

## Effect of pranayama versus aerobic exercise on hematological parameters in women with iron-deficiency anemia

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### ABSTRACT

A growing body of evidence shows that individuals with iron deficiency anemia have deficits in some of their hematological parameters that may be associated with increased fatigue, which affects their quality of life. This study aimed to differentiate between the efficacy of pranayama and aerobic exercise on hematological parameters in females with iron deficiency anemia. Sixty patients aged between 30 and 40 years were selected from the outpatient clinic of October 6 University Hospital and were randomly divided into two groups. Study group (I) (n=30) participated in 12 weeks of anemia medication, diet recommendations, and 50 minutes of yoga practice, divided into 15 minutes of asana, 30 minutes of pranayama, and 5 minutes of meditation, for six times/week. Control group (II) (n=30) participated in 12 weeks of medical treatment of anemia, dietary advice, and treadmill aerobic exercise sessions for six times per week. All subjects were assessed by a hematology analyzer, a six-minute walking test, and the fatigue severity scale before and after the treatment program. In both groups, there were statistically significant improvements in all assessed variables except lymphocytes ( $p<0.05$ ), with a higher percentage of improvement in favor of group I.

Pranayama is more effective than aerobic exercise in improving hematological parameters in females with iron deficiency anemia.

## **KEYWORDS**

Pranayama; Aerobic Exercise; Iron Deficiency; Anemic Females

## **1. INTRODUCTION**

Reduction in the absolute number of red blood cells (RBCs) in circulation is known as anemia, or the state in which the RBCs numbers and thus their ability to carry oxygen is inadequate to meet physiological requirements. Low hemoglobin (Hb) or hematocrit levels are the most common markers of anemia (Addo et al., 2021). Anemia frequently affects elderly people. If left undiagnosed or ignored, it can lead to serious consequences such as a higher risk of death, chronic illness, and diminished physical abilities (ELSherif et al., 2021). In clinical practice, iron deficiency anemia is thought to be the most frequent kind of anemia worldwide. The potential causes of anemia include chronic inflammation, malabsorption, and persistent bleeding (Tomasević et al., 2022).

Iron complexes containing selenium ligands are of increased interest due to their importance in several areas (Elkhateeb et al., 2019). The traditional treatment of hematological parameters of iron deficiency anemia was medical treatment and dietary advice, but nowadays there is strong evidence for adding yoga sessions, including pranayama, to the rehabilitation program of iron deficiency patients (Nandre & Patole, 2019). Furthermore, other research suggests adding aerobic exercise sessions to the rehabilitation program for patients with iron deficiency anemia (Nahas & Amir, 2017). Over the past century, yoga, a mind-body practice with roots in ancient India, has gained popularity in the West (Ismail & El-Azeim, 2021). There are numerous branches and variations of yoga, each with its beliefs and practices. However, all yoga classes share their incorporation of physical poses (asanas) and controlled breathing procedures (pranayama) (Ismail et al., 2022), occasionally along with the addition of meditation (dhyana) (Wieland et al., 2017; Ismail et al., 2022). The pranayama is the middle part of the yoga framework (Ismail et al., 2023). The pranayama is inferred from the two words "Prana" and "ayama", where "Prana" indicates energy and "ayama" indicates stretching (Elsheikh et al., 2023).

Exercise that relies primarily on the aerobic energy-generating mechanism, such as aerobic exercise (often called cardio), can range in intensity from low to high (Ismail et al., 2023). Swimming, cycling, running, rapid walking, jumping rope, hiking, playing tennis, regular training,

and lengthy slow-distance exercises are among the varieties of aerobic exercise (Balakrishnan & Abraham, 2021; Ismail, 2023).

Low Hb levels in females are linked to a high risk of cardiovascular disorders, cognitive decline, sleeplessness, depression, and a lower quality of life (QoL) (Ismail, 2023; Ismail et al., 2024). They are also linked to poor physical performance and executive function, elevated risk for fractures and falling, and more frequent and longer hospitalizations. Therefore, additional research on the efficacy of pranayama on hematological parameters in anemic females is necessary to learn more about this area (Chen-Edinboro et al., 2017). Thus, this research aims to compare the effectiveness of aerobic exercise and pranayama on females with iron deficiency anemia.

## **2. METHODS**

### **2.1. Design and Participants**

The pre-post-test control group design was utilized. This 12-week single-blind trial included sixty patients who had a documented diagnosis of iron deficiency anemia. The physician performed a preliminary physical examination on each patient. A clinical history was recorded, and each participant received an explanation of the study's protocol and goals. Participants were instructed to continue with their medications and routine activities throughout the study.

From October 6 University's outpatient clinics for internal medicine, sixty female patients with anemia were selected. They aged between 30 and 40 years and had body mass index (BMI) between 25 and 29.9 kg/m<sup>2</sup>. Every patient had an earlier history of anemia and was of a steady medical condition; she was multiparous (had  $\leq 3$  deliveries) and had a menstrual cycle lasting three to five days. Patients with cognitive or mental disabilities, other anemia types apart from iron deficiency anemia, auditory problems, diabetics, hypertensive patients, or those with neurological, cardiopulmonary, and musculoskeletal disorders were excluded from the study.

The Ethics Committee at the Faculty of Physical Therapy, Cairo University, gave approval for this study (P.T.REC/012/004556), which was also registered on ClinicalTrials.gov with the identifier (NCT05949437). Prior to the commencement of the study, patients were requested to sign informed consent for inclusion in the study and publication of the research's results.

### **2.2. Randomization**

The iron deficiency anemic females were assigned into two equal groups at random; 30 patients in each group: Group (I) received anemia medications, diet recommendations, and yoga

practice for 50 minutes, 6 days a week, for 12 weeks, while Group (II) received anemia medications, diet recommendations, and aerobic exercises in the form of a treadmill based on the target heart rate for 30 minutes, 6 days a week, for 12 weeks. The study was carried out between September 2023 and March 2024. To ensure randomization, patient groups were put in sealed, opaque envelopes and selected from a dark container.

## **2.3. Procedures**

### **2.3.1. Evaluation Procedures**

The demographic data (age, height, body weight, BMI) were collected during the initial interview for patients in both groups.

All females were evaluated before and following intervention by a hematology analyzer regarding the following hematological parameters: hemoglobin level, RBC count, hematocrit, lymphocytes, iron level, ferritin level, and iron binding capacity level. Also, the patient's functional capacity and fatigue level were evaluated via the six-minute walking test and fatigue severity scale, respectively.

A six-minute walking test (6 MWT) is utilized to evaluate the patient's functional capacity using a corridor with a distance of 30 meters, 2 cones, a stopwatch, a chair, a mark on the ground every 3 meters, and a sphygmomanometer. Blood pressure and heart rate were measured before the test. Then, instruct the patient to walk as far as possible for six minutes, record the distance walked at the end of the six minutes, and record the distance even if the patient did not complete the six minutes. However, document the reason for termination on the patient sheet (Rasekaba et al., 2009).

The Fatigue Severity Scale (FSS) is a tool for assessing the effects of fatigue; however, it is a brief questionnaire that asks you to rate your level of fatigue. The FSS comprises nine items that rate the severity of fatigue symptoms; the patient was instructed to read each item and circle a number between 1 and 7, depending on how well it describes their condition from the previous week and how much they agree or disagree that these items describe their symptoms. An overall score of less than 36 indicates that they may not be experiencing fatigue, while a total score of 36 or more indicates that they may need to see a medical professional for additional assessment (Kjeverud et al., 2021).

### **2.3.2. Treatment Protocols**

All of the patients in both groups (I and II) were given iron supplements (Ferroglabin capsules once a day) and dietary advice. They were told to eat more foods that are high in heme and non-heme iron, such as liver, red meat, chicken, seafood, nuts, eggs, dark-green leafy vegetables (like Spanish

and seaweed), and dried fruits like figs and prunes. To help the iron absorb better, they were also told to eat vitamin C-rich foods like orange, lemon, or guava (Jyothi et al., 2024).

*Exercise training protocols:* All participating females in group I received yoga practice for 50 minutes, 6 days a week for 12 weeks in the form of:

- Asanas for 15 minutes, which were divided into Tadasana, Shavasana, Supta-Baddhakonasana (reclining butterfly), and Balasana (Singh et al., 2008).
- Pranayama (Deep Breathing—Anuloma Viloma—Kapal Bhai—Ujjayi—Suryabhedhi Pranayama) for 30 minutes (Sharma & Gupta, 2016).
- Finally, engage in 5 minutes of meditation (Saeed et al., 2019).

### ***2.3.2.1. Asanas practice***

#### ***Steps of Tadasana***

Take a deep breath, raise your arms above your head, and maintain a slight distance between your feet while standing. With your hands facing up, clasp your fingers together, release your breath, lift your shoulders to your ears, then release all tension from your muscles and take a step back to the beginning position.

#### ***Steps of Shavasana***

After setting your limbs, relax any effort to keep them in place and allow your breath to proceed naturally. For support, push your shoulder blades into your back. Separate your knees. Bring your arms along your body, but slightly apart from your torso.

#### ***Steps of Balasana or Child's pose:***

Take a seat on your heels, with your knees wider than your hips. Bend your head toward the ground. Place your hands under your forehead or straighten your arms in front of you. Breathe into your backside. Hold this pose for a duration between 30 seconds and several minutes.

#### ***Steps of Reclining Butterfly Pose (Supta Baddhakonasana)***

On your yoga mat, lie down with your legs bent at the knee and your feet grounded. Keep the feet together, and by externally rotating your hips, tilt both knees sideways, and bring the soles of your feet together, just like you would in the seated version. Open your legs as far as possible, depending on your hip and thigh muscle flexibility. Place a rolled towel under your neck if you have trouble keeping your head completely on the floor. Keep your hands by your side, palms facing

down, or place them on your abdomen. Hold the pose for 5-7 breaths. This pose can be practiced for up to 7-10 minutes if performed as a restorative pose.

### **2.3.2.2. Pranayama**

For 30 minutes while setting at padmasana or lotus pose, which was divided into (Deep Breathing—Anuloma Viloma—Kapal Bhai—Ujjayi—Suryabhedhi pranayama). Each pranayama technique was practiced for 2 minutes, separated by a 1-minute rest until the 30-minute pranayama sessions ended. The pranayama session was composed of:

Deep Breathing: is the science of proper breathing, which involves slow and deep breaths held momentarily in full inspiration within the limits of comfort.

#### ***Steps of deep breathing pranayama***

Inhalation: Breathe in from the diaphragm, slowly, deeply, and steadily. Hold the breath for two seconds before releasing it and going back to the beginning step.

Anuloma Viloma: It is alternate nostril breathing with breath held to the count of 16.

#### ***Steps of Anuloma Viloma pranayama***

Sit comfortably with your legs crossed, place your hands on your knees, raise your right hand toward your nose, and exhale fully. Next, close your right nostril with your thumb, inhale from your left nostril, close it with your fingers, open your right nostril, and breathe out through this side.

Kapal Bhari: It detoxifies the body of toxins and purifies the blood. It involves short breaths with forceful expulsion of breath by contracting the abdomen.

#### ***Steps of Kapal Bhari pranayama***

Maintaining a straight spine, sit back and inhale deeply. As you exhale, pull your stomach inside. As your stomach muscles relax, the breath will automatically enter your lungs. To complete one round of Kapal Bhati Pranayama, exhale twenty times.

Ujjayi: It is loud breathing with closed glottis.

#### ***Steps of Ujjayi pranayama***

While keeping the mouth closed, tighten your throat so your breathing sounds rushed, similar to snoring; use your diaphragm to control your breathing; and make sure that the duration of your inspiration and expiration is the same.

Suryabhedhi pranayama: It entails breathing in deeply and slowly via the right nostril and out through the left (Sharma & Gupta, 2016)

### ***Steps of Suryabhedhi pranayama***

Sit in a comfortable position, inhale through your right nostril, retain the internal breath, exhale through your left nostril, and repeat the cycle for as long as comfortable.

#### ***2.3.2.3. Meditation for 5 minutes using the following steps:***

When you're ready, softly open your eyes after sitting up straight in a lotus or padmasana pose, breathe deeply, and slowly, and note how you feel while scanning your body. You should also be mindful of any thoughts you may be experiencing, and when your mind becomes distracted, return your attention to your breathing (Saeed et al., 2019).

All females participating in Group II practiced treadmill aerobic exercises based on the target heart rate for 30 minutes six days a week for 12 weeks.

The aerobic exercise sessions started by measuring the heart rate, respiratory rate, and blood pressure before the session and after 30 minutes of rest to ensure that the patient reached resting vital signs rates; the session was divided into 10 minutes of warming up, which subdivided into 5 minutes stretching exercises for tight lower limb muscles determined during assessment stage by flexibility test and 5 minutes walking of a low speed at a treadmill, then 20 minutes conditioning phase walking at treadmill according to exercise target heart rate, then 10 minutes of cooling down which subdivided into 5 minutes walking at low speed and the last 5 minutes consisted of stretching exercises combined with diaphragmatic breathing and finally 5 minutes rest followed by measuring heart rate, respiratory rate, and blood pressure to ensure that the vital signs returned into normal rates (Ismail et al., 2023).

## **2.4. Statistical Analysis**

Shapiro-Wilk and Levene's tests for homogeneity of variances were used to confirm the normality of the data and assess group homogeneity. The distribution of the data was normal, and the variance was homogeneous. When comparing groups based on all demographic characteristics, the unpaired t-test was used. The effects of treatment on hemoglobin level, RBC count, hematocrit, lymphocytes, serum iron level, ferritin level, iron-binding capacity level, six-minute walking test, and fatigue severity scale were investigated using mixed MANOVA. When the MANOVA showed significant results, additional univariate ANOVAs were conducted. For multiple comparisons, post-

hoc testing using the Bonferroni correction was employed. For all statistical tests, p-value = 0.05 was chosen as the significance level. SPSS version 23 was used.

### 3. RESULTS

Sixty females with iron deficiency were selected from the outpatient clinics of the internal medicine unit of October 6 University for recruiting. Four patients were dropped since they didn't fit the eligibility requirements and didn't want to take part. Table 1 shows the patient's characteristics of the Pranayama and aerobic groups. There were no statistically significant differences regarding patients' general characteristics between both groups (p-value  $\geq$  0.05).

**Table 1.** Demographic characteristics of patients (N=60)

	<b>Pranayama group</b>	<b>Aerobic group</b>	<b>t- value</b>	<b>p-value</b>
	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
<b>Age (years)</b>	34.17 $\pm$ 2.85	35.17 $\pm$ 3.3	-1.26	0.21 <sup>a</sup>
<b>Weight (kg)</b>	68.3 $\pm$ 4.74	67.77 $\pm$ 6.91	0.35	0.73 <sup>a</sup>
<b>Height (cm)</b>	162 $\pm$ 5.95	158.97 $\pm$ 4.65	1.03	0.06 <sup>a</sup>
<b>BMI (kg/m<sup>2</sup>)</b>	25.96 $\pm$ 1.48	26.82 $\pm$ 2.17	-1.78	0.08 <sup>a</sup>

Note. Data were expressed as mean  $\pm$  Standard deviation; N: number; P: probability; BMI: body mass index; <sup>a</sup>: non-significance difference

Mixed-design multivariate analysis was utilized to determine the efficacy of treatment on the measured variables. There was a statistically significant difference between groups, as Wilk's A = 0.27, F (9, 50) = 14.85, p-value < 0.0001, Partial Eta Squared ( $\eta^2$ ) = 0.73. Also, there was a statistically significant effect on time (before and after treatment) as Wilk's A = 0.02, F (9, 50) = 366.44, p-value < 0.0001,  $\eta^2$  = 0.99, as well as for the interaction between groups and time as Wilk's A = 0.04, F (9, 50) = 120.65, p-value < 0.0001,  $\eta^2$  = 0.96.

Table 2 shows within and between group analysis for CBC profile, 6MWT and fatigue severity scale, while Table 3 presents the within and between group analysis for iron profile. At baseline, no statistically significant differences between Pranayama and the aerobic group were revealed in all measured variables (p-value  $\geq$  0.05), as shown in Tables 2 and 3.

**Table 2.** Within and between group analysis for CBC profile, 6MWT and fatigue severity scale

Variables	Pranayama group	Aerobic group	MD (95% CI)	p-value (between groups)	$\eta^2$
<b>Hemoglobin level (gm/dl)</b>					
Pre-treatment	8.66±1.27	9±0.83	-0.34 (-0.9 to 0.52)	0.23 <sup>a</sup>	
Post-treatment	11.01±1.24	10.2±0.98	0.81 (0.23 to 1.39)	0.007 <sup>b</sup>	<b>0.12</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.0001 <sup>b</sup>			
<b>RBC count (mill/cmm)</b>					
Pre-treatment	3.41±0.27	3.51±0.21	-0.1(-0.22 to 0.03)	0.12 <sup>a</sup>	
Post-treatment	3.86±0.29	3.62±0.19	0.24 (0.11 to 0.37)	0.0001 <sup>b</sup>	<b>0.2</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.003 <sup>b</sup>			
<b>Hematocrit (%)</b>					
Pre-treatment	27.42±4.35	28.81±3.69	-1.39 (-3.47 to 0.7)	0.19 <sup>a</sup>	
Post-treatment	33.07±4.05	29.42±3.61	3.64 (1.66 to 5.63)	0.001 <sup>b</sup>	<b>0.19</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.03 <sup>b</sup>			
<b>lymphocytes %</b>					
Pre-treatment	37.28±3.21	37.61±2.74	-0.33 (-1.87 to 1.21)	0.67 <sup>a</sup>	
Post-treatment	35.62±3.44	37.65±2.67	-2.04 (-3.63 to -0.45)	0.01 <sup>b</sup>	<b>0.1</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.85 <sup>a</sup>			
<b>6MWT (m)</b>					
Pre-treatment	259.33±33.38	250.77±17.85	8.57 (-5.27 to 22.4)	0.22 <sup>a</sup>	
Post-treatment	307.17±35.51	268.9±15.34	38.27 (24.13 to 52.4)	0.0001 <sup>b</sup>	<b>0.34</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.0001 <sup>b</sup>			
<b>Fatigue Severity Scale</b>					
Pre-treatment	51.23±8.99	50.93±8.26	0.3(-4.21 to 4.81)	0.9 <sup>a</sup>	
Post-treatment	35.13±4.56	40.93±4.25	-5.8(-9.91 to -1.69)	0.007 <sup>b</sup>	<b>0.12</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.0001 <sup>b</sup>			

Note. gm/dl: gram per deciliter; mill/cmm: million per cubic millimeter; mcg/dl: Micrograms per deciliter; ng/ml: Nanograms per milliliter; 6MWT: 6 minute walk test; p-value: probability; <sup>a</sup>: non-significance difference; <sup>b</sup>: significance difference; CI: confidence interval.MD: mean difference;  $\eta^2$ : partial eta squared.

After twelve weeks of treatment, statistically significant differences were revealed between pranayama and aerobic groups at all measured variables, with more favor to the pranayama group (p-value < 0.05), as shown in Tables 2 and 3. There were statistically significant differences in all outcome measures when comparing the pre-and post-intervention results (p-value<0.0001) in the Pranayama group, as shown in Table 2 and 3. In the aerobic group, there were statistically significant differences in serum iron, ferritin, hematocrit, 6MWT, and the fatigue severity scale. However, there were no statistically significant differences in serum iron, RBC count, hematocrit, or iron binding capacity level (Table 2 and 3).

**Table 3.** Within and between group analysis for iron profile

Variables	Pranayama group	Aerobic group	MD (95% CI)	p-value (between groups)	$\eta^2$
<b>Serum Iron Level (mcg/dl)</b>					
Pre-treatment	23.76±3.56	24.43±4.98	-0.67 (-3.78 to 2.44)	0.67 <sup>a</sup>	
Post-treatment	41.8±5.56	23.96±4.94	17.84 (13.11 to 22.57)	0.0001 <sup>b</sup>	<b>0.5</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.65 <sup>a</sup>			
<b>Ferritin Level (ng/ml)</b>					
Pre-treatment	13.44±1.62	14.07±2.76	-0.63 (-1.8 to 0.54)	0.28 <sup>a</sup>	
Post-treatment	31.01±5.06	13.65±2.73	17.35 (15.25 to 19.46)	0.0001 <sup>b</sup>	<b>0.83</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.65 <sup>a</sup>			
<b>Iron Binding Capacity level (mcg/dl)</b>					
Pre-treatment	348.97±51.03	342.37±45.97	6.6 (-18.5 to 31.7)	0.6 <sup>a</sup>	
Post-treatment	314.1±45.2	351.43±45.58	-37.33 (-65 to -9.66)	0.009 <sup>b</sup>	<b>0.19</b>
p-value (within-group)	0.0001 <sup>b</sup>	0.52 <sup>a</sup>			

Note. gm/dl: gram per deciliter; mill/cmm: million per cubic millimeter; mcg/dl: Micrograms per deciliter; ng/ml: Nanograms per milliliter; p-value: probability; <sup>a</sup>: non-significance difference; <sup>b</sup>: significance difference; CI: confidence interval. MD: mean difference;  $\eta^2$ : partial eta squared

#### 4. DISCUSSION

The most common nutritional disorder in the world is nutritional anemia, which is a generalized public health issue that affects both developed and developing nations and has serious repercussions for people's health as well as their economic and social advancement. According to WHO (2008), an imbalance in food intake causes anemia in 24.8% of the world's population, or over 1.62 billion people, with 10 million cases reported in India. A nutritional imbalance occurs in a healthy individual for a variety of reasons, including decreased intake, increased losses, increased demands, reduced absorption, and diminished utilization. As a result, nutritional anemia causes the body to have insufficient one or more vital nutrients, particularly iron (Bhadra et al., 2020).

The pranayama consists of 3 stages: inhalation, retention of the breath, and exhalation. The pranayama has a mechanism for improving hematological parameters, thereby improving iron deficiency anemia. During inhalation, the heart rate slows down, and the diastole, or the heart's resting phase, lengthens. To better propel more blood into circulation during the subsequent contraction pumping action (systole), the heart's cavities fill with blood more readily during the retention of breath stage because more air is entering the lungs, lowering the blood's oxygen level. The brain is sensitive to this decreased oxygen tension, which indicates that the blood is of poorer

quality and seeks to obtain more blood. Cerebral anoxia causes cerebral vasodilation, which increases cerebral circulation and causes additional capillaries to open in the brain and throughout the body, reducing iron deficiency anemia (Saoji et al., 2019).

Additionally, when iron levels rise above the typical range for men and women, which is 65 to 175 mcg/dl and 50 to 170 mcg/dl, respectively, the liver produces the hormone hepcidin. This hormone increases to reduce the iron in cellular tissue, and when it decreases, the body needs to increase erythropoiesis, which in turn increases Hb levels and improves iron deficiency anemia. (Pagani et al., 2019).

The generalized tissue hypoxia that occurs, for example, when the abdominal viscera are squeezed during the breath retention stage of pranayama and then the pressure is released, reduces the liver's production of hepcidin, which in turn boosts erythropoiesis in the bone marrow, raises the RBC and Hb levels, and enhances the absorption of iron into body tissues. This, in turn, improves the symptoms of iron deficiency anemia, such as increasing the distance walking during the six-minute walking test and reducing the fatigue severity scale (Tiwari et al., 2017).

Hepatocytes secrete a peptide hormone called hepcidin. Since it prevents iron from leaving the enterocyte and entering the bloodstream, hepcidin is regarded as the ultimate controller of iron homeostasis. Hepcidin expression is influenced by iron levels, erythropoiesis, inflammatory conditions, and hypoxia. Hepcidin additionally restricts iron leakage from the duodenum, placenta, and macrophages. Stress factors including hypoxia and anemia, encourage erythropoiesis, which lowers hepcidin activity. Hepcidin suppression increases iron entry into plasma, which is necessary to meet the high demand for iron supply to the bone marrow for erythropoiesis. Because hypoxia causes the kidneys to produce more erythropoietin (EPO), which encourages the development of erythroid precursor cells, certain endurance athletes frequently exercise in hypoxic conditions to improve performance. Erythroferrone (ERFE) production is stimulated by the kidney's increased production of EPO. Erythroblasts release ERFE, a hormone that prevents the expression of hepcidin. (Rishi et al., 2015).

Meanwhile, lowering the level of hepcidin during aerobic exercise improves the symptoms of iron deficiency anemia, which increases the distance covered during the 6-MWT and lowers the fatigue severity scale. Because lowering hepcidin levels in the liver stimulates the bone marrow to synthesize more RBCs, raises Hb levels, and helps the body absorb iron into tissues, these changes help improve iron deficiency anemia (Larsuphrom & Latunde-Dada, 2021).

The current findings highlight the benefits of pranayama and aerobic exercise in improving hematological parameters in iron deficiency anemic females. These results agreed with the previous research investigating the effectiveness of pranayama and aerobic exercise programs in this patient's category. These results were supported by Nandre & Patole (2019), who found that practicing yoga for 1 hour six days a week for eight weeks increased Hb level from (9.5 to 12.2) gm/dl, which improved iron deficiency anemia.

The results of this randomized trial agreed with Singh et al.'s (2019) study, which found that pranayama practiced six days a week for six weeks might be a new, noninvasive way to help iron deficiency anemia patients raise their Hb levels. Also, the study's result was confirmed by Ramanath et al. (2013), who reported that using pranayama 1 hour daily for 3 months increased the Hb level from 7 to 12 gm/dl, which improved iron deficiency anemia. Furthermore, Sharma et al. (2014) documented that 1-hour daily yoga sessions for 30 days improved hemoglobin and hematocrit levels while slightly decreasing white blood cell (WBC) levels, which improved the condition of iron deficiency anemia.

Banerjee et al. (2019) also concluded that practicing a yoga session daily for 3 months showed significant improvement in Hb and platelet levels and non-significant improvement in WBC levels, which in turn improved iron deficiency anemia symptoms. Additionally, Sharma & Gupta (2016) found that practicing yoga for an hour a day for two months statistically increased hemoglobin and RBC count levels, non-statistically increased platelet levels, and significantly decreased WBC counts. Moreover, Singh & Phulkar (2019) found that practicing pranayama for 40 minutes daily for 8 weeks may be a new noninvasive treatment to improve Hb levels for patients with iron deficiency anemia. Also, Dayalan et al. (2012) found that practicing a yoga session daily for six weeks increased the following hematological parameters: Hb, neutrophils, lymphocytes, platelets, packed cell volume (PCV) and mean cell volume (MCV) levels, which improved iron deficiency anemia.

In line with our results, Chizoba O et al. (2020) stated that 30 minutes of treadmill training increased RBCs, Hb, hematocrit, and lymphocytes compared to before the exercise. These levels then dropped back to where they were before the exercise 24 hours later, which improved iron deficiency anemia. Additionally, Sepriadi et al. (2020) examined the effects of aerobic exercise, specifically jogging three times a week for six weeks, on hematological parameters in 20 participants between the ages of 18 and 22. They found that this exercise significantly increased Hb levels, which in turn improved the symptoms of iron deficiency anemia. Furthermore, Nahas & Amir (2017) confirmed

that aerobic exercise, specifically 30 minutes on a cycle ergometer, combined with iron supplementation three times a week for 12 weeks, improved hematological parameters and the fatigue scale. Although the reported increase in Hb level was not statistically significant, the significant improvement in fatigue symptoms demonstrated the improvement of iron deficiency anemia.

Additionally, Sazvar et al. (2013) partially agreed with the current findings, as they found that after 8-week aerobic morning exercise, the number of RBCs, Hb levels, and hematocrit percentage increased, which improved iron deficiency anemia, but disagreed with our result as the number of platelets decreased significantly.

Consistently, Cengiz and Çınar (2014) somewhat concurred with the current findings, finding that inactive females who participated in an 8-week core activity program experienced beneficial improvements in hematological values; however, these changes were not significant in others except for RBCs. Moreover, Khan et al. (2019) found that practicing aerobic exercise in the form of running 1 mile three times a week for eight weeks in 30 participants aged between 22 and 26 years old provided significant increases in RBCs, WBCs, and platelets, which improved iron deficiency anemia. As well, Singh (2017) revealed that the aerobic exercise performed 5 times a week for 6 weeks provided a significant increase of WBCs in 20 participants aged between 18 and 23 years old.

Furthermore, Elsherif & Yousef (2021) found that daily iron capsules and multivitamins, along with 30 minutes of treadmill exercise three times a week for three months, significantly improved the RBCs, Hb, hematocrit, and 6MWT values in 30 post-menopausal anemic females, thereby improving the condition of iron deficiency anemia. In contrast, Belkadi (2019) explored the efficacy of 75 minutes of aerobic exercise, specifically walking and ground exercises, three times a week for 8 weeks on hematological parameters in 9 participants aged between 25 and 29 years old. The study reported no significant increase in iron levels or total iron binding capacity, indicating no significant improvement in iron deficiency anemia. Johannsen et al. (2012) disagreed with the current results as they revealed a significant decrease in WBCs in 464 post-menopausal women aged between 45 and 75 years old who practiced aerobic exercise 3 times a week for 6 months. Furthermore, Çiçek (2018) opposed the present findings as they indicated that practicing regular aerobic exercise for a period of 16 weeks showed a non-significant decrease in Hb and hematocrit values, which means that aerobic exercise has no positive effect on iron deficiency anemia patients.

## 5. CONCLUSIONS

In conclusion, Pranayama is more effective than aerobic exercise in improving the hematological parameters of females with iron deficiency anemia. Incorporating Pranayama breathing exercises alongside regular aerobic exercise may be a highly effective approach to improving hematological health.

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The authors declare no conflict of interest.

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