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Effects of Combined Prenatal Yoga and Structured Pregnancy Exercise on Serum Cortisol Regulation and Active-Phase Labor Duration

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ABSTRACT

Prenatal stress and prolonged labor are important concerns in maternal health because they may affect maternal comfort, labor progression, and the need for obstetric intervention. Prenatal yoga combined with structured pregnancy exercise has been proposed as a non-pharmacological strategy to support stress regulation and physiological readiness for childbirth. This quasi-experimental study involved 26 third-trimester primigravida women from maternity clinics in Nganjuk Regency, Indonesia, with 13 participants in the intervention group and 13 participants in the control group. Participants in the intervention group received combined prenatal yoga and structured pregnancy exercise twice weekly for three weeks, whereas the control group received structured pregnancy exercise only with the same frequency and duration. Serum cortisol levels were measured before and after the intervention using ELISA. The active phase of first-stage labor was defined as the period from 4 cm cervical dilation to full dilation and was documented using a partograph by attending midwives. The intervention group showed a significantly greater mean reduction in serum cortisol than the control group (−209.67 ± 56.30 vs. −129.96 ± 186.93 ng/ml; $p = 0.010$, Mann-Whitney U) and a shorter active-phase labor duration (4.08 ± 1.29 vs. 5.54 ± 0.90 hours; $p = 0.003$, independent t-test). A significant reduction in cortisol was also observed within each group (intervention: $p < 0.001$, paired t-test; control: $p = 0.001$, Wilcoxon test). These findings indicate that combined prenatal yoga and structured pregnancy exercise was associated with improved serum cortisol regulation and shorter active-phase labor duration compared with structured pregnancy exercise alone. Delivery mode was not evaluated as an outcome; therefore, further studies are needed to assess whether this intervention influences cesarean section rates.

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1. INTRODUCTION

Pregnancy is a transformative physiological and psychological experience that can be accompanied by significant maternal stress. When prolonged or poorly regulated, maternal stress may contribute to unfavorable maternal and neonatal outcomes, including prolonged labor and increased need for obstetric intervention. One proposed mechanism involves activation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in increased cortisol secretion. Elevated maternal cortisol levels have been associated with altered uterine function, fetal developmental concerns, and labor complications (Curtis et al., 2012). As maternal anxiety intensifies during pregnancy and labor, it can activate the sympathetic nervous system, resulting in heightened uterine resistance, inefficient contractions, and labor dystocia (Field et al., 2012). Therefore, interventions that safely reduce maternal stress and support physiological readiness for childbirth remain important in prenatal care.

Prenatal yoga and pregnancy exercise have gained increasing attention as safe and accessible non-pharmacological approaches for reducing maternal stress and supporting labor preparedness. Prenatal yoga may help lower cortisol levels, promote relaxation, and improve psychological well-being (Aflahiyah et al., 2020). Structured pregnancy exercise may also improve physical readiness for labor by supporting flexibility, endurance, and maternal functional capacity (Cannon et al., 2023). However, evidence remains limited regarding whether combining prenatal yoga with structured pregnancy exercise provides additional benefits for serum cortisol regulation and active-phase labor duration compared with structured pregnancy exercise alone. Understanding this combined effect is important for developing prenatal care strategies that are feasible, low-risk, and clinically relevant.

Maternal stress has also been linked to delivery-related anxiety and preference for medical intervention. Anxiety about labor pain and complications may influence women's perceptions of childbirth and delivery-mode preference (Sun et al., 2019). For this reason, stress-reduction strategies such as prenatal yoga and structured pregnancy exercise may be relevant as supportive prenatal interventions. However, because cesarean section was not analyzed as a primary or secondary outcome in the present study, delivery-mode issues are presented only in the context of background and not as a direct finding of this study.

Previous research has extensively documented the benefits of prenatal yoga in improving maternal well-being. Yoga interventions have been associated with lower levels of perceived stress, enhanced maternal-fetal attachment, and reduced incidence of pregnancy-related depression (Hardaniyati et al., 2022; Villar-Alises et al., 2023). Physiologically, yoga improves blood circulation, strengthens pelvic muscles, and facilitates better fetal positioning, all of which contribute to a smoother labor process (Danti et al., 2020). Furthermore, breathing techniques and mindfulness exercises incorporated in yoga have been shown to help manage pain perception during labor, reducing the need for epidural anesthesia (Hamdiah et al., 2017) . Nevertheless, evidence on the effect of prenatal yoga combined with structured pregnancy exercise on objective hormonal markers, particularly serum cortisol, remains limited.

In parallel, studies on maternal exercise have demonstrated that regular physical activity during pregnancy is associated with numerous health benefits. Moderate exercise reduces the risk of gestational diabetes, improves cardiovascular health, and enhances maternal endurance for labor (Mourtakos et al., 2015). Additionally, exercise has been linked to better labor experiences, including reduced rates of prolonged labor and operative deliveries (Holden et al., 2019). However, while prenatal yoga and pregnancy exercise have each shown potential benefits, fewer studies have examined their combined effect on serum cortisol regulation and standardized active-phase labor duration.

Evidence on non-pharmacological labor-support interventions suggests that approaches such as breathing exercises, relaxation, reflexology, and massage may help reduce anxiety and pain during labor (Baljon et al., 2022; Eskandari et al., 2023). Pharmacological interventions remain important in obstetric care when clinically indicated, but complementary non-pharmacological strategies may provide additional support for maternal comfort and labor preparedness. Accordingly, this study aimed to evaluate whether combined prenatal yoga and structured pregnancy exercise reduced serum cortisol levels and shortened the active phase of first-stage labor among third-trimester primigravida women compared with structured pregnancy exercise alone.

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2. METHOD

2.1 Study Design

This study employed a quasi-experimental pretest-posttest design with a comparison group to assess the effect of combined prenatal yoga and structured pregnancy exercise on serum cortisol levels and active-phase labor duration. Cesarean section was not analyzed as a primary or secondary outcome in this study. A quasi-experimental design was selected because full randomization was not feasible in the clinical maternity-care setting, while a structured comparison between groups remained possible (Jha et al., 2023).

2.2 Study Setting and Participants

Participants were recruited from maternity clinics in Nganjuk Regency, Indonesia (Figure 1). The study included third-trimester primigravida women aged 20–35 years without known medical or obstetric complications. Participants were allocated into two groups: an intervention group receiving combined prenatal yoga and structured pregnancy exercise, and a control group receiving structured pregnancy exercise only with the same frequency and duration. The selection process used purposive sampling to ensure that participants met the inclusion criteria while allowing flexibility in clinical recruitment (Koh and Park, 2017). The final analytic sample consisted of 26 participants, with 13 women in each group. Two participants who underwent medically indicated cesarean section due to obstetric complications were excluded from the labor-duration analysis. Ethical approval was obtained from the Health Research Ethics Committee of the Office of National Unity, Politics and Community Protection of Nganjuk Regency (Kantor Kesatuan Bangsa, Politik dan Perlindungan Masyarakat Daerah Kabupaten Nganjuk), approval number 072/388/411.308/2015. All participants provided written informed consent before enrollment, and the study was conducted in accordance with the Declaration of Helsinki.

2.3 Intervention and Comparison Group

The intervention group received supervised 60-minute sessions combining prenatal yoga and structured pregnancy exercise, conducted twice per week for three weeks. The prenatal yoga component included breathing control, stretching, relaxation, and mindfulness-based movements intended to support maternal relaxation and stress regulation (Aflahiyah et al., 2020). The structured pregnancy exercise component included moderate-intensity movements targeting flexibility, pelvic stability, posture, circulation, and muscular endurance to support physical readiness for labor (Baena-García et al., 2023). The control group received structured pregnancy exercise only, delivered twice per week for three weeks, without the additional prenatal yoga component. The three-week duration was selected because participants were in the third trimester and the program needed to be feasible within routine late-pregnancy antenatal schedules. This relatively short intervention period was acknowledged as a methodological limitation.

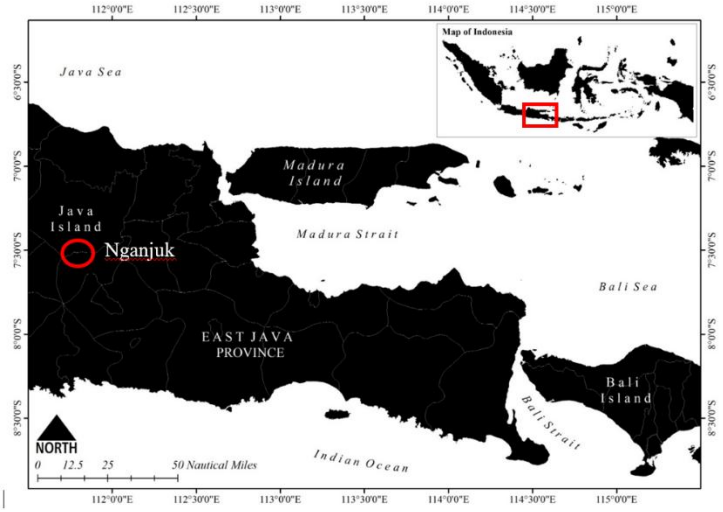

Figure 1. Research Location

2.4 Serum Cortisol Measurement

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Serum cortisol levels were measured before and after the intervention using venous blood samples collected from the median cubital vein. A 3 cc blood sample was collected using a sterile syringe and G24 needle. Blood sampling was performed in the morning to reduce the influence of diurnal cortisol variation. Only serum cortisol was measured in this study; salivary cortisol and cortisol awakening response were not assessed. Cortisol concentrations were measured using enzyme-linked immunosorbent assay (ELISA) following standardized laboratory procedures (Davenport et al., 2018).

2.5 Labor Duration Outcome

Blood samples were centrifuged and stored at −80°C until analysis. Serum cortisol concentration was determined using ELISA at the GAKI Laboratory, Universitas Diponegoro, Semarang. Blood sampling was performed in the morning between 07:00 and 09:00 WIB to control for diurnal variation. Labor duration was documented by attending midwives using a partograph. The primary labor outcome was active-phase duration of the first stage of labor, defined consistently as the time from 4 cm cervical dilation to full cervical dilation at 10 cm. All deliveries took place at independent midwifery practices (BPM) in Nganjuk Regency and were attended by licensed midwives. The overall research flow is shown in Figure 2.

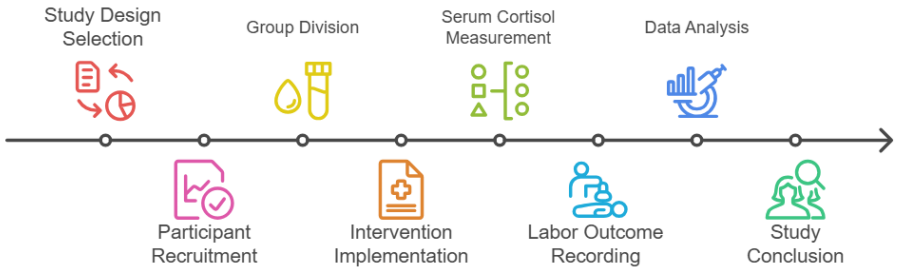

Figure 2. Research Method Flow

2.6 Statistical Analysis and Sample Size Consideration

The study employed both within-group and between-group analyses to compare serum cortisol levels and active-phase labor duration. Normality was assessed using the Shapiro-Wilk test. Within-group changes in cortisol were analyzed using the paired t-test for normally distributed data and the Wilcoxon signed-rank test for non-normally distributed data. Between-group differences in cortisol change were analyzed using the Mann-Whitney U test, while between-group differences in active-phase labor duration were analyzed using the independent t-test. Statistical significance was set at $p < 0.05$, and all analyses were performed using SPSS version 26.0. Effect sizes and 95% confidence intervals were reported where applicable. Cohen's d was used for normally distributed continuous outcomes, while non-parametric effect size r was used for Mann-Whitney U and Wilcoxon analyses. Because the control group showed high variability in cortisol change, descriptive statistics were interpreted cautiously.

2.7 Methodological Limitations

No formal a priori power calculation was conducted because this study was implemented as an exploratory quasi-experimental study within a limited clinical recruitment window. The final sample size of 26 participants should therefore be interpreted as modest and may limit statistical power, precision of estimates, and generalizability. In addition, the three-week intervention period was relatively short and may not fully capture the longer-term physiological effects of prenatal yoga and pregnancy exercise. The absence of full randomization may also introduce selection bias, although the use of comparable groups based on maternal age, gestational age, and baseline cortisol levels helped reduce this risk. Participant adherence was supported through supervised sessions and regular follow-up.

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3. RESULTS AND DISCUSSION

3.1. Serum Cortisol Regulation

The findings indicate that combined prenatal yoga and structured pregnancy exercise was associated with a greater reduction in serum cortisol than structured pregnancy exercise alone. Table 1 presents serum cortisol concentrations before and after the intervention. At baseline, cortisol levels did not show significantly different between the intervention and control (291.82 ± 48.58 vs. 303.85 ± 198.53 ng/ml; p = 0.739), suggesting initial comparability between groups. After the intervention, the intervention group showed a lower mean cortisol level than the control group (82.15 ± 27.05 vs. 167.53 ± 79.20 ng/ml; p = 0.002). The mean cortisol reduction was greater in the intervention group than in the control group (−209.67 ± 56.30 vs. −129.96 ± 186.93 ng/ml; p = 0.010, Mann-Whitney U). However, the large standard deviation in the control group indicates substantial inter-individual variability; therefore, this result should be interpreted cautiously. Effect size and confidence interval information are presented in Table 1 to improve the statistical interpretation of the findings. These findings are consistent with previous studies suggesting that prenatal yoga may contribute to stress-hormone regulation through relaxation, breathing control, and modulation of stress-related physiological responses (D'Anna-Hernandez et al., 2011; Romero-González et al., 2018).

Table 1. Changes in Serum Cortisol Levels Before and After Intervention

Group/Comparison	Before Intervention, ng/mL	After Intervention, ng/mL	Change (Post–Pre), ng/mL	Statistical Result
Intervention group (n = 13)	291.82 ± 48.58 95% CI: 262.46 to 321.18	82.15 ± 27.05 95% CI: 65.80 to 98.50	−209.67 ± 56.30 95% CI: −243.69 to −175.65	Within-group p < 0.001
Control group (n = 13)	303.85 ± 198.53 95% CI: 183.88 to 423.82	167.53 ± 79.20 95% CI: 119.67 to 215.39	−129.96 ± 186.93 95% CI: −242.92 to −17.00	Within-group p = 0.001
Between-group p-value	0.739	0.002	0.010	—
Between-group effect size	r = 0.07	r = 0.61	r = 0.51	—

Note. Values are presented as mean ± standard deviation. Change was calculated as post-intervention minus pre-intervention serum cortisol level; negative values indicate a reduction in serum cortisol. The high standard deviation in the control group indicates substantial inter-individual variability and should be considered when interpreting the between-group comparison.

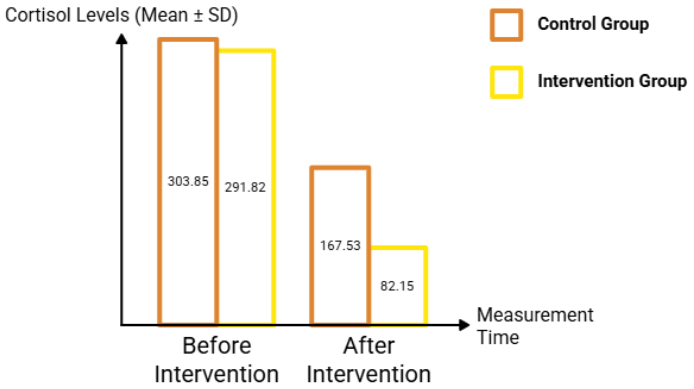

Figure 3. Serum Cortisol Levels Before and After Intervention

These results suggest that incorporating elements of prenatal yoga components, including breathing control, relaxation, mindfulness, and moderate physical activity, may support maternal endocrine regulation. The observed reduction in serum cortisol provides physiological evidence of improved stress regulation in the intervention

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group. Nevertheless, because this study used a small quasi-experimental sample, the findings should be interpreted as preliminary rather than definitive evidence of causal effectiveness (Dennis-Tiwary et al., 2017).

3.2. Active-Phase Labor Duration

The effect of the intervention on labor duration was assessed using partograph-based clinical documentation. Labor duration refers specifically to the active phase of the first stage of labor, defined as the period from 4 cm cervical dilation to full cervical dilation at 10 cm. Table 2 shows that active-phase labor duration was significantly shorter in the intervention group than in the control group (4.08 ± 1.29 vs. 5.54 ± 0.90 hours; p = 0.003). The mean difference was −1.46 hours, indicating that the intervention group experienced an active phase approximately 1.5 hours shorter than the control group. The estimated effect size was large (Cohen's d ≈ −1.31), with an approximate 95% confidence interval for the mean difference of −2.36 to −0.56 hours. These findings are consistent with previous research suggesting that maternal stress reduction and physical preparedness may contribute to more efficient labor progression (Daniyati and Mawaddah, 2021).

Table 2. Comparison of Active-Phase Labor Duration Between Groups

Group/Comparison	Active-Phase Labor Duration, hours	95% CI	p-value	Effect Size
Intervention group (n = 13)	4.08 ± 1.29	3.30 to 4.86	—	—
Control group (n = 13)	5.54 ± 0.90	5.00 to 6.08	—	—
Mean difference, Intervention–Control	−1.46 hours	−2.36 to −0.56	0.003	Cohen's d = −1.31

Prolonged labor has been associated with maternal fatigue, fetal distress, and greater likelihood of obstetric intervention. In the present study, women who received combined prenatal yoga and structured pregnancy exercise had a shorter active phase than those who received structured pregnancy exercise alone. This finding may reflect improved physical readiness, relaxation, breathing control, and pelvic muscle function; however, uterine contractility was not directly measured and should not be claimed as a demonstrated mechanism. This result is broadly consistent with previous studies reporting that structured prenatal exercise may shorten the duration of active-phase labor (Mutaqin et al., 2023).

3.3. Interpretation and Psychological Context

The psychological dimension of labor preparedness is relevant to labor outcomes, but formal psychological measures such as PSS or K10 were not analyzed in this study. Therefore, the observed reduction in serum cortisol should be interpreted as a physiological indicator of improved stress regulation, not as direct evidence of reduced perceived stress, anxiety, or psychological resilience. Cortisol is commonly used as a physiological marker of stress response. Previous studies have linked maternal anxiety with labor complications, including prolonged labor and delivery-mode preference rates rates (Størksen et al., 2015).. However, because cesarean section was not analyzed as an outcome in the present study, no conclusion can be made regarding cesarean section prevention. The present findings support a cautious interpretation: combined prenatal yoga and structured pregnancy exercise may improve physiological stress regulation and active-phase labor duration, but psychological and delivery-mode outcomes require direct measurement in future studies (Duncan et al., 2017).

3.4. Delivery Mode and Scope of Interpretation

Regarding delivery mode, two participants, one from each group, underwent cesarean section due to medically indicated obstetric complications, specifically premature rupture of membranes, and were excluded from the final labor-duration analysis. Therefore, the final analytic sample consisted of N = 26 participants, with 13 participants in each group. These cesarean deliveries were not analyzed as primary or secondary outcomes. Accordingly, the main findings of this study should be interpreted as evidence of improved serum cortisol regulation and shorter active-phase labor duration in the combined prenatal yoga and structured pregnancy exercise group compared with the structured pregnancy exercise-only control group. Although previous studies have suggested that prenatal yoga may support vaginal birth by improving relaxation, stress regulation, and physical preparedness (Mohyadin et al., 2020; Yekefallah et al., 2021),, the present study cannot conclude that the intervention prevents cesarean section.

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The results of this study suggest that combined prenatal yoga and structured pregnancy exercise may be beneficial for reducing serum cortisol levels and shortening active-phase labor duration. However, psychological well-being and cesarean section incidence were not analyzed as study outcomes, so conclusions regarding these endpoints should not be drawn from the present data. These findings support the potential integration of combined prenatal yoga and pregnancy exercise as a complementary prenatal-care approach, particularly for improving stress regulation and labor preparedness. Future research should examine whether these physiological and labor-duration benefits translate into broader maternal and neonatal outcomes using larger randomized controlled trials.

3.5. Physiological Interpretation of Cortisol Findings

The cortisol findings may be explained by the combined effects of breathing control, relaxation, mindfulness, stretching, and moderate physical activity, which may support regulation of the hypothalamic-pituitary-adrenal axis. Cortisol, as a primary stress hormone, naturally increases during pregnancy partly due to placental corticotropin-releasing hormone stimulation. Excessive cortisol elevation has been associated with unfavorable maternal and fetal outcomes, including prolonged labor and stress-related complications (Nadholta et al., 2023). In the present study, the greater reduction in serum cortisol observed in the intervention group suggests that adding prenatal yoga to structured pregnancy exercise may provide additional physiological benefits for stress regulation. However, because pregnancy-related anxiety and psychological stress were not directly measured, the lower post-intervention cortisol level should be interpreted as a physiological stress marker rather than direct evidence of reduced perceived anxiety. These findings are consistent with previous studies reporting that prenatal yoga and structured physical activity may attenuate maternal stress responses through relaxation, breathing control, and modulation of stress-related physiological pathways (D'Anna-Hernandez et al., 2011; Dennis-Tiwary et al., 2017; Romero-González et al., 2018).

3.6. Possible Mechanisms Related to Labor Duration

The shorter active-phase labor duration observed in the intervention group may be related to improved physical readiness, relaxation, breathing control, and pelvic muscle function. Prenatal yoga and structured pregnancy exercise may support maternal comfort and labor preparedness by improving flexibility, reducing muscular tension, and promoting controlled breathing during labor. Oxytocin plays an important role in labor progression by promoting uterine contractions; however, oxytocin was not measured in this study. Previous literature suggests that relaxation, controlled breathing, and physical activity may influence neuroendocrine pathways relevant to labor physiology (Babbar et al., 2012; Yüksel et al., 2019). Therefore, the possible role of oxytocin should be interpreted only as a plausible mechanism, not as a confirmed finding. The data from this study demonstrate shorter active-phase labor duration, but they do not directly prove changes in oxytocin release, uterine contractility, or hormonal balance. Future studies should include direct measurement of oxytocin, uterine activity, psychological outcomes, and other labor-related mediators to clarify the mechanisms linking prenatal yoga, structured pregnancy exercise, and labor progression.

3.7. Psychological and Clinical Implications

Anxiety and fear of childbirth have been associated with labor experience and delivery-mode preference in previous studies (Størksen et al., 2015). However, the present study did not measure childbirth fear, perceived stress, maternal confidence, or cesarean section preference. Therefore, it is not appropriate to state that the intervention reduced cesarean section rates or prevented fear-driven surgical delivery. The psychological relevance of the findings should be limited to the observed serum cortisol reduction, which may indicate improved physiological stress regulation. Previous studies suggest that mindfulness and relaxation techniques may reduce anxiety and pain perception during labor (Duncan et al., 2017; Ginting, 2024). Based on the present results, combined prenatal yoga and structured pregnancy exercise may be considered a complementary strategy to support stress regulation and labor preparedness, but its effect on psychological outcomes and delivery mode requires further investigation.

Public health initiatives may consider promoting safe and supervised structured pregnancy exercise programs with yoga-based components as part of maternal health education, particularly in community-based antenatal services where low-cost, non-pharmacological approaches are needed (Hasriantirisna et al., 2024). However, given the small sample size, quasi-experimental design, and short three-week intervention period, the

present findings should be interpreted as preliminary. Larger randomized controlled trials are needed to confirm whether the observed improvements in serum cortisol regulation and active-phase labor duration are reproducible and clinically meaningful.

3.8. Study Limitations and Future Research

Several limitations should be considered. First, the final sample size was small, and no a priori power calculation was conducted, which may limit statistical power and precision. Second, the intervention lasted only three weeks, which may be insufficient to capture longer-term physiological adaptation. Third, the quasi-experimental design without full randomization may introduce selection bias. Fourth, the control group showed high variability in cortisol change, indicating substantial inter-individual differences. Fifth, psychological outcomes, oxytocin levels, neonatal outcomes, total labor duration, and cesarean section rates were not analyzed. Future research should include larger randomized controlled trials, longer intervention periods, direct measurement of psychological and hormonal mediators, and broader maternal-neonatal endpoints.

4. CONCLUSION

This quasi-experimental study found that combined prenatal yoga and structured pregnancy exercise was associated with significantly greater reduction in serum cortisol and shorter active-phase first-stage labor duration compared with structured pregnancy exercise alone among third-trimester primigravida women. These findings suggest that adding prenatal yoga to structured pregnancy exercise may support physiological stress regulation and labor preparedness. However, the results should be interpreted with careful consideration due to the small sample size, absence of full randomization, lack of a priori power calculation, and short three-week intervention period. Cesarean section prevention, psychological well-being, oxytocin regulation, and neonatal outcomes were not directly analyzed and therefore cannot be concluded from this study. Future randomized controlled trials with larger sample sizes, longer intervention periods, psychological assessment, measurement of hormonal mediators, and maternal-neonatal follow-up are needed to confirm these preliminary findings.

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