

# Prenatal Yoga for Back Pain, Balance, and Maternal Wellness: A Randomized, Controlled Pilot Study

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## Abstract

**Background:** The objective was to assess the feasibility of a prenatal yoga randomized controlled trial (RCT) for gestational low back pain (LBP), mobility, and maternal well-being.

**Methods:** In this pilot, women aged 18 to 39 years with uncomplicated pregnancies at 12 to 26 weeks were randomized, stratified by presence of LBP, to attend a weekly yoga class or a time-matched educational support group for 12 weeks. Sample size was based on anticipated enrollment of 2 subjects per month. Primary outcomes were measures of feasibility and acceptability. Secondary outcomes included LBP disability, pregnancy symptom burden, childbirth self-efficacy, instrumented gait, balance, and falls at baseline, every 4 weeks, and 6 weeks postpartum.

**Results:** From April 2015 to December 2015, 168 women were contacted and 115 (68%) were eligible. Twenty women enrolled (N = 11 yoga; N = 9 control; mean gestational age 20.2 weeks). Retention at 12 weeks was 81% in yoga and 77% in control. There were no yoga-related adverse events. Exploratory analyses show no differences in back pain disability between groups. Significant groups effects were found on biomechanical assessments, including percentage change in gait speed ( $F = 4.4$ ,  $P = .04$ ), double support time ( $F = 23.6$ ,  $P < .01$ ), instrumented timed-up-and-go ( $F = 8.6$ ,  $P < .01$ ), and turn time ( $F = 5.7$ ,  $P = .02$ ) suggesting clinically relevant improvements with yoga. Pregnancy Symptom Inventory (PSI) scores improved (13.1 point difference, 95% confidence interval, 5.1–21.1) at 12 weeks in yoga compared to control, adjusted for baseline gestational age.

**Conclusion:** Conducting an RCT of prenatal yoga to improve gestational LBP and maternal well-being is feasible and safe. While no differences in back pain were observed, biomechanical measures were sensitive assessments for evaluating gestational LBP-related mobility impairment and showed group differences. Additionally, the PSI showed significant differences in symptom burden over 12 weeks, supporting the ongoing claims that yoga improves a pregnant woman's overall well-being.

## Keywords

yoga, pregnancy, falls, symptom burden, well-being

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## Introduction

Pregnancy-related back pain is a significant health problem affecting a large majority of women in the world.<sup>1</sup> Gestational low back pain (LBP) is likely caused by physiologic changes during pregnancy, including maternal weight gain, spinal lordosis, decreased abdominal muscle strength, changed center of mass, and relaxin-mediated joint laxity.<sup>2–4</sup> These increase shear forces across the joints of the lower back and pelvis, increasing the risk of LBP and falls during pregnancy.<sup>5</sup>

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In observational cohort studies, gestational LBP is associated with insomnia, impaired daily activity, loss of work, depression, pain medication use, and chronic recurrent back pain.<sup>6–9</sup> Some of these effects extend through childbirth and into motherhood.<sup>10</sup> Despite the high incidence of gestational LBP and the associated morbidity, treatments are limited and often not offered.<sup>11</sup>

As pregnancy progresses, the risk of falling increases with estimated rates of falls being 27%, similar to the rate of women who are older than 70 years.<sup>12</sup> Physical activity is a promising intervention for preventing falls and gestational LBP that may be associated with additional benefits including self-confidence and overall self-efficacy.<sup>13–15</sup>

Overarching the spectrum of gestational morbidity are psychosocial factors that independently impact maternal–fetal outcomes. Pregnancy-related depression and stress are associated with prematurity,<sup>16,17</sup> low birth rate,<sup>18,19</sup> and postpartum depression. Efforts to improve individual psychosocial factors include exercise,<sup>14</sup> mind–body interventions,<sup>20</sup> and group visits<sup>21</sup> using validated pregnancy-specific scales, which measure elements of maternal well-being such as depression, anxiety, and childbirth self-efficacy.

Yoga is a novel multimodal intervention that incorporates physical exercises such as stretching, core strengthening, and balance training, with the cultivation of mindfulness, acceptance, and self-compassion. International reviews suggest prenatal yoga's benefit for LBP, stress, quality of life, depression, anxiety, labor pain, and delivery duration.<sup>22–27</sup> In the United States, an estimated 13% of pregnant women practice yoga.<sup>28</sup> However, rigorous prospective feasibility, safety, and efficacy data are limited. In the nonpregnant patient population, U.S. studies suggest that yoga is an effective intervention for back pain and overall well-being.<sup>29</sup> Yoga may also improve gait, postural stability, and flexibility.<sup>30</sup>

We conducted a pilot randomized controlled trial (RCT) to primarily assess feasibility, safety, and acceptability of a 12-week prenatal yoga intervention in patients from an urban academic medical center in the United States. Secondarily, we sought to preliminarily assess the effect of yoga on pain-related disability, maternal well-being, and biomechanical measures in order to estimate measures that may be sensitive to change and variability over time to inform the design of future trials.

## Materials and Methods

This study was a prospective, randomized controlled pilot clinical trial of women aged 18 to 39 years with uncomplicated pregnancies that was funded by the externally reviewed Osher Pilot Research Award. Subjects were recruited from the Obstetrics and Gynecology clinic at

Beth Israel Deaconess Medical Center (BIDMC) during April 2015 to December 2015. We included pregnant women between 12 and 26 weeks of gestation with and without back pain who had no regular yoga practice. We excluded those who had significant back pathology (eg, spinal stenosis, fracture history, pain that required prescription medications), attended more than 10 yoga classes within the previous 3 months, had pregnancy complications (eg, uncontrolled hypertension, uncontrolled diabetes, placenta previa, twin gestations, advanced maternal age), or were non-English speakers. BIDMC's human subjects review board approved the study. All participants provided written informed consent for participation in the study.

Subjects were randomized (1:1) to a prenatal yoga program or an educational attention control immediately following consent and the baseline interview using a computer-generated random numbers. Randomization was stratified by presence of back pain and enrollment was done on a rolling basis.

Subjects assigned to the intervention attended a weekly, 1-hour prenatal yoga class. To isolate the impact of yoga from that of group support, those assigned to the control group attended a weekly educational support group. Classes were offered at 3 different times during the week. Subjects assigned to either yoga or control group were expected to attend their respective intervention once per week for at least 12 weeks. Those in the yoga arm were allowed and encouraged to continue attending through the end of their pregnancy.

## Intervention Development

The yoga intervention (Appendix 1) was developed through a modified Delphi process, including individual consultations and group discussion with an expert consensus panel of prenatal yoga teachers, mind–body experts and researchers, and clinicians with specialized training in obstetrical care and midwifery. The goals of the intervention explicitly included (1) the intention to be gentle with oneself; (2) the traditional elements of a comprehensive yoga class: relaxation, breathing exercises, mindfulness, and active poses; and (3) select poses, which could prevent or attenuate back pain and improve balance. For variety and to include multiple recommended poses, 2 classes that had similar overall structures, but different specific asanas were taught on alternating weeks. The pranayama practices included in this intervention were 2-part yogic breathing and alternate nostril breathing. Asanas included were child's pose, table pose, cat/cow, downward dog, mountain, chair, goddess, triangle, warrior 2, and bound angle. Two certified prenatal yoga teachers each with at least 4 years of yoga teaching experience were trained by the principal investigator in the study-specific class. Classes were offered in a yoga studio within walking distance

from BIDMC. Daily home practice was encouraged and facilitated with an illustrated manual. Participants were also supplied with a yoga mat and block.

### Control Group

Control subjects attended a 12-week educational support group led by an experienced health-care group facilitator from the local community who was trained by the study's staff. A 12-subject curriculum was developed based on publicly available patient educational materials offered by the American College of Obstetricians and Gynecologists (ACOG)<sup>31</sup> and the American College of Nurse-Midwives (ACNM).<sup>32</sup> The curriculum included the following pregnancy-related topics: self-care, nutrition, weight gain, exercise, vaccines, medications, screening tests, common symptoms, postpartum preparations, labor, breast feeding, and birth control. No exercises, meditation, or mindfulness practices were incorporated into the control group's educational curriculum. Participants in both intervention and control groups received written materials based on the extracted ACOG and ACNM curriculum.

### Assessments

*Feasibility, acceptability, and safety.* We tracked rate of recruitment into the study, including how many were screened, those who were interested, those who enrolled, and average number enrolled per month. Intervention and control group acceptability was assessed through attendance at classes and through a semistructured, postpartum qualitative exit interview. Overall study adherence was assessed through compliance with the assessment protocol (number of study visits completed). We systematically tracked adverse events at each weekly class and at each monthly study visit. Additionally, chart reviews of routine prenatal visits were conducted at monthly study visits to identify any unreported events.

*Clinical symptoms and psychosocial outcomes.* The primary outcome of interest was back pain-related disability as measured by the Roland Morris Disability Questionnaire (RMDQ).<sup>33</sup> Secondary outcomes included a visual analogue scale that measured back pain severity (0 = no pain, 10 = worst pain ever). The 41-item Pregnancy Symptom Inventory (PSI) tracked overall functional burden and common symptoms such as urinary symptoms, fatigue, dizziness, sleep disturbance, leg, and back pain.<sup>34</sup> The Edinburgh Postnatal Depression Scale (EDPS), which is also validated for prenatal depression screening,<sup>35</sup> was used to assess depression. Quality of life was tracked with the Short Form 12 questionnaire (SF12).<sup>36</sup> The stress subscale of the prenatal psychosocial profile was used to track

pregnancy-related stress.<sup>37</sup> The Childbirth Self Efficacy Inventory<sup>38</sup> was used to quantify maternal confidence toward childbirth.

*Postnatal outcomes.* Maternal satisfaction with labor and childbirth was measured with the Childbirth Experience Questionnaire.<sup>39</sup> Routine perinatal obstetrical measurement such as gestational age, weight gain, and pregnancy complications were tracked as well as common postnatal outcomes (ie, gestational age at birth, method of delivery, anesthesia use, duration of labor, birth weight, APGARs, and breastfeeding).

*Mobility and biomechanics.* Mobility was assessed through a series of tests conducted with the ADPM Mobility Lab System. While wearing wireless 3-dimensional biosensors strapped around their wrists, ankles, sternum and lower back, subjects completed 2 rounds of 3 mobility tests: the instrumented timed-up-and-go test (iTUG), a 30-second standing sway test (iSway), and a 90-second walk test (iWalk). The iTUG consists of standing from a chair, walking to a cone placed 7 m in front of the chair, turning, returning to the chair, and resuming a seated position. The iSway consists of standing still for 30 seconds. The iWalk consists of walking continuously for 90 seconds. From these tests, results of 2 trials were averaged to obtain individual measures of gait speed, double support time (proportion of time during iWalk spent with both feet on the ground), total iTUG time, and the amount of time to complete a turn. Fear of falling was assessed through the Falls Efficacy Scale International.<sup>40</sup>

Testing visits for both groups, which included surveys and mobility testing, occurred at baseline, then every 4 weeks until delivery. A final study visit that included a semistructured qualitative exit interview occurred at 6-week postpartum. All visits were conducted at BIDMC's Clinical Research Center. For subject convenience, study visits were scheduled to coincide with the subject's routine pre- and postnatal visits when possible. Subjects received \$25 for each study-testing visit.

### Statistical Analysis

For feasibility measures, we used descriptive statistics to assess the overall recruitment rate, attendance at classes, and study adherence. Our goals were to achieve >70% attendance in both yoga intervention and education control groups as well as retain >70% of subjects at completion of the 12-week assessment. Our sample size was determined based on practical considerations and anticipated enrollment rate of about 2 subjects per month over 9 months of enrollment. Analyses were performed on an intention-to-treat basis.

For the patient-reported outcomes, a linear mixed effects model with an autoregressive correlation structure was used to calculate the difference between groups in average change scores from baseline as well as differences in the percentage change from baseline scores. A repeated measures analysis that assumed a linear effect was conducted using weeks of intervention as a categorical variable and adjusted for the subject's gestational age. The estimated effects of between-group differences were calculated at 8 and 12 weeks of intervention to further inform selection of outcomes that are potentially sensitive to yoga in this population. Change in back pain-related disability (RMDQ) was defined, a priori, as the clinical outcome measure of primary interest.

For the biomechanical outcomes, we calculated the percentage change of sway speed and area, gait speed, double support time, iTUG time, and turn time from baseline to

each subsequent visit. The effects of group, follow-up visit, and their interaction on each outcome were calculated using repeated measures analysis of covariance models adjusted for the gestational age and body mass.

The continuous postnatal measures were compared using a 2-tailed Student's *t* test. The categorical postnatal measurements were compared using a Fisher's Exact test.

## Results

### Feasibility and Acceptability

Of the 681 screened subjects, 168 subjects were contacted and 115 (68%) were interested and eligible. Among those interested and eligible, the most common reason for not enrolling was class scheduling (73%). Twenty subjects

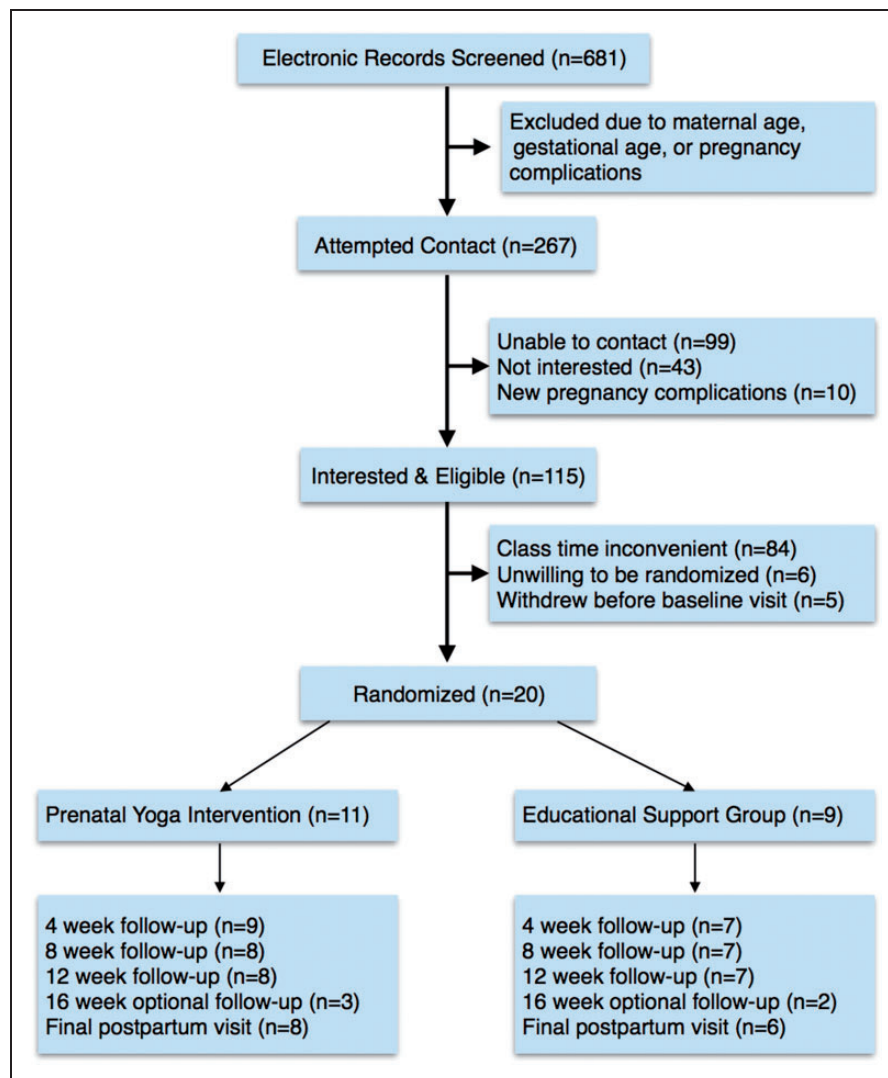


Figure 1. CONSORT Flow Diagram.

(17.3%) were willing to be randomized and able to commit to the available class times. Subject recruitment rate was 2.2 subjects per month during the 9 months of active recruitment. Figure 1 shows the CONSORT flow diagram for recruitment and randomization, 11 to yoga and 9 to educational support.

Average class attendance rates were 74% in the yoga group and 90% in the control group. Subject retention rates at the completion of the 12-week intervention were 81% in the yoga group and 77% in the control group. We were only able to assess 14 (70%) at the postpartum visit and one did not have a qualitative exit interview. Patients in the yoga (N=7) and control (N=6) groups both reported positive feedback for their respective study interventions. All in the yoga group would recommend yoga to a pregnant friend.

Intervention fidelity was excellent. There were no issues identified with respect to instructors deviating from the stated protocol.

## Safety

No adverse events occurred during the yoga classes or educational support groups. In the yoga group, there was a case of maternal thrombocytopenia and placental abruption during labor. In the educational control group, there was a case of cholestasis with elevated liver enzymes, one subject with kidney stones, and one with shoulder dystocia. None of these routine complications of pregnancy or childbirth were directly related to the yoga classes, educational support group meetings, or the data collection.

## Exploratory Analyses

Table 1 presents the baseline characteristics of the 20 subjects who were enrolled. Mean gestational age was 20.2 weeks, and average maternal age was 31.4 years. Treatment groups were similar in race, insurance status, recorded health conditions, gravidity, and

**Table 1.** Baseline Characteristics of Participants.

	Mean $\pm$ SD or Number (%)			P
	Total n = 20	Yoga n = 11	Education n = 9	
<i>Sociodemographics</i>				
Average age	31.4 $\pm$ 4.7	29.6 $\pm$ 5.1	33.4 $\pm$ 3.5	.07
Race				.37
White	13 (65)	6 (55)	7 (77)	
Black	2 (10)	2 (18)	0	
Hispanic	3 (15)	1 (11)	2 (22)	
Other	2 (10)	2 (18)	0	
Insurance				.64
Private	14 (70)	7 (64)	7 (78)	
Public/Government	4 (20)	3 (28)	1 (14)	
Other	2 (10)	1 (11)	1 (14)	
<i>Clinical factors</i>				
<i>Comorbidities</i>				
Anxiety	1 (5)	1 (11)	0	.64
Asthma	1 (5)	1 (11)	0	
Autoimmune conditions	1 (5)	1 (11)	1 (14)	
Depression	2 (10)	1 (11)	1 (14)	
Hypertension	0	0	0	
Cardiac disease	0	0	0	
Seizure disorders	0	0	0	
Psychiatric conditions	0	0	0	
<i>Obstetrical</i>				
Gravidity average	2 $\pm$ 1.3	1.73 $\pm$ 0.8	2.33 $\pm$ 1.7	.29
Parity average	0.5 $\pm$ 0.7	0.55 $\pm$ 0.7	0.44 $\pm$ 0.7	.75
Gestational age average weeks	19.8 $\pm$ 4.4	20.8 $\pm$ 4.5	18.6 $\pm$ 4.2	.26
<i>Current low back pain?</i>				
No, not at all	7 (35)	4 (36)	3 (33)	1
Rarely, some or most of the time	13 (65)	7 (64)	6 (66)	
Average RMDQ score	2.5	3.2	1.9	.5

Abbreviations: RMDQ, Roland Morris Disability Questionnaire; SD, standard deviation.

parity, although those in the education group tended to be older. Groups were also similar in back pain history and current back pain symptoms. The baseline prevalence of back pain for all the subjects was 65%, with a mean RMDQ score of 2.5 (range 0–14).

**Table 2.** Effect Estimates of Between-Group Differences at 8 and 12 Weeks.

	Effect at 8 weeks			Effect at 12 weeks		
	Estimate	SE	$P >  t $	Estimate	SE	$P >  t $
<b>Physical</b>						
RMDQ	0.004	1.98	0.99	0.82	1.98	0.68
Back pain VAS	-1.4	1	0.19	0.77	1	0.46
PSI	9.0	4.0	0.03	13.1	4.1	0.0025
<b>Psychosocial</b>						
Depression	0.3	1.3	0.83	2.3	1.3	0.07
PPP	-1.5	0.93	0.12	0.19	0.93	0.84
SF12-physical	1	4.2	0.81	-1.5	4.24	0.72
SF12-mental	0.9	3.6	0.81	-2.65	3.6	0.47
CBSE	8.0	8.7	0.37	10.7	8.9	0.23

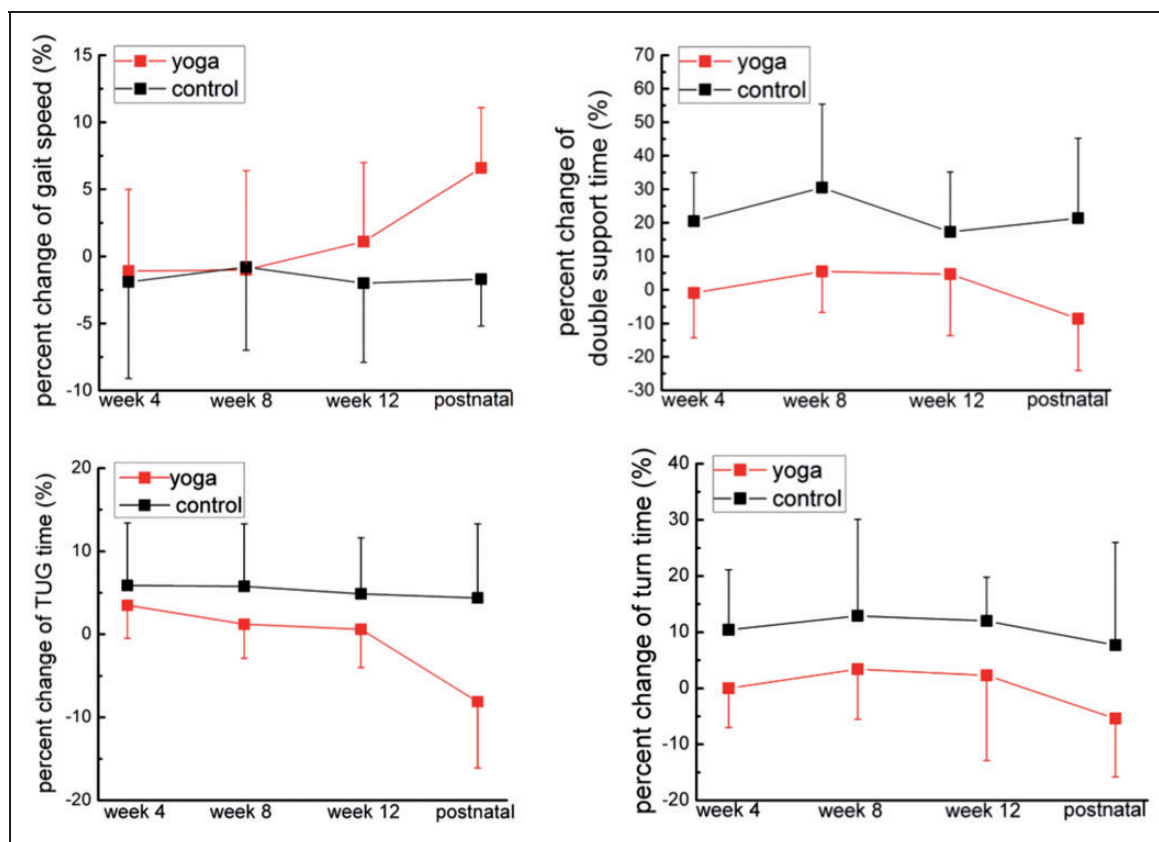
Abbreviations: CBSE, Childbirth Self Efficacy Scale; PPP, Prenatal Psychosocial Profile; PSI, Pregnancy Symptom Inventory; RMDQ, Roland Morris Disability Questionnaire due to back pain; SE, standard error; SF12, Short Form 12; VAS, Visual Analogue Scale.

## Clinical Symptoms and Psychosocial Measures

The effect estimates of the between-group differences for the patient-reported symptoms and psychosocial measures are shown in Table 2. After adjusting for baseline gestational age, women randomized to the prenatal yoga class reported a greater improvement in the PSI at 8 and 12 weeks of intervention compared to control (change of 9 points, 95% confidence interval [CI], 0–17.0,  $P < .03$  and 13.1 points, 95% CI, 5.1–21.1,  $P < .0025$ , respectively). No other significant differences were noted in the reported symptoms or psychosocial measures.

## Mobility Measures

After adjusting for gestational age and body mass, there was a significant longitudinal difference between groups in the percentage change in mobility from baseline through 4-, 6-, 8-, and 12-week postnatal visits (Figure 2). Specifically, there was a higher percentage increase in gait speed in the yoga group compared to the control group (main effect of group,  $F = 4.4$ ,  $P = .04$ ). Main effects of group were also for the percentage change of double support time ( $F = 23.6$ ,  $P < .0001$ ), iTUG completion time ( $F = 8.6$ ,  $P < .001$ ), and 180° turn time



**Figure 2.** Gait Analyses. TUG, timed-up-and-go.

( $F = 5.7$ ,  $P = .02$ ). For each of these outcomes, percentage changes were higher (reflecting worse performance) in the control group as compared to the yoga group. No effects of visit, or group by visit interactions, were observed for any outcome. Both groups increased their fear of falling, while no difference was found between groups ( $P = .5$ , standard error = 1.5).

### Postnatal Outcomes

At birth, no differences were found in average gestational age, maternal weight gain and the time spent in the first stage of labor. However, a clinically significant lower amount of time was spent in the second stage of labor for the women who participated in the yoga intervention (95% CI, 19.0–179.2,  $P = .01$ ). When asked about their childbirth experience, the yoga participants felt more confident in their own capacity (95% CI, 1.2–9.6,  $P = .01$ ) and perceived a greater sense of safety (95% CI, 0.3–4.8,  $P = .01$ ). This is shown in Table 3.

**Table 3.** Postnatal Outcomes.

	All n = 20	Yoga n = 11	Education n = 9	P
Average gestational age (weeks)	39.5	39.9	39.1	.20
Average weight gain (pounds)	21.6	23.5	19.6	.34
Type of delivery				1
Spontaneous vaginal	15	8	7	
Scheduled C-section	3	2	1	
Urgent/emergent C-section	2	1	1	
Anesthesia used				.19
None/natural	1	0	1	
Spinal/epidural	18	11	7	
General	1	1	0	
Average labor times (min)				
Stage 1	516.9	515.0	518.7	.99
Stage 2	87.2	37.5	136.8	.01
Stage 3	7.4	5.3	9.6	.21
Birth weight (g)	3412	3273	3550	.11
Average Apgar scores				
1 min	7.2	7.7	6.6	.21
5 min	8.7	8.9	8.5	.40
Feeding				1
Exclusively breast milk	11	6	5	
Some breast and formula	8	4	4	
Exclusively formula	1	1	0	
Childbirth Experience Questionnaire				
Own capacity	20.9	23.6	18.2	.01
Professional support	20.7	17.8	17.8	.90
Perceived safety	19.1	20.4	18.0	.01
Participation	14.6	8.9	8.2	.68

## Discussion

### Main Findings

This pilot RCT of prenatal yoga for gestational LBP and maternal well-being is feasible, safe, and acceptable. We successfully developed, implemented, and tested a tailored, gentle prenatal yoga program to target back health in pregnancy. The relatively high rates of class attendance, overall subject retention, and qualitative feedback in both groups favorably support study acceptability. Specifically for the yoga intervention, the majority of subjects found the program helpful or very helpful and would recommend the program to a pregnant friend.

While there was no detected difference in back pain disability as measured by the RMDQ, our exploratory analyses detected clinical differences between the groups in several other measures. A lower burden of overall pregnancy symptoms was found as well as a trend toward improvement in depression scores in the yoga group compared to education. There were also important and provocative biomechanical improvements seen with yoga including gait speed, double support time, and iTUG time.

### Strengths and Limitations

As a small, pilot trial, this study has several limitations. Recruited subjects were mostly white and had private insurance, limiting the generalizability of our findings. There was some imbalance, although not significant, in mean maternal age at baseline that may have affected results. By necessity, participants were unblinded to treatment assignment, thereby possibly increasing the therapeutic influence of expectation. Also, due to limited resources, the research staff members conducting the testing visits were not always blinded to the subject's randomization assignment. Despite the limitations of a small pilot, this study provides valuable information regarding the feasibility and safety of studying prenatal yoga for pregnancy-related back pain, mobility, and overall well-being. Importantly, it is the first study to show changes in sensitive measures of biomechanical measures and gait with yoga, which may be protective in pregnancy. Future investigations could consider active controls such as physical therapy and a longer term follow-up.

### Interpretation

While our recruitment rate was greater than anticipated, many potential participants could not attend due to the limited availability of classes. Offering a greater flexibility in class times or utilizing technologies that promote

home practice could improve accessibility for a larger study with this population.

We note that perhaps the RMDQ was not a straightforward measure of gestational LBP. Questions such as “Because of your back pain, do you have difficulty sleeping at night?” were often met with confusion, as subjects routinely stated their disabilities were due to being pregnant in general. Even if they had back pain, simply being pregnant was the more common reason why the participants needed a railing to get upstairs or had more difficulty putting on their stockings. Future investigations may consider alternative instruments such as the Pregnancy Mobility Index, a validated self-report questionnaire developed by Van de Pol that has been used with pregnant women to evaluate mobility and quality of life in relation to LBP.<sup>41</sup>

Our findings of an improvement in overall burden of pregnancy-related symptoms, as measured by the PSI, suggest that prenatal yoga may impact the general well-being of expecting mothers and that the PSI is sensitive to change with yoga. This finding and the trend toward improvement in the depression scale (EDPS) parallel the literature on yoga in the general and pregnant populations in helping mood, anxiety, depression, and quality of life.<sup>22,42</sup>

The changes in biomechanics during pregnancy has been described by Branco et al.<sup>43</sup> and suggest that decreases in gait speed and increases in double support time in a pregnant woman’s stride are mechanisms to help avoid falls as center of gravity dramatically shifts during pregnancy. These changes may also be involved in back pain-related kinesiophobia. To our knowledge, our study is the first report of an intervention that may favorably alter the trajectory of this change. The improvements seen in the yoga group, including improvements in iTUG time and turn time, suggest that women were more confident with walking and perhaps less likely to fall. Since some reports suggest falls are the second leading cause of emergency room visits and the reason for up to 30% of all hospital admissions during pregnancy,<sup>12,44</sup> future studies could evaluate the potential cost savings if yoga was offered to a larger pregnant population.

While both groups of women had similar gestational ages at birth, total birth times, APGAR scores, and birth weights, the difference in the second stage of labor time suggests that the woman in the yoga group spent less time in the active pushing stage of childbirth. Jahdi et al. reported similar outcomes in a prenatal yoga trial conducted in Iran.<sup>45</sup> One possible explanation for this difference is that Kegel exercises were specifically included in the asanas of the prenatal

yoga class, which may have contributed to a more efficient labor. The improved feeling of one’s own capacity and perceived sense of safety in the yoga groups also reflect a mother’s overall confidence and well-being. One of the often cited and possible mechanisms of mindfulness practices inherent in yoga may be an increase in self-efficacy and decrease in emotional reactivity.

We did not find any safety issues with our yoga approach, as participants were encouraged to listen to their bodies, modify poses as needed, and be gentle with oneself. When our trial initially began, yoga was not yet a recommended exercise activity during pregnancy per the ACOG guidelines.<sup>46</sup> Since completion of the trial, ACOG updated the practice guidelines, which now include yoga as a recommended general exercise during pregnancy.<sup>47</sup> One caution is that this study did not specifically investigate “hot yoga” classes, where a vigorous series of postures are practiced in studios where the temperature is turned to temperatures over 90°F. Since heat-inducing environments such as hot tubs and spas are associated with adverse birth outcomes,<sup>48</sup> no inferences about the safety of vigorous hot yoga styles can be made with this study’s results. Even though Polis et al. reported the relative safety of 26 different common yoga postures on acute maternal and fetal physiological outcomes,<sup>49</sup> a theoretical risk of injury during yoga practice still exists.<sup>50</sup> We therefore strongly emphasize that participants should have access to trained, experienced instructors who understand the importance of a gentle, modified approach.

## Conclusion

Based on the observed recruitment, adherence, and acceptability, a prenatal yoga intervention to improve gestational LBP and maternal well-being appears feasible and safe. In preliminary analyses, our ability to detect clinically and statistically significant differences between groups in several measures informs the design and outcome selection of future yoga trials in this population. This analysis supports the possible benefit of prenatal yoga in reducing the overall symptom burden of pregnancy and improving the stability of a pregnant woman’s stride. Further study of prenatal yoga utilizing a larger adequately powered RCT is warranted.

## Précis

A pilot prenatal yoga randomized controlled trial is feasible, safe, and may improve maternal mobility and well-being.



## Appendix I: Prenatal Yoga Class Schedule

Week A	Week B	Minutes
Sitting (Sukhasana) and centering with Dirga Pranayama Body scan Ohm, welcome, check-in, weekly topic introduction	Intention setting	0–15
Table (Goasana) Child's pose (Balasana) Cat inhale/exhale (Marjaryasana/Bitilasana) Hip circles (with Goasana) Bird dog (Dandayamna Bharmanasana) Downward dog (Adho Mukha Svanasana) Tip toe mountain (Tadasana)	Arm circles (with Goasana) Thread the needle (Parsva Balasana) Downward dog (Adho Mukha Svanasana)	15–25
Modified sun salutations (Surya Namaskara) Chair (Utkatasana) Goddess (Utkata Konasana) Wide forward bend (Upavistha Konasana)	Warrior 2 (Virabhadrasana II) Triangle (Trikonasana) 1/2 moon (Ardha Chandrasana)	25–35
Squat with kegel (Malasana) 1 leg forward bend (Janu Sirsasana)	Half straddle (Janu Sirsasana) Bound angle (Baddha Konasana)	35–45
Savasana with guided progressive relaxation Pranayama (Nadi Shodhana or Dirga) Body scan	Intention meditation Ohm-mantra	45–60

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### Authors' Contribution

SCH, CZ, and GYY contributed to the development of interventions. SCH secured funding and led the project implementation with GYY's guidance. RBD assisted with the statistical analysis. BM and JZ assisted with the biomechanical assessments and analysis. All authors have contributed to, reviewed, and approved final draft.

### Ethics Approval

The study was approved by Beth Israel Deaconess Medical Center's human subjects review board (February 2015 IRB Protocol# 2014P000344).

### Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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### References

1. Gutke A, Boissonnault J, Brook G, Stuge B. The severity and impact of pelvic girdle pain and low-back pain in pregnancy: a multinational study. *J Women Health*. 2017;27(4):510–517.
2. MacLennan AH, Nicolson R, Green RC, Bath M. Serum relaxin and pelvic pain of pregnancy. *Lancet*. 1986;328(8501):243–245.
3. Sabino J, Grauer JN. Pregnancy and low back pain. *Curr Rev Musculoskel Med*. 2008;1(2):137–141.

4. Cakmak B, Inanir A, Nacar MC, Filiz B. The effect of maternity support belts on postural balance in pregnancy. *PM R*. 2014;6(7):624–628.
5. McCrory JL, Chambers AJ, Daftary A, Redfern MS. Dynamic postural stability during advancing pregnancy. *J Biomech*. 2010;43(12):2434–2439.
6. Wang SM, Dezinno P, Maranets I, Berman MR, Caldwell-Andrews AA, Kain ZN. Low back pain during pregnancy: prevalence, risk factors, and outcomes. *Obstet Gynecol*. 2004;104(1):65–70.
7. Virgara R, Maher C, Van Kessel G. The comorbidity of low back pelvic pain and risk of depression and anxiety in pregnancy in primiparous women. *BMC Pregnancy Childbirth*. 2018;18(1):288.
8. Bergstrom C, Persson M, Mogren I. Pregnancy-related low back pain and pelvic girdle pain approximately 14 months after pregnancy—pain status, self-rated health and family situation. *BMC Pregnancy Childbirth*. 2014;14:48.
9. Mackenzie J, Murray E, Lusher J. Women's experiences of pregnancy related pelvic girdle pain: a systematic review. *Midwifery*. 2018;56:102–111.
10. Mogren IM. BMI, pain and hyper-mobility are determinants of long-term outcome for women with low back pain and pelvic pain during pregnancy. *Eur Spine J*. 2006;15(7):1093–1102.
11. Skaggs CD, Prather H, Gross G, George JW, Thompson PA, Nelson DM. Back and pelvic pain in an underserved United States pregnant population: a preliminary descriptive survey. *J Manipulative Physiol Ther*. 2007;30(2):130–134.
12. Dunning K, Lemasters G, Bhattacharya A. A major public health issue: the high incidence of falls during pregnancy. *Matern Child Health J*. 2010;14(5):720–725.
13. Liddle SD, Pennick V. Interventions for preventing and treating low-back and pelvic pain during pregnancy. *Cochrane Database Syst Rev*. 2015;(9):CD001139.
14. Field T. Prenatal exercise research. *Infant Behav Dev*. 2012;35(3):397–407.
15. Brewin D, Nannini A. Women's perspectives on falls and fall prevention during pregnancy. *MCN Am J Matern/Child Nurs*. 2014;35(5):300–305.
16. Dole N, Savitz DA, Hertz-Picciotto I, Siega-Riz AM, McMahon MJ, Buekens P. Maternal stress and preterm birth. *Am J Epidemiol*. 2003;157(1):14–24.
17. Li D, Liu L, Odouli R. Presence of depressive symptoms during early pregnancy and the risk of preterm delivery: a prospective cohort study. *Hum Reprod*. 2009;24(1):146–153.
18. Grote NK, Bridge JA, Gavin AR, Melville JL, Iyengar S, Katon WJ. A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. *Arch Gen Psychiatry*. 2010;67(10):1012–1024.
19. Zhu P, Tao F, Hao J, Sun Y, Jiang X. Prenatal life events stress: implications for preterm birth and infant birth-weight. *Am J Obstet Gynecol*. 2010;203(1):34 e31–38.
20. Beddoe AE, Lee KA. Mind-body interventions during pregnancy. *J Obstet Gynecol Neonatal Nurs*. 2008;37(2):165–175.
21. Ickovics JR, Kershaw TS, Westdahl C, et al. Group prenatal care and perinatal outcomes: a randomized controlled trial. *Obstet Gynecol*. 2007;110(2 Pt 1):330–339.
22. Babbar S, Shyken J. Yoga in pregnancy. *Clin Obstet Gynecol*. 2016;59(3):600–612.
23. Jiang Q, Wu Z, Zhou L, Dunlop J, Chen P. Effects of yoga intervention during pregnancy: a review for current status. *Am J Perinatol*. 2015;32(6):503–514.
24. Dhillon A, Sparkes E, Duarte RV. Mindfulness-based interventions during pregnancy: a systematic review and meta-analysis. *Mindfulness*. 2017;8(6):1421–1437.
25. Shi Z, MacBeth A. The effectiveness of mindfulness-based interventions on maternal perinatal mental health outcomes: a systematic review. *Mindfulness*. 2017;8(4):823–847.
26. Lever Taylor B, Cavanagh K, Strauss C. The effectiveness of mindfulness-based interventions in the perinatal period: a systematic review and meta-analysis. *PLoS One*. 2016;11(5):e0155720.
27. Kinser PA, Pauli J, Jallo N, et al. Physical activity and yoga-based approaches for pregnancy-related low back and pelvic pain. *J Obstet Gynecol Neonatal Nurs*. 2017;46(3):334–346.
28. Holden SC, Gardiner P, Birdee G, Davis RB, Yeh GY. Complementary and alternative medicine use among women during pregnancy and childbearing years. *Birth*. 2015;42(3):261–269.
29. Wieland LS, Skoetz N, Pilkington K, Vempati R, D'Adamo CR, Berman BM. Yoga treatment for chronic non-specific low back pain. *Cochrane Database Syst Rev*. 2017;1:CD010671.
30. Jeter PE, Nkodo AF, Moonaz SH, Dagnelie G. A systematic review of yoga for balance in a healthy population. *J Altern Complement Med*. 2014;20(4):221–232.
31. American College of Obstetricians and Gynecologists. Patient Education FAQs. <http://www.acog.org/Resources-And-Publications/Patient-Education-FAQs-List>. 2014.
32. Nurse-Midwives ACo. Share with women. <http://www.midwife.org/Share-With-Women>. Published 2014 Accessed August 12, 2019.
33. Roland M, Morris R. A study of the natural history of back pain. *Spine*. 1983;8(2):141–144.
34. Foxcroft K, Callaway L, Byrne N, Webster J. Development and validation of a pregnancy symptoms inventory. *BMC Pregnancy Childbirth*. 2013;13(3):1–9.
35. Gibson J, McKenzie-McHarg K, Shakespeare J, Price J, Gray R. A systematic review of studies validating the Edinburgh Postnatal Depression Scale in antepartum and postpartum women. *Acta Psychiatr Scand*. 2009;119(5):350–364.
36. Ware J, Kosinski M, Keller S. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care*. 1996;34(3):220–233.
37. Curry M, Burton D, Fields J. The prenatal psychosocial profile: a research and clinical tool. *Res Nurs Health*. 1998;21(3):211–219.
38. Lowe N. Maternal confidence for labor: development of the childbirth self-efficacy inventory. *Res Nurs Health*. 1983;16:141–149.

39. Dencker A, Taft C, Bergqvist L, Lilja H, Berg M. Childbirth Experience Questionnaire (CEQ): development and evaluation of a multidimensional instrument. *BMC Pregnancy Childbirth*. 2010;10:81.
40. Yardley L, Beyer N, Hauer K, Kempen G, Piot-Ziegler C, Todd C. Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age Ageing*. 2005;34(6):614–619.
41. van de Pol G, de Leeuw JR, van Brummen HJ, Bruinse HW, Heintz AP, van der Vaart CH. The Pregnancy Mobility Index: a mobility scale during and after pregnancy. *Acta Obstet Gynecol Scand*. 2006;85(7):786–791.
42. Jeter PE, Slutsky J, Singh N, Khalsa SB. Yoga as a therapeutic intervention: a bibliometric analysis of published research studies from 1967 to 2013. *J Altern Complement Med*. 2015;21(10):586–592.
43. Branco M, Santos-Rocha R, Vieira F. Biomechanics of gait during pregnancy. *ScientificWorldJournal*. 2014;2014:527940.
44. Kuo C, Jamieson DJ, McPheeters ML, Meikle SF, Posner SF. Injury hospitalizations of pregnant women in the United States, 2002. *Am J Obstet Gynecol*. 2007;196(2):161 e161–166.
45. Jahdi F, Sheikhan F, Haghani H, et al. Yoga during pregnancy: the effects on labor pain and delivery outcomes (a randomized controlled trial). *Complement Ther Clin Pract*. 2017;27:1–4.
46. American College of Obstetricians and Gynecologists. ACOG committee opinion no. 267: exercise during pregnancy and the postpartum period. *Obstet Gynecol*. 2002; 99(1):171.
47. American College of Obstetricians and Gynecologists. ACOG committee opinion no. 650: physical activity and exercise during pregnancy and the postpartum period. *Obstet Gynecol*. 2015;126(6):135–142.
48. Chambers CD. Risks of hyperthermia associated with hot tub or spa use by pregnant women. *Birth Defects Res A Clin Mol Teratol*. 2006;76(8):569–573.
49. Polis RL, Gussman D, Kuo YH. Yoga in pregnancy: an examination of maternal and fetal responses to 26 yoga postures. *Obstet Gynecol*. 2015;126(6):1237–1241.
50. Swain TA, McGwin G. Yoga-related injuries in the United States from 2001 to 2014. *Orthop J Sports Med*. 2016;4(11):2325967116671703.