Obstet Med. 2013 Jun; 6(2):52–7. https://doi.org/10.1177/1753495X12473751 PMID: 27757157
16. Schneiderman N, Ironson G, Siegel SD. Stress and health: psychological, behavioral, and biological determinants. Annu Rev Clin Psychol. 2005; 1:607–28. https://doi.org/10.1146/annurev.clinpsy.1.102803.144141 PMID: 17716101

17. Pais M, Pai MV. Stress Among Pregnant Women: A Systematic Review. J Clin Diagn Res [Internet]. 2018 [cited 2023 Aug 15]; Available from: http://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2018&volume=12&issue=5&page=LE01&issn=0973-709x&id=11561

18. Abera M, Hanlon C, Fedlu H, Fewtrell M, Tesfaye M, Wells JCK. Stress and resilience during pregnancy: A comparative study between pregnant and non-pregnant women in Ethiopia. Waqas A, editor. PLOS Glob Public Health. 2023 May 22; 3(5):e0001416. https://doi.org/10.1371/journal.pgph.0001416 PMID: 37216320

19. Woods SM, Melville JL, Guo Y, Fan MY, Gavin A. Psychosocial stress during pregnancy. Am J Obstet Gynecol. 2010 Jan; 202(1):61.e1–7. https://doi.org/10.1016/j.ajog.2009.07.041 PMID: 19766975

20. Vijayaselvi DrR. Risk Factors for Stress During Antenatal Period Among Pregnant Women in Tertiary Care Hospital of Southern India. J Clin Diagn Res [Internet]. 2015 [cited 2023 Aug 15]; Available from: http://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2015&volume=9&issue=10&page=QC01&issn=0973-709x&id=6580 https://doi.org/10.7860/JCDR/2015/13973.6580 PMID: 26557568

21. Jha S, Salve HR, Goswami K, Sagar R, Kant S. Burden of common mental disorders among pregnant women: A systematic review. Asian J Psychiatry. 2018 Aug; 36:46–53. https://doi.org/10.1016/j.ajp.2018.06.020 PMID: 29966886

22. Fawcett EJ, Fairbrother N, Cox ML, White IR, Fawcett JM. The Prevalence of Anxiety Disorders During Pregnancy and the Postpartum Period: A Multivariate Bayesian Meta-Analysis. J Clin Psychiatry [Internet]. 2019 Jul 23 [cited 2023 Aug 15]; 80(4). Available from: https://www.psychiatrist.com/JCP/article/Pages/2019/v80/18r12527.aspx https://doi.org/10.4088/JCP.18r12527 PMID: 31347796

23. Dadi AF, Miller ER, Bisetegn TA, Mwanri L. Global burden of antenatal depression and its association with adverse birth outcomes: an umbrella review. BMC Public Health. 2020 Dec; 20(1):173. https://doi.org/10.1186/s12889-020-8293-9 PMID: 32019560

24. Van den Bergh BRH, van den Heuvel MI, Lahti M, Braeken M, de Rooij SR, Entringer S, et al. Prenatal developmental origins of behavior and mental health: The influence of maternal stress in pregnancy. Vol. 117, Neuroscience and Biobehavioral Reviews. Elsevier Ltd; 2020 Oct. p. 26–64. https://doi.org/10.1016/j.neubiorev.2017.07.003 PMID: 28757456

25. Ward RK, Zamorski MA. Benefits and risks of psychiatric medications during pregnancy. Am Fam Physician. 2002 Aug 15; 66(4):629–36. PMID: 12201556

26. Yu X, Liu Y, Huang Y, Zeng T. The effect of nonpharmacological interventions on the mental health of high-risk pregnant women: A systematic review. Complement Ther Med. 2022 Mar; 64:102799. https://doi.org/10.1016/j.ctim.2022.102799 PMID: 34995769

27. Dimidjian S, Goodman S. Nonpharmacologic Intervention and Prevention Strategies for Depression During Pregnancy and the Postpartum. Clin Obstet Gynecol. 2009 Sep; 52(3):498–515. https://doi.org/10.1097/GRF.0b013e3181b52da6 PMID: 19661764

28. Moher D, Liberati A, Tetzlaff J, Altman DG, Grp P. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement (Reprinted from Annals of Internal Medicine). Phys Ther. 2009; 89(9):873–80.

29. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJM, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? Control Clin Trials. 1996; 17(1):1–12. https://doi.org/10.1016/0197-2456(95)00134-4 PMID: 8721797

30. Verhagen AP, De Vet HCW, De Bie RA, Kessels AGH, Boers M, Bouter LM, et al. The Delphi list: A criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. J Clin Epidemiol. 1998; 51(12):1235–41. https://doi.org/10.1016/s0895-4356(98)00131-0 PMID: 10086815

31. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ Online. 2011; 343(7829). https://doi.org/10.1136/bmj.d5928 PMID: 22008217

32. Beevi Z, Low WY, Hassan J. The Effectiveness of Hypnosis Intervention in Alleviating Postpartum Psychological Symptoms. Am J Clin Hypn. 2019 Apr 1; 61(4):409–25. https://doi.org/10.1080/00029157.2018.1538870 PMID: 31017553

33. Beevi Z, Low WY, Hassan J. The Effectiveness of Hypnosis Intervention for Labor: An Experimental Study. Am J Clin Hypn. 2017 Sep 11; 60(2):172–91. https://doi.org/10.1080/00029157.2017.1280659 PMID: 28891771

34. Beevi Z, Low WY, Hassan J. Impact of Hypnosis Intervention in Alleviating Psychological and Physical Symptoms During Pregnancy. Am J Clin Hypn. 2016 Apr 12; 58(4):368–82. https://doi.org/10.1080/00029157.2015.1063476 PMID: 27003486

35. Novelia S, Sitanggang TW, Lutfiyanti A. The Effect of Yoga Relaxation on Anxiety Levels among Pregnant Women. Nurse Media J Nurs. 2019 Mar 4; 8(2):86.

36. Abd Elgwad F, Mourad M, Mahmoud N. Effect of Benson's Relaxation Therapy on Stress and Physiological Parameters among Women with Preeclampsia. Alex Sci Nurs J. 2021 Jul 1; 23(1):63–74.

37. Bastani F, Hidarnia A, Kazemnejad A, Vafaei M, Kashanian M. A Randomized Controlled Trial of the Effects of Applied Relaxation Training on Reducing Anxiety and Perceived Stress in Pregnant Women. J Midwifery Womens Health. 2005 Jul 8; 50(4):e36–40. https://doi.org/10.1016/j.jmwh.2004.11.008 PMID: 15973255

38. Chang MY, Chen CH, Huang KF. Effects of music therapy on psychological health of women during pregnancy. J Clin Nurs. 2008 Oct; 17(19):2580–7. https://doi.org/10.1111/j.1365-2702.2007.02064.x PMID: 18298503

39. Satyapriya M, Nagendra HR, Nagarathna R, Padmalatha V. Effect of integrated yoga on stress and heart rate variability in pregnant women. Int J Gynecol Obstet. 2009 Mar; 104(3):218–22. https://doi.org/10.1016/j.ijgo.2008.11.013 PMID: 19110245

40. Tragea C, Chrousos GP, Alexopoulos EC, Darviri C. A randomized controlled trial of the effects of a stress management programme during pregnancy. Complement Ther Med. 2014 Apr; 22(2):203–11. https://doi.org/10.1016/j.ctim.2014.01.006 PMID: 24731890

41. Chang HC, Yu CH, Chen SY, Chen CH. The effects of music listening on psychosocial stress and maternal–fetal attachment during pregnancy. Complement Ther Med. 2015 Aug; 23(4):509–15. https://doi.org/10.1016/j.ctim.2015.05.002 PMID: 26275644

42. Liu YH, Lee CS, Yu CH, Chen CH. Effects of music listening on stress, anxiety, and sleep quality for sleep-disturbed pregnant women. Women Health. 2016 Apr 2; 56(3):296–311. https://doi.org/10.1080/03630242.2015.1088116 PMID: 26361642

43. Muthukrishnan S. Effect of Mindfulness Meditation on Perceived Stress Scores and Autonomic Function Tests of Pregnant Indian Women. J Clin Diagn Res [Internet]. 2016 [cited 2023 Aug 8]; Available from: http://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2016&volume=10&issue=4&page=CC05&issn=0973-709x&id=7679 https://doi.org/10.7860/JCDR/2016/16463.7679 PMID: 27190795

44. Pan WL, Chang CW, Chen SM, Gau ML. Assessing the effectiveness of mindfulness-based programs on mental health during pregnancy and early motherhood—a randomized control trial. BMC Pregnancy Childbirth. 2019 Dec; 19(1):346. https://doi.org/10.1186/s12884-019-2503-4 PMID: 31601170

45. Guardino CM, Dunkel Schetter C, Bower JE, Lu MC, Smalley SL. Randomised controlled pilot trial of mindfulness training for stress reduction during pregnancy. Psychol Health. 2014 Mar 4; 29(3):334–49. https://doi.org/10.1080/08870446.2013.852670 PMID: 24180264

46. Yang M, Li L, Zhu H, Alexander IM, Liu S, Zhou W, et al. Music Therapy To Relieve Anxiety In Pregnant Women On Bedrest: A Randomized, Controlled Trial. MCN Am J Matern Nurs. 2009 Sep; 34(5):316–23. https://doi.org/10.1097/01.NMC.0000360425.52228.95 PMID: 19713801

47. Urech C, Fink NS, Hoesli I, Wilhelm FH, Bitzer J, Alder J. Effects of relaxation on psychobiological well-being during pregnancy: A randomized controlled trial. Psychoneuroendocrinology. 2010 Oct; 35(9):1348–55. https://doi.org/10.1016/j.psyneuen.2010.03.008 PMID: 20417038

48. Newham JJ, Wittkowski A, Hurley J, Aplin JD, Westwood M. EFFECTS OF ANTENATAL YOGA ON MATERNAL ANXIETY AND DEPRESSION: A RANDOMIZED CONTROLLED TRIAL: Research Article: Effects of antenatal yoga RCT on maternal anxiety. Depress Anxiety. 2014 Aug; 31(8):631–40.

49. Davis K, Goodman SH, Leiferman J, Taylor M, Dimidjian S. A randomized controlled trial of yoga for pregnant women with symptoms of depression and anxiety. Complement Ther Clin Pract. 2015 Aug; 21(3):166–72. https://doi.org/10.1016/j.ctcp.2015.06.005 PMID: 26256135

50. García González J, Ventura Miranda MI, Requena Mullor M, Parron Carreño T, Alarcón Rodriguez R. Effects of prenatal music stimulation on state/trait anxiety in full-term pregnancy and its influence on childbirth: a randomized controlled trial. J Matern Fetal Neonatal Med. 2018 Apr 18; 31(8):1058–65. https://doi.org/10.1080/14767058.2017.1306511 PMID: 28287005

51. Rajeswari S, SanjeevaReddy N. Efficacy of Progressive Muscle Relaxation on Pregnancy Outcome among Anxious Indian Primi Mothers. Iran J Nurs Midwifery Res. 2020; 25(1):23–30. https://doi.org/10.4103/ijnmr.IJNMR_207_18 PMID: 31956594

52. Estrella-Juarez F, Requena-Mullor M, Garcia-Gonzalez J, Lopez-Villen A, Alarcon-Rodriguez R. Effect of Virtual Reality and Music Therapy on the Physiologic Parameters of Pregnant Women and Fetuses and on Anxiety Levels: A Randomized Controlled Trial. J Midwifery Womens Health. 2023 Jan; 68(1):35–43. https://doi.org/10.1111/jmwh.13413 PMID: 36383473

53. Abarghoee SN, Mardani A, Baha R, Aghdam NF, Khajeh M, Eskandari F, et al. Effects of Benson Relaxation Technique and Music Therapy on the Anxiety of Primiparous Women Prior to Cesarean Section: A Randomized Controlled Trial. Minervini G, editor. Anesthesiol Res Pract. 2022 Dec 23; 2022:1–9. https://doi.org/10.1155/2022/9986587 PMID: 36589598

54. Simavli S, Kaygusuz I, Gumus I, Usluogulları B, Yildirim M, Kafali H. Effect of music therapy during vaginal delivery on postpartum pain relief and mental health. J Affect Disord. 2014 Mar; 156:194–9. https://doi.org/10.1016/j.jad.2013.12.027 PMID: 24411681

55. Simavli S, Gumus I, Kaygusuz I, Yildirim M, Usluogullari B, Kafali H. Effect of Music on Labor Pain Relief, Anxiety Level and Postpartum Analgesic Requirement: A Randomized Controlled Clinical Trial. Gynecol Obstet Invest. 2014; 78(4):244–50. https://doi.org/10.1159/000365085 PMID: 25227477

56. García González J, Ventura Miranda MI, Manchon García F, Pallarés Ruiz TI, Marin Gascón ML, Requena Mullor M, et al. Effects of prenatal music stimulation on fetal cardiac state, newborn anthropometric measurements and vital signs of pregnant women: A randomized controlled trial. Complement Ther Clin Pract. 2017 May; 27:61–7. https://doi.org/10.1016/j.ctcp.2017.03.004 PMID: 28438283

57. Chuntharapat S, Petpichetchian W, Hatthakit U. Yoga during pregnancy: Effects on maternal comfort, labor pain and birth outcomes. Complement Ther Clin Pract. 2008 May; 14(2):105–15. https://doi.org/10.1016/j.ctcp.2007.12.007 PMID: 18396254

58. Bastani F, Hidarnia A, Montgomery KS, Aguilar-Vafaei ME, Kazemnejad A. Does Relaxation Education in Anxious Primigravid Iranian Women Influence Adverse Pregnancy Outcomes?: A Randomized Controlled Trial. J Perinat Neonatal Nurs. 2006 Apr; 20(2):138–46. https://doi.org/10.1097/00005237-200604000-00007 PMID: 16714913

59. Ahmadi M, Rahimi F, Rosta F, AlaviMajd H, Valiani M. Effect of Progressive Muscle Relaxation Training on Postpartum Blues in High-risk Pregnant Women. J Holist Nurs Midwifery. 2019 Oct 30;192–9.

60. Ghorbannejad S, MehdizadehTourzani Z, Kabir K, Mansoureh Yazdkhasti. The effectiveness of Jacobson's progressive muscle relaxation technique on maternal, fetal and neonatal outcomes in women with non-severe preeclampsia: a randomized clinical trial. Heliyon. 2022 Jun; 8(6):e09709.

61. Liu YH, Chang MY, Chen CH. Effects of music therapy on labour pain and anxiety in Taiwanese first-time mothers. J Clin Nurs. 2010 Apr; 19(7–8):1065–72. https://doi.org/10.1111/j.1365-2702.2009.03028.x PMID: 20492051

62. Zarenejad M, Yazdkhasti M, Rahimzadeh M, Mehdizadeh Tourzani Z, Esmaelzadeh-Saeieh S. The effect of mindfulness-based stress reduction on maternal anxiety and self-efficacy: A randomized controlled trial. Brain Behav [Internet]. 2020 Apr [cited 2023 Aug 11]; 10(4). Available from: https://onlinelibrary.wiley.com/doi/10.1002/brb3.1561 PMID: 32162450

63. Bauer I, Hartkopf J, Wikström AK, Schaal NK, Preissl H, Derntl B, et al. Acute relaxation during pregnancy leads to a reduction in maternal electrodermal activity and self-reported stress levels. BMC Pregnancy Childbirth. 2021 Dec; 21(1):628. https://doi.org/10.1186/s12884-021-04099-4 PMID: 34535120

64. Legge AW. On the Neural Mechanisms of Music Therapy in Mental Health Care: Literature Review and Clinical Implications. Music Ther Perspect. 2015; 33(2):128–41.

65. Dingle GA, Sharman LS, Bauer Z, Beckman E, Broughton M, Bunzli E, et al. How Do Music Activities Affect Health and Well-Being? A Scoping Review of Studies Examining Psychosocial Mechanisms. Front Psychol. 2021 Sep 8; 12:713818. https://doi.org/10.3389/fpsyg.2021.713818 PMID: 34566791

66. Music Rebecchini L., mental health, and immunity. Brain Behav Immun—Health. 2021 Dec; 18:100374.

67. Toussaint L, Nguyen QA, Roettger C, Dixon K, Offenbächer M, Kohls N, et al. Effectiveness of Progressive Muscle Relaxation, Deep Breathing, and Guided Imagery in Promoting Psychological and Physiological States of Relaxation. Taylor-Piliae R, editor. Evid Based Complement Alternat Med. 2021 Jul 2; 2021:1–8. https://doi.org/10.1155/2021/5924040 PMID: 34306146

68. Kato K, Vogt T, Kanosue K. Brain Activity Underlying Muscle Relaxation. Front Physiol. 2019 Dec 3; 10:1457. https://doi.org/10.3389/fphys.2019.01457 PMID: 31849707

69. Cahyati A, Herliana L, Februanti S. Progressive Muscle Relaxation (PMR) Enhances Oxygen Saturation in Patients of Coronary Heart Disease. J Phys Conf Ser. 2020 Mar 1; 1477(6):062018.

70. Ohmori F, Shimizu S, Kagaya A. Exercise-induced blood flow in relation to muscle relaxation period. Dyn Med. 2007 Dec; 6(1):5. https://doi.org/10.1186/1476-5918-6-5 PMID: 17490481

71. Czamanski-Cohen J, Weihs KL. The bodymind model: A platform for studying the mechanisms of change induced by art therapy. Arts Psychother. 2016 Nov; 51:63–71. https://doi.org/10.1016/j.aip.2016.08.006 PMID: 27777492

72. Gordon EM, Chauvin RJ, Van AN, Rajesh A, Nielsen A, Newbold DJ, et al. A somato-cognitive action network alternates with effector regions in motor cortex. Nature. 2023 May 11; 617(7960):351–9. https://doi.org/10.1038/s41586-023-05964-2 PMID: 37076628

73. Burnett-Zeigler I, Schuette S, Victorson D, Wisner KL. Mind–Body Approaches to Treating Mental Health Symptoms Among Disadvantaged Populations: A Comprehensive Review. J Altern Complement Med. 2016 Feb; 22(2):115–24. https://doi.org/10.1089/acm.2015.0038 PMID: 26540645

74. Daviu N, Bruchas MR, Moghaddam B, Sandi C, Beyeler A. Neurobiological links between stress and anxiety. Neurobiol Stress. 2019 Nov; 11:100191. https://doi.org/10.1016/j.ynstr.2019.100191 PMID: 31467945

75. Tafet GE, Nemeroff CB. The Links Between Stress and Depression: Psychoneuroendocrinological, Genetic, and Environmental Interactions. J Neuropsychiatry Clin Neurosci. 2016 Apr; 28(2):77–88. https://doi.org/10.1176/appi.neuropsych.15030053 PMID: 26548654

76. Krishnakumar D, Hamblin MR, Lakshmanan S. Meditation and Yoga can Modulate Brain Mechanisms that affect Behavior and Anxiety- A Modern Scientific Perspective. Anc Sci. 2015 Apr 1; 2(1):13. https://doi.org/10.14259/as.v2i1.171 PMID: 26929928

77. Hölzel BK, Carmody J, Vangel M, Congleton C, Yerramsetti SM, Gard T, et al. Mindfulness practice leads to increases in regional brain gray matter density. Psychiatry Res Neuroimaging. 2011 Jan; 191 (1):36–43. https://doi.org/10.1016/j.pscychresns.2010.08.006 PMID: 21071182

78. Satyanarayana V, Lukose A, Srinivasan K. Maternal mental health in pregnancy and child behavior. Indian J Psychiatry. 2011; 53(4):351. https://doi.org/10.4103/0019-5545.91911 PMID: 22303046

79. Chauhan A, Potdar J. Maternal Mental Health During Pregnancy: A Critical Review. Cureus [Internet]. 2022 Oct 25 [cited 2023 Aug 26]; Available from: https://www.cureus.com/articles/108368-maternal-mental-health-during-pregnancy-a-critical-review https://doi.org/10.7759/cureus.30656 PMID: 36426343

80. Nillni YI, Mehralizade A, Mayer L, Milanovic S. Treatment of depression, anxiety, and trauma-related disorders during the perinatal period: A systematic review. Clin Psychol Rev. 2018; 66:136. https://doi.org/10.1016/j.cpr.2018.06.004 PMID: 29935979

81. Dimidjian S, Goodman SH, Felder JN, Gallop R, Brown AP, Beck A. An open trial of mindfulness-based cognitive therapy for the prevention of perinatal depressive relapse/recurrence. Arch Womens Ment Health. 2015; 18(1):85–94. https://doi.org/10.1007/s00737-014-0468-x PMID: 25298253

82. Fink NS, Urech C, Cavelti M, Alder J. Relaxation during pregnancy: What are the benefits for mother, fetus, and the newborn? A systematic review of the literature. J Perinat Neonatal Nurs. 2012; 26 (4):296–306. https://doi.org/10.1097/JPN.0b013e31823f565b PMID: 23111717

83. Richter J, Bittner A, Petrowski K, Junge-Hoffmeister J, Bergmann S, Joraschky P, et al. Effects of an early intervention on perceived stress and diurnal cortisol in pregnant women with elevated stress, anxiety, and depressive symptomatology. J Psychosom Obstet Gynecol. 2012; 33(4):162–70. https://doi.org/10.3109/0167482X.2012.729111 PMID: 23078196

84. Alder J, Urech C, Fink N, Bitzer J, Hoesli I. Response to induced relaxation during pregnancy: Comparison of women with high versus low levels of anxiety. J Clin Psychol Med Settings. 2011; 18(1):13–21. https://doi.org/10.1007/s10880-010-9218-z PMID: 21225321