



# The Influence of Birth Ball Exercise and Lemon Aromatherapy on Cortisol Levels in Pregnant Women

Wenny Indah Purnama Eka Sari<sup>1</sup>, Kurniyati<sup>1</sup>, Yusniarita<sup>2</sup>, Ida Mardalena<sup>2</sup>

<sup>1</sup>Midwifery Program, Poltekkes Kemenkes Bengkulu, Indonesia.

<sup>2</sup>Nursing Program, Poltekkes Kemenkes Yogyakarta, Indonesia.

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Corresponding Author:

Wenny Indah Purnama Eka Sari  
[wenny@poltekkesbengkulu.ac.id](mailto:wenny@poltekkesbengkulu.ac.id)

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**Abstract:** Pregnancy is a natural and physiological condition. During pregnancy, various changes occur in the body due to the hormones estrogen and progesterone, which affect both the physical and psychological conditions of the mother. Anxiety during pregnancy is an emotional reaction related to the mother's concerns about her baby. Persistent anxiety can affect the sympathetic nervous system and the release of the stress hormone cortisol. The purpose of this study is to examine the effect of birth ball exercise and lemon aromatherapy on cortisol levels in pregnant women. This study employed a posttest-only control group approach in a quasi-experimental design. Thirty third-trimester pregnant women who engaged in pregnancy exercises made up the study sample; they were chosen using purposive sampling. For four weeks, the respondents in the intervention group received the lemon aromatherapy and birth ball exercise twice a week for forty-five minutes each. A questionnaire with respondent characteristics and a cortisol level column were part of the research tool. The non-parametric Mann-Whitney test was used for data analysis. The average cortisol levels in the intervention group and the control group differed significantly, as indicated by the results, which showed  $p = 0.000$ . This indicates that cortisol levels in third-trimester pregnant women are considerably impacted by lemon aromatherapy and birth ball exercise. Cortisol levels are lowered by the physiological and psychological effects of the birth ball exercise and lemon aromatherapy, which relax the body and calm the mind. Pregnant women may benefit from combining lemon aromatherapy with birth ball exercise to lower anxiety levels and avoid excessive cortisol elevation.

**Keywords:** Birth ball; Cortisol; Exercise; Lemon aromatherapy; Pregnancy.

## Introduction

Pregnancy is a natural and physiological condition. During pregnancy, expectant mothers experience physical and psychological changes due to increased levels of oestrogen and progesterone. Physical changes cause psychological changes and emotional instability (Mardliyana, 2022). Psychological changes that often occur in pregnant women, especially in the late stages of pregnancy, include anxiety and stress. Anxiety during pregnancy is an emotional reaction that occurs in relation to the mother's concerns about her fetus. Research by Biaggi et al. (2016) shows that there is a

relationship between anxiety in pregnant women and pregnancy complications such as premature labour.

Persistent anxiety can affect the sympathetic nervous system and the release of the stress hormone cortisol. Cortisol is a steroid hormone of the glucocorticoid class produced by cells in the fasciculate zone of the adrenal glands in response to stimulation by the ACTH hormone secreted by the pituitary gland. Cortisol plays many roles in the body's metabolic system. Cortisol is physiologically effective in regulating blood pressure and anti-inflammatory activity by inhibiting white blood cells from participating in the inflammatory response (Jesica & Friadi, 2019).

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Increased progesterone during stressful situations can facilitate negative feedback in the hypothalamic-pituitary-adrenal axis through metabolic allopregnenolone, reducing feelings of anxiety and tension and stimulating sedative effects. Progesterone also enhances beneficial social closeness responses during times of stress. Although the mechanism is not yet certain, the interpretation of these findings suggests that higher progesterone levels increase cortisol levels in response to stressful situations (Bjelanović et al., 2016).

During pregnancy, a mother's cortisol levels increase 2-4 times above normal levels. Stress can stimulate the hypothalamus to produce Corticotropin-Releasing Hormone (CRH), which triggers the release of Adrenocorticotropic Hormone (ACTH) from the pituitary gland. The release of ACTH stimulates the adrenal cortex, which ultimately releases the hormone cortisol. Under normal circumstances, cortisol is released in very small amounts over a period of 72 hours, but during times of stress, cortisol levels can increase dramatically, even up to 20 times. High cortisol levels cannot inhibit CRH and ACTH secretion because glucocorticoid receptors are downregulated during stress (Kane et al., 2019).

Progressively, cortisol levels during pregnancy increase from 25 weeks of gestation. The HPA axis of pregnant women and the placenta produce cortisol during fetal maturation and delivery. However, an increase in maternal cortisol due to prenatal stress can affect placental cortisol production. Increased cortisol levels in mothers have a negative impact on the fetus. Therefore, reducing suboptimal increases in cortisol levels and maintaining optimal cortisol function during pregnancy can benefit both the mother and the fetus (Li et al., 2019).

Efforts to overcome anxiety and stress during pregnancy can include physical activity and relaxation. Prenatal exercise using a birth ball, a form of exercise that incorporates a birth ball, can help prevent and manage anxiety in pregnant women. Research by Sari & Kurniyati (2021) shows that this type of exercise, with educational content on childbirth preparation, affects anxiety levels in women in their third trimester.

Physiologically, pregnancy exercises reverse the effects of stress involving the parasympathetic part of the central nervous system. Relaxation inhibits the increase in sympathetic nerve activity, thereby reducing the hormones that cause bodily dysregulation. As a result, there is a decrease in heart rate, breathing rhythm, blood pressure, muscle tension, metabolic rate, and production of stress-causing hormones, so that the whole body begins to function at a healthier level. The more frequently a mother performs prenatal exercise, the lower her anxiety score and the greater the effect on

changes in diastolic blood pressure and breathing patterns (Septiani, 2017). Prenatal exercise can reduce anxiety and influence the function of the Hypothalamic-Pituitary-Adrenal (HPA) axis, leading to lower cortisol levels. The findings of Sartika et al. (2023) indicate that there are differences in cortisol levels and anxiety levels among primigravida patients before and after prenatal exercise prior to childbirth.

Other complementary therapies to overcome anxiety and stress in pregnant women include relaxation using aromatherapy. Aromatherapy is a therapeutic practice that uses essential oils to improve physical and psychological well-being. In addition to improving physical and psychological well-being, aromatherapy can help relax tense nerves and muscles. Relaxation is one way to overcome anxiety or stress by loosening muscles and nerves. Relaxation can improve overall health by facilitating the body's metabolic processes, reducing aggression, and certain behaviours (Ochthaviany, 2016).

Lemon aromatherapy is one of the benefits of aromatherapy for pregnant women. The main component of lemon essential oil is limonene. This compound is mentally stimulating, anti-inflammatory, antispasmodic, hypotensive, anti-stress, and sedative. Lemon aromatherapy works through the olfactory process, which is located behind the nose. This process accelerates the absorption of the medicine (Darvishpor et al., 2018). Lemon essential oil exhibits strong anti-stress effects and is an effective antidepressant. It accelerates the hippocampus-regulated metabolic rate, promoting rational thinking. Lemon essential oil is indicated to connect with emotional triggers. It energises and refreshes the body and mind. It also improves focus and memory, and enhances clarity when decision-making is needed. Psychologically, the scent of lemon oil reduces mental fatigue and feelings of being overwhelmed (Stiles, 2017). Inhalation for 10 minutes at 30-minute intervals has been shown to reduce anxiety levels in pregnant women (Claudia & Rasyid, 2021).

Lemon aromatherapy produces a calming effect and significantly influences cortisol levels. The mechanism behind the calming effect of aromatherapy may involve the rapid diffusion of volatile aroma oil molecules into the bloodstream, which can activate the brain through systemic circulation. Essential oils inhaled use their volatile molecules to rapidly diffuse into the bloodstream, which then activates the brain. When these scents spread through the air, they activate olfactory receptors in the nose, triggering an electrophysiological response that spreads to the brain. This physiological response affects the sense of smell and reaches specific areas of the limbic system, such as the amygdala and hypothalamus, where hormone levels and emotional

states are controlled, most likely activating the neocortex (Kowshihan & Ravikumar, 2023).

Based on the 2023 Rejang Lebong District Health Profile, the main cause of neonatal mortality is complications in low birth weight (LBW) and premature babies, accounting for 63% of cases. The high mortality rate due to prematurity is a determinant caused by anxiety/stress in pregnant women, leading to hypertension and pre-eclampsia. Maternal mortality in Rejang Lebong District increased in 2023 compared to 2022, with the highest cause of death being hypertension in pregnancy (Dinkes RL, 2024). Therefore, this study specifically aims to determine whether *Birth Ball* prenatal exercise and lemon aromatherapy affect cortisol levels in pregnant women at Independent Midwifery Practice Rejang Lebong District in 2025.

## Method

This study used a quasi-experimental posttest-only control group design. The population is all third-trimester pregnant women in Rejang Lebong District, Bengkulu Province. The sample is 30 third-trimester pregnant women participating in prenatal exercise, selected purposively. The study was conducted from June to July 2025.

In the intervention group, respondents received prenatal exercise, a birth ball, and lemon aromatherapy via a diffuser containing 100ml of water mixed with 1 cc of lemon essential oil for 45 minutes, twice a week for 4 weeks. Lemon aromatherapy was administered simultaneously during the birth ball prenatal exercise. In the control group, respondents received routine prenatal exercise led by a midwife once a week for 4 weeks. Saliva samples for cortisol hormone testing were collected in the fourth week after the intervention, in the afternoon.

The research instrument consisted of two parts: respondent characteristics, which included questions on name, age, pregnancy number, occupation, address, and contact number, and a column for recording cortisol level measurement results. Data analysis used the non-parametric Mann-Whitney test. This study was approved by the Research Ethics Committee of the Bengkulu Ministry of Health Polytechnic with No. KEPK.BKL/430/05/2025.

## Result and Discussion

### Age

Women under the age of 20 are considered at risk because their reproductive organs are not yet fully developed/ready for pregnancy. In addition, young mothers are relatively unprepared for pregnancy and are therefore highly susceptible to psychological stress.

Age also affects psychological symptoms and stress biomarkers from the age of 30, peaking at the age of 35. Psychological stress can activate the hypothalamic-pituitary-adrenal (HPA) axis, leading to increased secretion of hormones and epinephrine. Research findings reveal that older age is associated with lower cortisol levels (García-Blanco et al., 2017).

Younger maternal age correlates with higher cortisol levels. In younger women, the hypothalamic-pituitary-adrenal (HPA) stress hormone system tends to be more active. Therefore, during pregnancy, the natural increase in cortisol (which rises 2–3 times) is greater than in older mothers. The younger the pregnant mother, the higher the cortisol levels. This reflects stronger hormonal activity at a younger age. Younger maternal age is associated with higher cortisol levels during pregnancy (Bleker et al., 2017).

### Parity

Pregnancy is a physiological event that occurs in women of childbearing age. During pregnancy, the pregnant mother undergoes physical and psychological changes. Almost all primigravidae pregnant women experience worry, anxiety, and fear during pregnancy, during childbirth, and after childbirth. Pregnant women have disturbing thoughts as a result of developing anxiety reactions to the stories they hear. If not taken seriously, worry and anxiety in pregnant women will have physical and psychological effects and influences on both the mother and the foetus. Pregnant women who experience anxiety or stress signal through the HPA (Hypothalamic-Pituitary-Adrenal) axis, which can cause stress, including adrenocorticotropic hormone (ACTH), cortisol, epinephrine,  $\beta$ -Endorphin, Growth hormone (GH), prolactin, and Lutenizing hormone (LH) / Follicle-stimulating hormone (FSH) (Usman et al., 2021).

The study found more primigravida respondents. Pregnant women who have never given birth before have significantly higher cortisol levels compared to multiparous women. During the first pregnancy, the mother's body undergoes hormonal, immunological, and metabolic adaptations that have never been experienced before. This can activate the HPA axis (hypothalamus-pituitary-adrenal), leading to increased cortisol production (Bleker et al., 2017).

### Occupation

Occupation is the activity of earning a living. In this context, there is an element of necessity that may cause anxiety stemming from the work itself, rather than from preparations for childbirth. One factor that can cause anxiety is work. Workload, such as feelings of incompetence at work or the inability to produce optimal results, can trigger anxiety. Jobs that involve

high physical risk (e.g., jobs that require heavy lifting or exposure to chemicals) can increase anxiety due to concerns about fetal health. Research shows that this anxiety can be exacerbated by feelings of insecurity or discomfort in the work environment. Psychologically challenging jobs, such as those involving important decisions, interpersonal conflicts, or emergency situations, can also increase the risk of anxiety in pregnant women (Suyani, 2020).

Employment status is often associated with better economic conditions. Low socio-economic status can increase physiological stress (although this study shows that psychological factors do not directly increase cortisol, biological/social factors do play a role). Work provides daily structure, physical activity, and routine that may help regulate stress hormones. Conversely, mothers who do not work may experience a less regular daily rhythm, which affects cortisol secretion. Working mothers tend to have more regular sleep/activity schedules, whereas not working can affect sleep quality and increase cortisol levels. Bleker et al. (2017) research found that employment status is associated with cortisol levels in pregnant women.

Table 1 shows that almost all respondents were aged 20-35 years (86.7%), most respondents were primigravida (63.3%), and most respondents were employed (66.7%). The results of the chi-square test show that there were no significant differences between the two research groups ( $p > 0.05$ ), indicating that the groups are homogeneous and comparable.

**Table 1.** Respondent Characteristics

Variable Characteristics	Frequency		<i>p value*</i>
	n	%	
Age			1.000
Age < 20 and > 35	4	13.3	
20-35 years old	26	86.7	
Parity			1.000
Primigravida	19	63.3	
Multigravida	11	36.7	
Occupation			1.000
Employed	20	66.7	
Unemployed	15	33.3	

\* *chi-square test*

Table 2 shows that the average cortisol level in the intervention group was 0.13, while in the control group it was 0.23. This indicates that the average cortisol level was lower in the intervention group.

During pregnancy, cortisol levels in mothers increase progressively as part of physiological adaptation. Compared with non-pregnant conditions, total cortisol levels can increase by 3–4 times towards the end of pregnancy (third trimester) (Peterson et al., 2020). In the first trimester, cortisol begins to increase from baseline levels, but is still within the range of non-pregnant women. In the second trimester, there is a more pronounced increase, averaging about 30–50% higher than in the first trimester. Cortisol levels peak, reaching about three to four times the normal level, playing an important role in the maturation of foetal organs, especially the lungs, as well as in preparing for the delivery process (Bleker et al., 2017).

**Table 2.** Average cortisol levels in pregnant women

Variable	Intervention			Control		
	Mean	Min-Max	SD	Mean	Min-Max	SD
Cortisol Level's	0.13	0.07 - 0.20	0.032	0.23	0.15-0.64	0.118

The increase in cortisol in pregnant women is due to several mechanisms, including the placenta secreting corticotropin-releasing hormone (pCRH), which progressively increases with gestational age. pCRH stimulates the mother's hypothalamic-pituitary-adrenal (HPA) axis, increasing the production of ACTH and cortisol. High oestrogen levels during pregnancy increase CBG levels, thereby increasing total cortisol. The 11 $\beta$ -HSD2 enzyme in the placenta converts active cortisol into inactive cortisone, protecting the foetus from excessive exposure. However, the activity of this enzyme is limited, so some cortisol still reaches the foetus. The daily rhythm (high in the morning, low at night) continues, but with overall higher levels throughout all stages of pregnancy (Chourpiliadi & Paparodis, 2023).

Risk factors and causes that affect cortisol levels in pregnant women include maternal age, psychological stress levels, nutritional status, comorbidities such as anxiety or depression, and the pregnancy itself. Pregnant women with chronic stress, high-risk pregnancies, or poor environmental exposure tend to have higher cortisol levels. Excessive increases in cortisol can have negative effects, such as increasing the risk of premature birth or affecting the baby's birth weight. Thus, understanding the physiological changes in cortisol levels during pregnancy and the factors that influence them is very important in maintaining the health of the mother and fetus (Miranda et al., 2025).

High cortisol levels in pregnant women are a poor predictor of foetal *outcomes*. Maternal cortisol levels are more strongly associated with adverse outcomes in

infants, including IUGR, low birth weight, lower gestational age, neurocognitive development (such as attention scores), and decreased populations of protective microbiota (such as *Lactobacillus*, *Slackia*, and *Actinobaculum*). A study by Gonzalez et al. (2022) found that prenatal cortisol levels, as a biological indicator, have stronger predictive validity for infant outcomes such as foetal growth, birth weight, cognitive development, and gut microbiota condition. Maternal anxiety influences increased cortisol levels in pregnant women. Heuvel et al. (2018) revealed the underlying mechanism of the relationship between maternal psychological stress and cortisol and explored mechanisms beyond the HPA axis, finding a relationship between maternal psychological stress and salivary cortisol during pregnancy. Mothers with higher anxiety levels showed higher cortisol levels.

**Table 3.** Difference in average cortisol levels

Cortisol Level's	Group		p-value*
	Intervention (n = 15)	Control n = 15	
$\bar{X}$ (SD)	0.13(0.03)	0.23(0.11)	
Median	0.14	0.21	0.000
Range	0.07-0.20	0.15-0.64	

\*Mann Whitney Test

The analysis using the Mann-Whitney test obtained  $p = 0.000$ , indicating a difference in average cortisol levels between the intervention and control groups, suggesting that *birth ball* exercise and lemon aromatherapy affected cortisol levels in pregnant women in their third trimester.

Pregnancy is a natural and physiological condition. During pregnancy, various changes occur in the body due to the hormones estrogen and progesterone, which affect both the mother's physical and psychological condition (Sari et al., 2024). Anxiety during pregnancy is an emotional reaction that occurs in relation to the mother's concerns about her fetus. Continuous anxiety can affect the sympathetic nervous system and the release of the stress hormone cortisol. Cortisol is physiologically effective in regulating blood pressure and exerting anti-inflammatory activity by inhibiting white blood cells from participating in the inflammatory response (Jesica & Friadi, 2019).

During pregnancy, a mother's cortisol levels increase 2-4 times above normal levels. Stress can stimulate the hypothalamus to produce Corticotropin-Releasing Hormone (CRH), which triggers the release of Adrenocorticotrophic Hormone (ACTH) from the pituitary gland. The release of ACTH stimulates the adrenal cortex, which ultimately releases the hormone cortisol. Under normal conditions, cortisol is released in very small amounts over 72 hours, but under stress,

cortisol levels increase dramatically, even up to 20 times. High cortisol levels cannot inhibit CRH and ACTH secretion because glucocorticoid receptors decrease during stress (Kane et al., 2019).

Cortisol levels progressively rise during pregnancy, starting at 25 weeks of gestation. During maturation and delivery, the HPA axis of pregnant women and the placenta produce cortisol. However, prenatal stress can increase maternal cortisol, which in turn can affect placental cortisol production. Elevated maternal cortisol negatively impacts the foetus. Therefore, maintaining optimal cortisol function by reducing suboptimal increases during pregnancy benefits both mother and fetus (Li et al., 2019).

Efforts to overcome anxiety and stress during pregnancy can be done through physical activity and relaxation. Physical activities that can be done to prevent and overcome anxiety in pregnant women include pregnancy exercises using a birth ball. Pregnancy exercises using a birth ball are a modification of pregnancy exercises that use a birth ball as an aid. The results of a study by Sari & Kurniyati (2021) show that prenatal exercise using a birth ball with educational content on preparing for childbirth has an effect on the anxiety of pregnant women in their third trimester.

Physiologically, pregnancy exercises reverse the effects of stress involving the parasympathetic part of the central nervous system. Relaxation inhibits the increase in sympathetic nerve activity, thereby reducing the hormones that cause bodily dysregulation. As a result, there is a decrease in heart rate, breathing rhythm, blood pressure, muscle tension, metabolic rate, and production of stress-causing hormones, so that the whole body begins to function at a healthier level. The more frequently and regularly a mother performs prenatal exercise, the lower her anxiety score will be, and this will affect changes in diastolic blood pressure and breathing patterns (Septiani, 2017). Prenatal exercise can reduce anxiety and influence the hypothalamic-pituitary-adrenal (HPA) axis, thereby decreasing cortisol levels. The results of a study by Sartika et al. (2023) state that there are differences in cortisol levels and anxiety levels in primigravida patients before and after prenatal exercise prior to delivery.

Physical activity reduces cortisol in pregnant women by regulating the HPA axis, increasing relaxation hormones, improving sleep, and reducing anxiety and inflammation. Birth ball exercises can relieve physical tension by increasing baseline endorphin levels, which can trigger feelings of pleasure (Mirzakhani et al., 2016). Light to moderate physical activity stimulates the release of endorphins, neurotransmitters that provide relaxation and a 'feel-good' effect. These endorphins play a role in

suppressing the stress system by drawing a line between psychology and physiology by modulating the HPA axis: reducing CRH (hypothalamus) and ACTH (pituitary), ultimately suppressing cortisol production in the adrenal gland (De Nys et al., 2022).

Another complementary therapy to overcome anxiety and stress in pregnant women is relaxation using aromatherapy. Aromatherapy is a therapeutic treatment that uses essential oils to improve physical and psychological well-being. In addition to improving physical and psychological well-being, aromatherapy can relax tense nerves and muscles. Relaxation is one way to overcome anxiety or stress by relaxing the muscles and nerves. Relaxation can improve overall health by facilitating the body's metabolic processes and reducing aggression and certain behaviours (Octaviany, 2016).

One type of aromatherapy that is beneficial for pregnant women is lemon aromatherapy. The main component of lemon essential oil is limonene, which has benefits such as being mentally stimulating, anti-inflammatory, antispasmodic, hypotensive, anti-stress, and sedative. Lemon aromatherapy works through the olfactory process located behind the nose, thereby accelerating the absorption of the medication (Darvishpor et al., 2018). Lemon essential oil contains 66-80% limonene, geranyl acetate, nerol, linalyl acetate, 0.4-15%  $\beta$ -pinene, 14%  $\alpha$ -pinene, 6-14% terpinene, and myrcene. Chemical compounds such as geranyl acetate, nerol, and linalyl acetate have antidepressant, antiseptic, and mild sedative effects (Sari et al., 2023). Psychologically, the scent of lemon oil reduces mental fatigue and feelings of being overwhelmed (Stiles, 2017). Inhalation for 10 minutes at 30-minute intervals has been shown to reduce anxiety levels in pregnant women (Claudia & Rasyid, 2021).

Lemon aromatherapy produces a calming effect and significantly reduces cortisol levels. The calming effect may result from the rapid diffusion of volatile aroma oil molecules into the bloodstream, activating the brain through systemic circulation. When inhaled, these volatile molecules spread through the air and activate olfactory receptors in the nose, triggering an electrophysiological response that reaches specific areas of the limbic system, such as the amygdala and hypothalamus, where hormone levels and emotional states are controlled, most likely activating the neocortex (Kowshihan & Ravikumar, 2023).

Birth ball exercise and lemon aromatherapy affects cortisol levels in pregnant women. Birth ball exercise increases endorphin and serotonin levels, leading to decreased HPA axis activation and reduced CRH, ACTH, and cortisol levels. Lemon aromatherapy activates the limbic system, increases the levels of

relaxation neurotransmitters (GABA, dopamine, serotonin), and reduces stress responses, resulting in lower cortisol levels. The physiological effect is bodily relaxation, while the psychological effect is mental calmness, leading to reduced cortisol levels.

## Conclusion

Birth ball exercises and lemon aromatherapy affect the cortisol levels of pregnant women. Birth ball exercises and lemon aromatherapy have physiological effects that relax the body and psychological effects that calm the mind, thereby lowering cortisol levels. Physical activity in the form of birth ball exercises combined with lemon aromatherapy can be recommended for pregnant women to reduce anxiety during pregnancy and prevent excessive increases in cortisol levels.

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## Author Contributions

Conceptualization, W.I.; methodology, W.I.; validation, KUR, and YUS.; formal analysis, I.M.; investigation, W.I. resources, W.I.; data curation, KUR, and YUS.; writing original draft preparation, W.I.; writing—review and editing, W.I.; visualization, W.I. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

Authors declared no conflicts of interest

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