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The effect of prenatal Hatha yoga on affect, cortisol and depressive symptoms

Svetlana Bershadsky [a], Linda Trumpfheller [b], Holly Beck Kimble [c], Diana Pipaloff [c], Ilona S. Yim [a,*]

[a] Department of Psychology and Social Behavior, University of California, Irvine, 4562 Social & Behavioral Sciences Gateway, Irvine, CA 92697-7085, USA
[b] YogaWorks, 27001 La Paz Rd, Suite 112, Mission Viejo, CA 92691, USA
[c] Yoga Shakti, 4249 Campus Dr, Irvine, CA 92612, USA

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A B S T R A C T

Perinatal depression impacts maternal and child health, and little is known about effective interventions. The effects of prenatal Hatha yoga on cortisol, affect and depressive symptoms were investigated in 51 women. Twice during pregnancy, yoga group participants reported on affect and provided a saliva sample before and after a 90-min prenatal Hatha yoga session. Corresponding measures were obtained from yoga and control group participants on days of usual activity. Depressive symptoms were assessed in pregnancy and post partum. Cortisol was lower ($p < .01$) and positive affect higher ($p < .001$) on yoga compared to usual activity days. Negative affect and contentment ($p < .05$) improved more in response to the yoga session. Yoga group participants showed fewer postpartum ($p < .05$) but not antepartum depressive symptoms than control group participants. Findings indicate that prenatal Hatha yoga may improve current mood and may be effective in reducing postpartum depressive symptoms.

Antepartum depression (APD) and postpartum depression (PPD), disorders characterized by mood changes during pregnancy and after delivery, negatively impact maternal and child physical and mental health [1–4]. Prevalence rates range from 4.8% to 18.4% for minor and from 5.1% to 12.7% for major depression [5–7]. APD and PPD, also collectively referred to as perinatal depression, share their diagnostic criteria with major depression, but have their onset during pregnancy or within four weeks after delivery, respectively [8].

Considerable evidence indicates that women with a lifetime history of depression [9–11], high levels of stress [12–15], anxiety [16,17], and poor social support [10,11] during pregnancy are at increased risk for perinatal depression. Nevertheless, a great deal of variation in perinatal depression remains unexplained. A growing body of evidence suggests that the activity of the stress-responsive hypothalamic-pituitary-adrenal axis and its end-product cortisol also may be associated with perinatal emotional well-being [17–21]. Depressive symptoms have been linked to increased basal cortisol levels [22], an increased cortisol response to awakening [23–27] and poorer cortisol recovery after psychological stress [28]. While increases in cortisol over the course of gestation are normative and adaptive [29], excessive elevations of maternal stress hormones have been implicated in the development of PPD [21,30–32].

A number of successful preventive intervention efforts targeting psychosocial and physiological risk factors for perinatal depression have utilized mind-body practices, which embody the idea that the mind interacts with the body to influence physical functioning, improve symptoms, and promote health [33]. Yoga has provoked particular interest given its increasing acceptance in the West [34] and the growing evidence of its association with improvements in affect [35–38], decreases in depressive symptoms [39–41], and reductions in cortisol [36,42–45] in non-pregnant populations. Nascent work suggests that the psychophysiological benefits of yoga may extend to pregnancy. Evidence from non-randomized trials suggests that yoga practice is associated with reduced risk of low birth weight and preterm labor [46]. Randomized controlled trials further suggest that perinatal anxiety [47,48], perceived stress [46], psychological health [49], and autonomic nervous system responses to stress [50] can be improved and the incidence of pregnancy-related hypertension alleviated [51] with yoga. Furthermore, there is preliminary

* Corresponding author. Department of Psychology and Social Behavior, University of California, Irvine, 4562 Social & Behavioral Sciences Gateway, Irvine, CA 92697-7085, USA. Tel.: +1 949 824 0130; fax: +1 949 824 3002.
E-mail address: ilona.yim@uci.edu (I.S. Yim).

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evidence that yoga practice can help reduce depressive symptoms during pregnancy [52–56].

The present study contributes to the existing literature by examining the effectiveness of yoga on APD and PPD symptoms. The first aim was to evaluate the immediate effects of a prenatal yoga session on cortisol and affect at two gestational ages. We proposed that women practicing yoga during pregnancy would show greater decreases in cortisol and greater improvements in affect in response to a 90-min yoga session relative to a "usual activity" within-subject comparison condition, and a between-subject control group. The second aim was to evaluate the effects of prenatal yoga practice on APD and PPD symptoms. We hypothesized that women practicing yoga during pregnancy would show fewer APD and PPD symptoms relative to a between-subject control group. Because psychological and physiological states have been linked to depressive symptoms, we further posited that cortisol and negative affect would be positively associated, and positive affect negatively associated with perinatal depressive symptoms.

1. Method

1.1. Participants

Women practicing yoga during pregnancy (yoga group) were recruited from two yoga studios in Southern California. Women who did not practice yoga or other relaxation techniques during pregnancy (control group) were recruited from an ongoing unrelated study of perinatal depression (data unpublished) via obstetrician referrals and community advertisements. Women were eligible to participate if they were at least 18 years old, English-speaking, nulliparous, between 12 and 19 weeks' gestational age, and self-reported no current depressive and/or anxiety disorder diagnosis. All participants provided written informed consent. The study was approved by the Institutional Review Board of the University of California, Irvine.

1.2. Procedure

This study employed a mixed within- and between-subject design (Fig. 1). Women completed assessments in early and mid-pregnancy and within two months post partum.

1.2.1. Yoga group

Women in the yoga group completed antepartum assessments in the yoga studio and on a separate day in their typical environment ("usual activity" assessments). To account for circadian variations in cortisol secretion, all yoga studio assessments were scheduled between 3:30 p.m. and 8:30 p.m. and were matched for time with usual activity assessments. Women were instructed to abstain from eating, drinking caffeine-containing beverages, and engaging in strenuous physical activity for one hour prior to saliva collection.

In early pregnancy, women came to the yoga studio and five minutes before the start of the yoga session provided a baseline saliva sample and completed a brief questionnaire assessing their current affect, the Derogatis Affects Balance Scale (DABS) [57]. Women then participated in a 90-min session of prenatal Hatha yoga, a type of yoga emphasizing physical, mental and breathing techniques to condition the body, focus the mind, and connect the body and mind [58]. Each session, taught by studio-specific certified prenatal yoga instructors collaborating on the project, consisted of 10–15 min of dialogue regarding pregnancy-related concerns and gestational age-specific modifications, 60 min of asanas (i.e., body postures), 10 min of stretching, and 5–10 min of savasana (i.e., final relaxation), with pranayama (i.e., breathing) instruction throughout the practice. A typical class emphasized squat and balance poses, chest and hip openers, and restorative postures with props. Immediately after the session, women again completed the DABS and provided a saliva sample.

Approximately two days later, using materials provided earlier, women completed the DABS and provided saliva samples at times exactly matching those at the yoga studio. In the 90-min interval

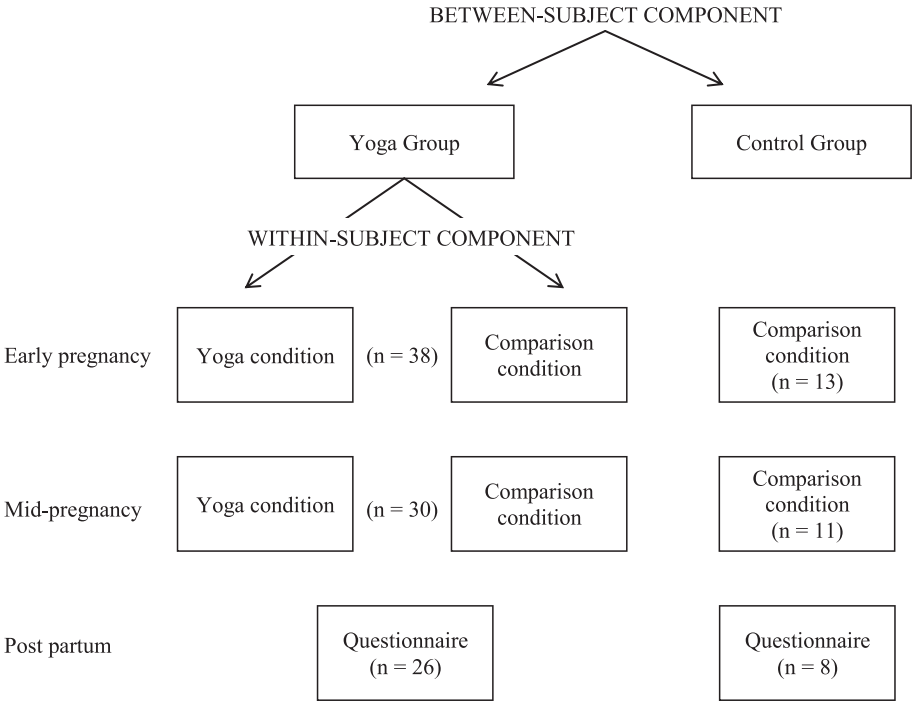

Fig. 1. Study design and participant flow chart.

between assessments, women completed questionnaires assessing sociodemographic and health information, behavioral characteristics, and depressive symptoms and then engaged in light activities of their choosing (e.g., reading, watching TV) until collection of the second saliva sample. Medication Event Monitoring System (MEMS; AARDEX, Zurich, Switzerland) caps were used to document adherence to collection times.

In mid-pregnancy, women again completed all procedures as described above and answered questionnaires assessing changes in health and behaviors since early in pregnancy. Within two months after delivery, women were mailed a questionnaire inquiring about past-week depressive symptoms. Thus, yoga group participants were assessed on five occasions: twice each in early and mid-pregnancy, and once within two months of delivery. Participating women received a 20% discount on their prenatal yoga class series.

1.2.2. Control group

Control group participants completed assessments identical to those described for the yoga group only on days of usual activity at each gestational age. Timing of assessments with regard to gestational/postpartum week and time of day was matched to that of yoga group assessments. Women in the control group received a modest monetary incentive for participation.

1.3. Measures

1.3.1. Saliva collection and cortisol assay

Cortisol was collected with cotton swabs (Salivettes, Sarstedt, Nümbrecht, Germany). Samples were stored at room temperature (yoga days) or in a refrigerator (days of usual activity) until transported to the laboratory the following day where they were stored at −80 °C until assayed. After thawing for biochemical analysis, samples were centrifuged for 10 min at 2,000 *g* and 4 °C. Free cortisol in saliva was determined in duplicate by a commercially available enzyme immunoassay (ELISA, IBL-America, Minneapolis, Minnesota). Inter- and intra-assay coefficients of variance are less than 4.9% and 4.1% respectively, and the sensitivity of the assay is reported at .012 ng/mL.

1.3.2. Affect

Affect was assessed with the DABS [57], which has the advantages of measuring both affective valance (positive, negative) and activation (high, low) and being suitable for use with both clinical and non-clinical populations. Participants rated to what extent (1 = not at all, 5 = extremely) they were currently experiencing each of 40 affect-based adjectives that constitute four positive (joy, contentment, vigor, affection) and four negative (anxiety, depression, guilt, hostility) affects. A positive affects total and a negative affects total score were computed. Internal consistency of the DABS ranges from $\alpha = .79$ to $\alpha = .92$ and test–retest correlations range from $r = .78$ to $r = .84$ [59].

1.3.3. Depressive symptoms

Depressive symptoms were assessed with the 9-item Center for Epidemiologic Studies Depression Scale (CES-D) [60]. Participants were asked how frequently they experienced a set of feelings and engaged in certain behaviors in the last week on a scale ranging from 0 = rarely or none of the time (less than 1 day) to 3 = most or all of the time (5–7 days). The internal consistency of the 9-item CES-D has been demonstrated ($\alpha = .87$) [60].

1.3.4. Yoga, relaxation technique, and exercise practice

Researcher-created questions assessed the timing, frequency, and duration of lifetime and prenatal practice of relaxation techniques, including yoga. Additional questions assessed the frequency of exercise in the year prior to the woman's pregnancy and the average weekly frequency of strenuous, moderate, and mild intensity exercise during the current pregnancy. Participants' activity levels between cortisol samples in the usual activity comparison condition and the control group were assessed by self-report.

1.4. Statistical analyses

Cortisol and negative affect values were positively skewed and thus were log transformed. To evaluate the immediate effects of a prenatal yoga session on cortisol and affect relative to a usual activity comparison condition and a control group (Aim 1), Generalized Estimating Equations (GEEs) were performed. A Gaussian family distribution, identity link and exchangeable correlation structure were specified to evaluate the effects of time (pre-to-post), condition (yoga, usual activity) or group (yoga, control), and gestational age (early, mid). To evaluate the effects of prenatal yoga practice on APD and PPD symptoms (Aim 2), one-way between-groups analyses of covariance (ANCOVAs) were performed comparing symptoms in yoga and control groups. To evaluate the bivariate relationships of cortisol and affect with perinatal depressive symptoms, average values and pre-post difference scores were computed. Pearson product–moment correlations were performed when data were normally distributed and Spearman rank correlations when data were not normally distributed. Multiple regression examined the relative contribution of selected summary measures to perinatal depressive symptoms. Data were analyzed using Stata 12 (StataCorp, College Station, Texas). Unstandardized beta coefficients (B) and two-tailed *p*-values are reported.

2. Results

2.1. Participants

Fifty-one pregnant women enrolled in this study at a mean of 15.16 weeks' gestational age ($SD = 1.29$, range = 12–19). At the mid-pregnancy assessment ($M = 25.88$ weeks' gestational age, $SD = 1.95$, range = 22–31), 43 women were retained; 34 women completed the postpartum questionnaire (retention rate: 64%) (Fig. 1).

Most yoga group participants (87%) had previous experience with yoga, ranging from several months to 10 years. A majority of women reported practicing yoga at least once a week in early (92%) and mid- (66%) pregnancy. Neither differences in change in cortisol nor affect were observed as a function of yoga studio (all *n.s.*). Data from both studios were therefore combined.

Control group participants were younger, less likely to be White, less educated, had lower income, and were less likely to be married at the time of recruitment than yoga group participants (all $ps < .05$), but did not differ from yoga group participants with regard to gestational age at each assessment (Table 1). Importantly, there were no group differences in depressive symptoms at study onset, affect on days of usual activity during pregnancy, and frequency of exercise participation (all *n.s.*). Women who did not complete the study did not differ from those who remained in the study with regard to sociodemographic characteristics or depressive symptoms at study onset (all *n.s.*).

2.2. Compliance with data collection in the usual activity condition and the control group

Among the 34 participants for whom these data were available in early pregnancy, MEMS cap openings occurred 17.79 ($SD = 30.14$)

Table 1
Baseline sociodemographic and obstetric characteristics by yoga and control group.

		Yoga group	Control group
		$n = 38$[a]	$n = 13$
		n (%)	*n* (%)
Race*	Asian	3 (8)	0 (0)
	White	28 (74)	5 (39)
	Other (e.g., Mixed, Hispanic or Latino)	7 (18)	8 (61)
Marital status*	Single	1 (3)	4 (31)
	Married	34 (90)	9 (69)
	Divorced/Separated	1 (3)	0 (0)
Education**	Elementary/ Junior/High School	5 (13)	7 (58)
	Associates Degree	3 (8)	2 (17)
	Bachelor's Degree	13 (34)	2 (17)
	Graduate Degree	17 (45)	1 (8)
Annual household income*	≤$15,000	0 (0)	1 (8)
	$15,000–$35,000	4 (11)	5 (39)
	$35,000–$50,000	2 (5)	2 (15)
	$50,000–$100,000	6 (16)	2 (15)
	$100,000–$150,000	13 (34)	2 (15)
	≥$150,000	13 (34)	1 (8)
		M (SD)	M (SD)
Gestational age (weeks)	Early pregnancy	15.16 (1.18)	15.16 (1.63)
	Mid-pregnancy	25.87 (1.98)	25.91 (1.97)
	Post partum	8.91 (4.29)	8.67 (1.86)
Chronological age**		32.95 (5.51)	26.85 (5.13)

Note. *p*-values are associated with Fisher's exact tests for categorical variables or *t*-tests for continuous variables, as appropriate.
*$p < .05$, **$p < .01$.
[a] Two participants in the yoga group dropped out of the study after the first yoga session and demographic information is not available for these participants.

and 16.03 ($SD = 35.91$) minutes from the scheduled times of saliva collection, indicating good compliance. Among the 21 participants for whom these data were available in mid-pregnancy, MEMS cap openings occurred 33.05 ($SD = 60.35$) and 23.76 ($SD = 49.88$) minutes from the scheduled saliva collection times, confirming acceptable compliance.

During the 90-min interval between cortisol samplings in early and mid-pregnancy, approximately 75% of women reported not being physically active and 25% reported engaging in light activity. Both groups reported spending approximately 30 min completing study questionnaires and the remaining time watching television, talking on the phone, browsing the internet, or doing light housework.

2.3. Effects of prenatal yoga on cortisol and affect

2.3.1. Cortisol

Means and standard deviations for cortisol and affect across conditions and groups are reported in Table 2. Within the yoga group, cortisol levels were lower on yoga days relative to days of usual activity ($B = .28$, SE $= .10$, $p = .005$) and, as expected, were lower in early compared to mid-pregnancy ($B = .32$, SE $= .11$, $p = .003$). Cortisol levels decreased over the 90-min time interval ($B = -.29$, SE $= .10$, $p = .004$); however, there was no indication of a more pronounced decrease in cortisol in response to a yoga session relative to usual activity ($B = -.06$, SE $= .14$, *n.s.*).

Lower cortisol levels were also observed in the yoga relative to the control group in early pregnancy ($B = -.50$, SE $= .23$, $p = .029$). Cortisol levels did not change over time ($B = -.28$, SE $= .18$, *n.s.*) and no differences in trajectories were observed between groups ($B = -.01$, SE $= .20$, *n.s.*). Due to the small number of valid (i.e., uncontaminated, containing sufficient saliva) cortisol samples available for control group participants in mid-pregnancy ($n = 6$), differences in cortisol between yoga and control groups were not tested.

2.3.2. Positive affect

Positive affect increased over time ($B = 4.37$, SE $= 2.20$, $p = .047$); however, this increase was not different across yoga days and days of usual activity ($B = -4.59$, SE $= 3.11$, *n.s.*). Similar to the cortisol findings, positive affect was higher on yoga days relative to days of usual activity ($B = -9.17$, SE $= 2.20$, $p < .001$) and in early compared to mid-pregnancy ($B = -6.15$, SE $= 2.32$, $p = .008$). These main

Table 2
Comparison of affect and cortisol between conditions and groups (Mean ± SD).

	Yoga group ($n = 38$)[a]				Control group ($n = 12$)[a]	
	Yoga		Usual activity			
	Pre	Post	Pre	Post	Pre	Post
Cortisol (ng/mL)[b,c,d,e]						
Early Pregnancy[f]	.79 ± .98	.47 ± .55	1.25 ± 1.34	.77 ± 1.02	1.65 ± 1.62	1.46 ± 2.71
Mid-Pregnancy	1.66 ± 2.43	1.35 ± 2.20	1.66 ± 1.54	1.05 ± .78	–	–
Total Positive Affect[c,d,e,i]						
Early Pregnancy	59.66 ± 12.65	64.03 ± 15.28	50.49 ± 17.86	50.26 ± 16.79	53.75 ± 12.14	53.00 ± 10.51
Mid-Pregnancy[g]	54.28 ± 13.46	63.38 ± 12.88	52.32 ± 14.91	52.30 ± 14.63	50.50 ± 16.73	48.00 ± 15.61
Contentment[c,d,e,g,h]						
Early Pregnancy	16.53 ± 3.37	19.79 ± 3.30	14.49 ± 4.90	14.66 ± 4.44	15.50 ± 3.42	15.75 ± 2.56
Mid-Pregnancy	14.78 ± 4.04	19.50 ± 3.44	14.19 ± 4.38	14.83 ± 4.04	14.70 ± 4.14	14.50 ± 4.88
Total Negative Affect[c,g,h]						
Early Pregnancy	24.58 ± 5.87	20.74 ± 1.18	24.37 ± 5.41	23.03 ± 4.48	22.83 ± 5.25	22.75 ± 5.21
Mid-Pregnancy	23.84 ± 3.15	20.56 ± 1.11	24.58 ± 8.80	21.67 ± 2.80	26.10 ± 9.70	24.70 ± 7.85

Note. Sensitivity analyses were performed with and without extreme outlying values. No substantial differences were observed and results are therefore presented with extreme outliers included.
[a] In mid-pregnancy, Yoga Group $n = 32$, Control Group $n = 10$.
[b] Yoga group sample size for cortisol varies due to missing data ($n = 29$–38). Cortisol values for the control group are not reported due to limited sample size ($n = 6$).
[c] Significant main effect of time (pre, post).
[d] Significant main effect of GA (early, mid).
[e] Significant main effect of condition (yoga vs. usual activity).
[f] Significant main effect of group (yoga vs. control).
[g] Significant condition × time interaction.
[h] Significant group × time interaction.
[i] Significant condition × GA interaction.

effects were qualified by an interaction between condition and gestational age ($B = 7.65$, SE = 3.27, $p = .019$) such that the difference in overall positive affect between the two conditions was greater in early than mid-pregnancy. GEEs therefore were run separately by gestational age and revealed that positive affect was higher on yoga days relative to days of usual activity only in early pregnancy ($B = -9.17$, SE = 2.05, $p < .001$). Comparisons of yoga and control groups revealed no change in positive affect over time or across gestation, and no differences between groups (all *n.s.*).

GEEs were subsequently performed including only the contentment subscale (low-activation positive affect), for which the largest effects were hypothesized. Within the yoga group, contentment increased over time ($B = 3.26$, SE = .66, $p < .001$), was higher in early than mid-pregnancy ($B = -2.01$, SE = .70, $p = .004$), and was overall higher on yoga days compared to days of usual activity ($B = -2.04$, SE = .66, $p = .002$). As expected, contentment increased more in response to a yoga session relative to usual activity (condition × time interaction, $B = -3.09$, SE = .93, $p = .001$). Comparisons of yoga and control groups revealed no change in contentment over time or across gestation, and no group differences in overall contentment (all *n.s.*). However, contentment increased to a greater extent in the yoga relative to the control group (condition × time interaction, $B = 3.01$, SE = 1.31, $p = .021$).

2.3.3. Negative affect

Negative affect decreased more in response to a yoga session relative to usual activity (condition × time interaction, $B = .04$, SE = .02, $p = .035$); however, a main effect of condition was not detected ($B = -.004$, SE = .01, *n.s.*). Between-subject comparisons suggested a similar pattern with negative affect decreasing more in the yoga compared to the control group ($B = -.06$, SE = .02, $p = .007$). Main effects of group and gestational age and their interaction were not detected (all *n.s.*).

2.4. Perinatal depressive symptoms

As shown in Table 3, women in the yoga group reported fewer depressive symptoms than women in the control group in the postpartum period, after adjusting for APD symptoms in early [$F(1, 32) = 5.20$, $p = .030$, partial $\eta^2 = .14$] or mid-pregnancy [$F(1, 31) = 5.89$, $p = .021$, partial $\eta^2 = .16$]. In contrast, differences in APD symptoms between groups were not detected at either gestational age.

Exploratory one-way ANOVAs and Pearson correlations indicated that depressive symptoms were not dependent on sociodemographic characteristics (all *n.s.*) and *t*-tests indicated that APD symptoms were not dependent on frequency of yoga practice (all *n.s.*). However, women who practiced yoga twice a week or more in the weeks prior to the first assessment reported fewer PPD symptoms ($M = 2.13$, $SD = 1.55$) than women who practiced yoga once a week or less ($M = 4.72$, $SD = 2.72$; $t(24) = 2.51$, $p < .05$).

No significant associations among cortisol and affect with APD symptoms were found. Neither positive nor negative affect were significantly associated with PPD symptoms. The change in cortisol over time on yoga days and average cortisol levels on days of usual activity in mid-pregnancy were significantly and positively associated with PPD symptoms (Table 4). However, when all cortisol summary measures in mid-pregnancy were simultaneously included in a regression model, none emerged as significant predictors of PPD symptoms (all *n.s.*), suggesting that cortisol did not explain the presence of PPD symptoms.

Table 3
Depressive symptoms by gestational age.

Outcome variable	Yoga group			Control group		
	n	*M*	*SD*	*n*	*M*	*SD*
Early pregnancy	38	5.29	3.14	13	4.54	3.43
Mid-pregnancy	31	5.87	3.52	10	5.00	3.62
Post partum*	26	3.92	2.68	8	6.63	2.83

*$p < .05$.

3. Discussion

The present study examined whether women practicing yoga during pregnancy would show acute health benefits reflected in more adaptive cortisol and affective responses to a single 90-min yoga session, and longer-term benefits as reflected by reduced perinatal depressive symptoms. Findings in part support these hypotheses. Women who practiced yoga during pregnancy showed lower mean cortisol levels and higher positive affect on days of yoga practice relative to days of usual activity, greater immediate improvements in contentment and negative affect but not cortisol in response to yoga relative to a usual activity comparison condition and to a control group, and fewer PPD symptoms but not APD symptoms relative to a control group. These findings build on a small but growing body of research suggesting that yoga may confer psychophysiological benefits during pregnancy, and highlight the potential importance of prenatal yoga for postpartum well-being.

The first aim of this study was to investigate the immediate effects of a prenatal yoga session on changes in cortisol and affect. Greater improvements in response to a yoga session than to a usual activity comparison condition and a control group were not detected for cortisol; however, average cortisol levels were lower on days that participants engaged in a yoga session compared to days of usual activity. Overall lower cortisol levels on yoga days may reflect women's expectation of a relaxing, beneficial activity. These expectations may have led to anticipatory reductions in cortisol before the start of the yoga session, thereby reducing the potential of improvement in response to the yoga session itself. In line with this argument, a previous study of pregnant women indicated that the simple instruction to reduce stressors and increase relaxation on the following day was associated with significantly decreased cortisol levels 45 min after awakening [61].

As predicted, greater improvements in negative affect and contentment in response to a yoga session relative to both a comparison condition and a control group were observed. Differences in change in positive affect were not observed; however, positive affect was higher on days that yoga participants engaged in a yoga session compared to days of usual activity. These findings corroborate previous studies showing significant decreases in acute negative affect in response to a yoga session [36,62] and suggest that yoga can buffer against negative affect, perhaps by decreasing rumination and changing affective appraisals of and coping with stress [63]. Congruent with the essence of yoga – to focus the mind and cultivate unity of the body and mind – these findings also suggest that Hatha yoga may confer immediate advantage for low- (e.g., contentment) rather than high-activation positive affect. Similar to the findings for cortisol, overall higher positive affect on yoga days but no evidence of greater increases in positive affect in response to a yoga session also may reflect women's expectations and associated anticipatory increases in positive affect before the start of the yoga session.

The second aim was to investigate the effects of prenatal yoga practice on APD and PPD symptoms. Our data suggest that regular yoga practice during pregnancy, while not associated with concurrent depressive symptoms, is, in fact, associated with fewer PPD symptoms experienced several months later. This finding is in line

Table 4
Correlations between PPD symptoms and cortisol and affect average and change scores.

	Early pregnancy			Mid-pregnancy		
	Cortisol	Affect		Cortisol	Affect	
		Positive (Total/Contentment)	Negative		Positive (Total/Contentment)	Negative
Avg yoga	.12	.03/.17	−.11	−.18	−.03/.05	−.10
Diff yoga	−.05	.24/.30	.00	.43*	.12/.16	−.05
Avg usual activity	.10	−.13/−.15	.13	.47*	−.06/−.03	.17
Diff usual activity	.26	−.12/.21	−.23	−.03	.02/.13	−.21

Note. Avg = average of pre- and post-values; Diff = post value − pre value.
*$p < .05$.

with other prospective reports that suggest yoga-related improvements in depressive symptoms [64] and rumination [65] with time in non-pregnant individuals, and has important implications for the timing of interventions because it suggests that prenatal interventions may yield postpartum benefits. The lack of group differences in APD symptoms is inconsistent with several recent reports of greater reductions in APD symptoms in yoga relative to control groups [53,54,56] in women who were either clinically depressed or at high risk for developing perinatal depression. Our study sample involved women with no self-reported depressive and/or anxiety disorder diagnosis at study onset. As such, it may be that differences in APD symptoms between groups are less pronounced among non-clinically depressed women. We did not assess postpartum yoga practice and, therefore, cannot comment on whether similar improvements in PPD symptoms can be achieved with yoga practice in the postpartum period. In sum, this pattern of findings suggests that the effects of yoga practice during pregnancy may not be immediate, but develop over the course of pregnancy and post partum.

Lastly, we did not find evidence for an association of PPD symptoms with cortisol and affect. It is possible that the relatively narrow range of depressive symptoms exhibited by participants in our study could have weakened the associations of cortisol and affect with PPD symptoms. Furthermore, it may be that other physiological or psychosocial factors are responsible for the antidepressant effects of yoga. Recent studies have proposed autonomic responses to stress, social support, pregnancy mindfulness, and mother-infant attachment as underlying mechanisms of the beneficial impact of yoga on depressive symptoms [55,63].

The present study improved on methodological limitations of previous studies by employing both within- and between-subject controls and both psychological and physiological outcome measures. Nevertheless, certain limitations should be noted. The main limitation is the potential presence of selection bias as yoga group participants were recruited among pregnant women already enrolled in prenatal yoga classes. Yoga group participants differed sociodemographically from control group participants, which poses a threat to the internal validity of the findings and impacts the ability to generalize findings to the broader population of pregnant women. These sociodemographic group differences, however, also point to the lower availability, affordability, and/or appeal of yoga to pregnant women of lower SES, and thus highlight the need for prenatal yoga programs targeted toward diverse populations. An additional limitation is the small sample size of the study, and of the control group in particular, which may have limited the statistical power to detect meaningful differences between yoga and control groups and did not allow for adjustment of baseline sociodemographic differences between them. Of importance, that differences in APD symptoms between groups were not observed suggests that group differences in PPD symptoms can tentatively be interpreted in favor of intervention effects. Future randomized controlled trials with larger, more diverse samples and other mind-body comparison intervention programs are needed to corroborate the findings of the present study.

In summary, the present study provides preliminary evidence for immediate benefits of yoga on negative affect and on feelings of contentment, as well as overall benefits on cortisol and positive affect during pregnancy. Moreover, the more favorable PPD symptom outcomes in yoga relative to control group participants are promising and suggest that Hatha yoga may have the potential to improve maternal postpartum well-being.

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Conflict of interest statement

The authors have no competing interests to report. In the interest of full disclosure, Linda Trumpfheller is a yoga instructor at YogaWorks and Holly Beck Kimble is a yoga instructor at and Diana Pipaloff owner of Yoga Shakti, the sites of data collection in the present study.

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