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Effects of prenatal yoga exercise on hepcidin and ferritin levels in pregnant women

Farida Tandi Bara[1]*, Suryani As'ad[2,3], Irfan Idris[4], Deviana Soraya Riu[5], Mardiana Ahmad[6]

[1] Faculty of Medicine, Universitas Hasanuddin, Indonesia.

[2] Department of Clinical Nutrition, Faculty of Medicine, Universitas Hasanuddin, Indonesia.

[3] Faculty of Medicine, Universitas Muhammadiyah Makassar, Indonesia.

[4] Department of Physiology, Faculty of Medicine, Universitas Hasanuddin, Indonesia.

[5] Department of Obstetrics and Gynecology, Faculty of Medicine, Universitas Hasanuddin, Indonesia.

[6] Postgraduate School, Midwifery Master Program, Universitas Hasanuddin, Indonesia.

* Correspondence: Farida Tandi Bara; faridatandibara@gmail.com

ABSTRACT

Prenatal yoga is a modification of hatha yoga tailored for pregnant women. This exercise is recommended throughout pregnancy. This study aimed to determine the effect of prenatal yoga exercise on the serum levels of hepcidin and ferritin in pregnant women. The study employed a quasi-experimental design with a pre- and post-test. A total of 134 second-trimester pregnant women participated and were divided into two groups (intervention group = 62, control group = 72). The intervention group received prenatal yoga exercises for 8 weeks (twice a week), while the control group attended only the standard pregnancy class. Each group was further divided into subgroups: anemic pregnant women, normal pregnant women, and overweight pregnant women. Demographic data were obtained through a basic questionnaire, while pre-pregnancy BMI data, obstetric history, and pregnancy examinations were sourced from the KIA book. Serum hepcidin levels significantly decreased in pregnant women who participated in prenatal yoga exercises (p=0.002), with the highest significance observed in overweight pregnant women (p=0.001). The average serum ferritin levels increased in all groups but were not statistically significant (p=0.759). Regular prenatal yoga exercises can reduce serum hepcidin levels in pregnant women, with a significant reduction noted in overweight pregnant women. Ferritin levels might be influenced by iron supplementation.

KEYWORDS

Prenatal Yoga; Hepcidin; Ferritin; Hemoglobin; Pregnant Women

1. INTRODUCTION

Prenatal yoga is widely practiced by pregnant women and has been shown to improve psychological conditions and reduce pregnancy complications. Prenatal yoga combines posture exercises (asana), breathing techniques (pranayama), and meditation (dhyana). Asana is categorized as a physical exercise (Ray et al., 2011) with light to moderate intensity. Yoga exercises enhance hematological parameters (Carranque et al., 2012; Sahai et al., 2019; Suna, 2017), increasing levels of hemoglobin, red blood cells, and platelets in anemic adolescents (Sharma & Gupta, 2016). Regular physical activity lowers hepcidin levels (Belaya et al., 2021). As a form of physical exercise, prenatal yoga may enhance iron metabolism by suppressing hepcidin, a key regulator of cellular iron metabolism, and increasing iron reserves in anemic pregnant women. This study focuses on the regulation of iron metabolism and iron reserves in pregnant women.

Iron is essential for metabolic processes, including oxygen transport, cell growth regulation, and differentiation. Iron deficiency is the leading cause of anemia. In addition to limiting oxygen delivery to cells, iron deficiency can lead to dysfunctions in the epithelial, muscular, and nervous systems. Iron deficiency anemia is the most common form of anemia in pregnant women. During pregnancy, iron is vital to support placental and fetal growth, meet the increased demand for erythrocyte production, and compensate for blood loss during childbirth.

Overweight and obesity during pregnancy increase the risk of iron deficiency (Garcia-Valdes et al., 2015) and are associated with elevated hepcidin levels (Dao et al., 2013). Obese pregnant women have lower iron reserves, and their iron absorption is reduced compared to overweight and average-weight women (Arabin & Stupin, 2014).

2. METHODS

2.1. Study Design and Participants

The study employed a quasi-experimental design with a pre-test and post-test, including control and treatment groups. It was conducted in the Pangkajene and Islands District from October 2022 to 2023. A total of 134 second-trimester pregnant women participated and were divided into two groups (intervention group and control group). The intervention group received prenatal yoga exercises for 8 weeks (twice a week), while the control group only attended the standard pregnancy class. Each group was further divided into subgroups: anemic pregnant women, normal pregnant women, overweight pregnant women.

Inclusion criteria: singleton pregnancy, pregnant women with mild anemia (Hb 9 - <11 g/dL), Gravida 1-3, pre-pregnancy BMI >25, a minimum gap of 2 years between deliveries for multigravida, second-trimester pregnancy, regular iron supplement consumption, willingness to participate in yoga sessions twice a week for 8 weeks (90 minutes per session), and fundal height consistent with gestational age. Exclusion criteria: anemia due to other causes, pregnant women with complications, concomitant diseases, or signs of infection.

The research protocol has been approved by the Ethics Committee of the Faculty of Medicine, Universitas Hasanuddin with protocol number UH22100605.

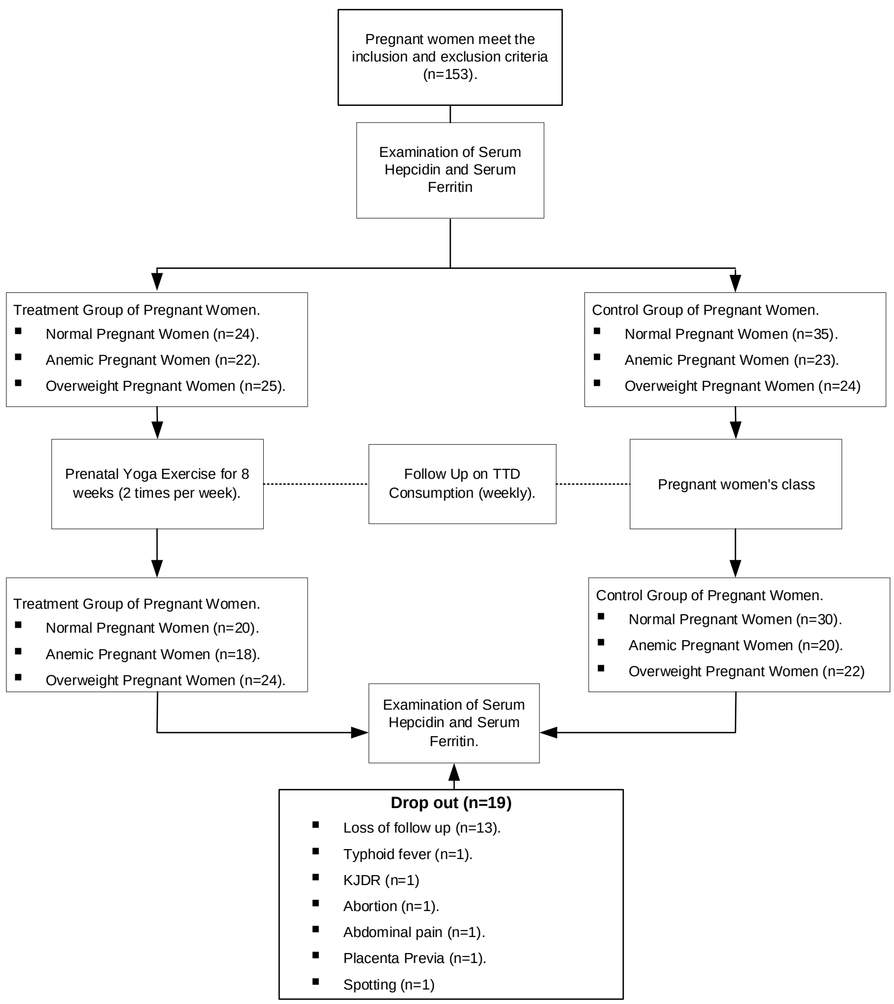

Figure 1. Flowchart of the study

2.2. Instrument and Procedure

Demographic data were obtained through a basic questionnaire, while pre-pregnancy BMI data, obstetric history, and pregnancy examinations were sourced from the KIA book. A 3 ml venous blood sample was collected into a serum tube, and centrifugation was performed at the Prodifa Laboratory in Pangkajene and Islands District. The samples were then transported to the HUMRc Laboratory of Hasanuddin University for hepcidin and ferritin serum examinations using ELISA. Table 1 presents the sequence and duration of prenatal yoga exercises.

Table 1. Sequence and duration of prenatal yoga exercises

Initial Relaxation (5 minutes)		
Breathing Exercise (5 minutes)	Dirgha Sawasam, Brahmari	
Pemanasan (Warm-up) (10 minutes)		
Asana (50 minutes)	Surya namsakara	Repetition 4 time
	Vidabadrasan 1, 2 dan viparita	Repetition 3 times
	Utkatasana dan tadasana	Repetition 3 times
	Prasarita Paddotasana	Hold for 3 breaths
	Bilikasana	Repetition 4-5 times. Hold for 3 breaths at the end of the movement
	Balancing table pose variations	Repetition 4-5 times. Hold for 3 breaths for each movement
	Balancing cow pose variations	Repetition 4-5 times. Hold for 3 breaths for each movement
	Child Pose	
Restorative (3-5 minutes)	Jathara Parvitartanasana	
Relaxation (15 minutes)	Savasana modifikasi	

2.3. Statistical Analysis

The study utilized several statistical methods to analyze the data, including Fisher's Exact Test, Mann-Whitney U Test, Wilcoxon Rank Test, and Kruskal-Wallis Test, all performed using SPSS software.

3. RESULTS

Table 2 shows a statistically significant difference between the basic to secondary education group and the higher education group in both the treatment and control groups (p=0.000), as well as with occupation (p=0.007). However, for the characteristics of gravida, hemoglobin levels, and body mass index classification, there was no statistically significant difference between the treatment and control groups (p>0.05). Additionally, the distribution of maternal age and gestational age showed no difference between the treatment and control groups (p>0.05). The consumption of Fe tablets over eight weeks also showed no statistically significant difference between the two groups (p>0.05) (Table 3).

Table 2. Differences between the control and intervention groups according to study variables

Characteristics	**Treatment (n=62)**	**Control (n=72)**	**Total (n = 134)**	**p-value**
	n (%)	**n (%)**	**n (%)**	
Education				0.000*
Basic-Intermediate	43 (38.7)	68 (61,3)	111 (100.0)	
Higher	19 (82.6)	4 (17.4)	23 (100.0)	
Occupation				0.007*
Housewife	47 (41.2)	67 (58.8)	114 (100.0)	
Working Mother	15 (75.0)	5 (25.0)	20 (100.0)	
Gravida				0.859
1	18 (42.9)	24 (57.1)	42 (100.0)	
2	26 (47.3)	29 (52.7%)	55 (100.0)	
3	18 (48.6)	19 (51.4)	37 (100.0)	
Hemoglobin Level				0.872
Anemia	18 (47,4)	20 (52.6)	38 (100.0)	
Normal	44 (45.8)	52 (54.2)	96 (100.0)	
BMI Classification				0.322
Overweight	24 (52.2)	22 (47.8)	46 (100.0)	
Normal	38 (43.2)	50 (56.8)	88 (100.0)	
			Fisher Exact, p<0,05	
Characteristics	Treatment (n=62)	Control (n = 72)		p - value*
	Mean (SD)	Mean (SD)		
Mother's Age (Years)	27.7 (4.6)	27,0 (4.5)		0.428
Gestational Age (Week	17.7 (3.2)	18.0 (3.4)		0.644
Height (cm)	154.7 (6.0)	154.5 (4.9)		0.589
			Mann-Whitney test, p<0,05	

Table 3. Differences in fe tablet consumption between control and intervention groups

Iron Tablet Intake*	Treatment			Control		
	Min-Max	Mean	SD	Min-Max	Mean	SD
Week 1	0.0-7.0	5.7	2.5	0.0-7.0	5.7	2.2
Week 2	0.0-7.0	6.2	1.9	0.0-7.0	6	1.6
Week 3	0.0-14.0	6.6	2.3	0.0-14.0	6.3	1.8
Week 4	0.0-14.0	6.8	2.2	0.0-7.0	6	1.6
Week 5	0.0-14.0	6.5	2.3	0.0-7.0	6	1.8
Week 6	0.0-14.0	6.5	2.4	1.0-7.0	6.2	1.4
Week 7	0.0-14.0	6.5	1.7	1.0-7.0	6.2	1.3
Week 8	0.0-14.0	6.7	1.8	1.0-7.0	6.5	1.1

The following table (Table 4) shows the differences between treatment and control groups according to hepcidin and ferritin levels pre- and post-intervention. The table indicates that the hepcidin levels in the treatment group significantly decreased (p=0.002). The highest decrease was observed in the overweight group (p=0.001), while the anemia group showed an average decrease of (2.3 -0.9 pg/mL), which was not significant (p=0.071), and the normal group (p=0.881). In the control group, a significant decrease also occurred (p=0.004). The Serum Ferritin levels in the treatment group significantly increased (p=0.001). In the normal group, it was p=0.005, in the anemia group p=0.012, and in the overweight group p=0.005. A significant increase was also observed in the control group (p=0.001). In the normal group, it was p=0.001, in the anemia group p=0.000, and in the overweight group p=0.000. From the results of evaluations before and after treatment, out of the three measurable changes, Hepcidin levels after Prenatal Yoga exercises experienced significant changes among the three comparison sub-groups (normal, anemia, and overweight), with a p-value of 0.002. The Ferritin levels did not show significant differences between the two groups.

Table 3. Differences between treatment and control groups according to hepcidin and ferritin levels pre- and post-intervention.

Variabel	Treatment (n=62)		p-value*	Control (n = 72)		p-value*
	Pre	Post		Pre	Post	
Hepcidin			**0.002**			**0.004**
Normal Pregnant Women	1.9 (0.9)	1.8 (0.9)	0.881	2.3 (1.6)	2.6 (1.5)	0.165
Anemic Pregnant Women	2.3 (1.1)	0.9 (1.1)	0.071	2.3 (1.1)	2.6 (1.2)	0.093
Overweight Pregnant Women	2.4 (1.1)	0.9 (1.1)	0.001	2.0 (0.7)	2.4 (0.9)	0.058
Ferritin			**0.001**			**0.001**
Normal Pregnant Women	53.4 (60.0)	123.8 (74.8)	0.005	57.2 (49.0)	107.4 (64.5)	0.001
Anemic Pregnant Women	53.6 (37.8)	103.4 (51.2)	0.012	35.8 (23.4)	123.4 (75.3)	0
Overweight Pregnant Women	61.4 (42.6)	135.6 (129.9)	0.005	55.2 (38.8)	94.4 (43.5)	0

*Wilcoxon Rank Test, p<0,05

Variable	Treatment (n=62)	Control (n = 72)	p-value*
	Mean (SD)	Mean (SD)	
Hepcidin-pre			**0.681**
Normal Pregnant Women	1.9 (0.9)	2.3 (1.6)	
Anemic Pregnant Women	2.3 (1.1)	2.3 (1.1)	
Overweight Pregnant Women	2.4 (1.1)	2.0 (0.7)	
Hepcidin-post			**0.002**
Normal Pregnant Women	1.8 (0.9)	2.6 (1.5)	
Anemic Pregnant Women	0.9 (1.1)	2.6 (1.2)	
Overweight Pregnant Women	0.9 (1.1)	2.4 (0.9)	
Ferritin-pre			
Normal Pregnant Women	53.4 (60.0)	57.2 (49.0)	**0.363**
Anemic Pregnant Women	53.6 (37.8)	35.8 (23.4)	
Overweight Pregnant Women	61.4 (42.6)	55.2 (38.8)	
Ferritin-post			
Normal Pregnant Women	123.8 (74.8)	107.4 (64.5)	**0.759**
Anemic Pregnant Women	103.4 (51.2)	123.4 (75.3)	
Overweight Pregnant Women	135.6 (129.9)	94.4 (43.5)	

*Kruskal Wallis test

4. DISCUSSION

4.1. Hepcidin Levels in Pregnant Women

Hepcidin levels in both the treatment and control groups showed a significant decrease on the second measurement ($p<0.05$). The highest decrease was observed in overweight mothers in the treatment group ($p<0.05$). Pregnant women with anemia in the treatment group experienced a decrease in hepcidin levels from an average of 2.3 ng/mL to 0.9 ng/mL, although this was not statistically significant ($p>0.05$). Pregnant women who participated in prenatal yoga exercises experienced a significant decrease in hepcidin levels, with the most significant decrease in the overweight pregnant women and anemic pregnant women groups. In the control group, the average serum hepcidin level increased, with the highest increase in the overweight pregnant women group. The hepcidin levels of pregnant women who participated in prenatal yoga exercises were lower than the control group.

In a healthy pregnancy, hepcidin levels decrease as pregnancy progresses. The decline in maternal hepcidin levels allows for an increase in iron supply into circulation through enhanced iron absorption from food and increased release of iron from storage sites (Fisher & Nemeth, 2017). Compared to the group of normal pregnant women and anemic pregnant women, hepcidin levels in the overweight pregnant women group significantly decreased in this study. Mild inflammation due to a healthy pregnancy is insufficient to raise hepcidin levels (Koenig et al., 2014). The average decrease in hepcidin levels in pregnant women with anemia is due to the regulation of hepcidin by decreased iron reserves.

Yoga asanas involve exercises that coordinate breath with movement, holding positions to stretch and strengthen specific body parts. It teaches individuals to stay focused and feel body sensations during uncomfortable poses while maintaining regular and deep breathing. Muscle contractions when holding certain poses result in an acute response leading to an increase in pro-inflammatory cytokines. With regular practice, an adaptive mechanism is achieved against prenatal yoga exercises. Inflammatory cytokines (such as IL-6 and TNF) decrease after yoga intervention (Chen et al., 2017). Vijayaraghava et al. (2015) showed that in the group performing regular yoga, baseline IL-6 levels, during and post-exercise, were lower compared to the control group (Ambarish et al., 2015). With lower plasma IL-6 levels, the upregulation of hepcidin can be suppressed.

The static poses of yoga asanas require isometric muscle contractions. Skeletal muscle, the primary organ that responds to exercise, increases metabolic activity, enhances the antioxidant system, and reduces inflammation (Hoffmann & Weigert, 2017). Improved flexibility is one of the most immediate and evident benefits of yoga (Woodyard, 2011). With regular training, there is gradual strengthening of muscles and connective tissues around bones and joints.

4.2. Ferritin Levels in Pregnant Women

There was a significant increase in ferritin levels in anemic pregnant women, normal-weight pregnant women, and overweight pregnant women who participated in prenatal yoga exercises ($p<0.05$) The average hepcidin level in the group of pregnant women who participated in prenatal yoga exercises was also higher than the control group of pregnant women (122.5 pg/mL vs 107 pg/mL). However, when comparing the average Ferritin levels in both groups, there was no significant difference between the group of pregnant women who participated in prenatal yoga exercises and the control group ($p>0.05$).

According to Fisher (2017), serum Ferritin concentration progressively decreased, reaching its lowest concentration in the third trimester. The increase in serum Ferritin levels after the second measurement in all groups is likely due to weekly monitoring of iron tablet intake, thereby improving adherence among pregnant women during the study. A cohort study by Hirosawa et al. (2022) found that iron supplementation significantly increased Ferritin levels.

In the group of overweight pregnant women who participated in prenatal yoga exercises, serum Ferritin levels increased more significantly than in other groups ($p<0.05$). In contrast, in the control group, the highest increase was in the group of anemic pregnant women. Among the group of pregnant women who participated in yoga exercises and the control group of pregnant women, the increase in Ferritin levels was not significantly different ($p>0.05$) Behzadnezhad et al. (2021) found that Ferritin levels were not influenced by physical exercise, including the intensity of the exercise.

Valdes's study (2015) found that the iron reserves of obese pregnant women were lower than those of pregnant women with a normal weight. Iron absorption in obese women is lower compared to overweight women and women with a normal weight (Arabin & Stupin, 2014). The decrease in body iron in obese women is due to an increase in Ferritin because of inflammation, and therefore it does not truly reflect iron reserves. Ferritin is an inflammation marker linked to obesity in several studies. In the context of obesity or overweight, Ferritin is more of an inflammation marker rather than an iron status indicator. Serum ferritin concentration has a strong correlation with total body iron reserves. During pregnancy, Ferritin levels drop due to hemodilution and possibly because of the mobilization of iron from storage with the decrease in hepcidin levels (Fisher & Nemeth, 2017; Possamai & Blasi, 2020). Serum Ferritin levels are lower in anemic conditions and decline further in moderate to severe anemia (Sharma et al., 2016).

Iron supplementation during pregnancy is needed to meet the daily iron requirements. Serum Ferritin levels in pregnant women with iron supplementation are higher (Means, 2020). Oral iron is often not well-tolerated, limiting its effectiveness. Oral iron might need to be consumed for three to six months to replenish iron reserves (Govindappagari et al., 2019). Without iron supplementation, Ferritin concentrations decrease throughout pregnancy and then gradually increase afterward (Milman, 2006).

5. LIMITATIONS

The exercises were conducted over a duration of 8 weeks, and measurements were taken only from pregnant women in their second trimester. A longer study duration and a larger sample size are needed to determine the effects of regular prenatal yoga on hematological indicators.

6. CONCLUSIONS

Regular prenatal yoga exercises may lead to a significant reduction in serum Hepcidin levels in pregnant women, especially in those who are overweight. Ferritin levels, however, are likely influenced by iron supplementation.

7. RECOMMNEDATIONS

Based on the conclusions regarding the effects of regular prenatal yoga exercises on serum Hepcidin levels and the influence of iron supplementation on ferritin levels, the following recommendations can be made:

1. **Incorporate Prenatal Yoga**: Encourage pregnant women, particularly those who are overweight, to incorporate regular prenatal yoga sessions into their routines to help reduce serum Hepcidin levels, which may contribute to improved iron metabolism.
2. **Monitor Iron Supplementation**: Healthcare providers should closely monitor ferritin levels in pregnant women and consider the impact of iron supplementation on these levels. Adjustments to supplementation may be necessary based on individual needs.
3. **Promote a Holistic Approach**: Combine prenatal yoga with nutritional counseling to address overall health, emphasizing the importance of a balanced diet that supports iron levels alongside physical activity.
4. **Educate on Benefits**: Provide education to pregnant women about the potential benefits of prenatal yoga for both physical and mental well-being, particularly in managing weight and improving iron metabolism.
5. **Conduct Further Research**: Encourage further research into the relationship between prenatal yoga, Hepcidin, and ferritin levels to strengthen evidence-based guidelines and recommendations for pregnant women.

6. **Personalize Care Plans**: Develop personalized care plans that consider each woman's unique circumstances, including weight, dietary habits, and exercise preferences, to optimize health outcomes during pregnancy.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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