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Yogic Practices and Their Influence on Hematological Responses: A Physiological Perspective

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Abstract

Background. Yoga, an ancient discipline integrating physical postures, breath control, and meditation, has been linked to various physiological benefits. Investigating its influence on hematological parameters is essential, as these are key indicators of health and performance.

Objectives. This study aimed to assess the effects of yogic practices on hematological parameters —specifically hemoglobin (Hb), red blood cell (RBC) count, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) — among college students.

Materials and Methods. A total of 20 male college students aged 17 to 22 years participated in the study. They were randomly assigned to either an experimental group ($n = 10$), which underwent the yogic intervention, or a control group ($n = 10$), which did not participate in any structured physical activity. The experimental group (EG) engaged in daily 60-minute sessions, six days per week, comprising Surya Namaskar, asanas, pranayama, and relaxation techniques. Hematological parameters were measured at baseline and after 12 weeks using the Tulip Coralyzer Smart 200, an automated hematology analyser. Statistical analysis was performed using paired and independent t-tests, with significance set at $p < 0.05$.

Results. Post-intervention analysis revealed a statistically significant increase in Hb levels within the EG ($p = .015$), indicating enhanced oxygen-carrying capacity. No significant changes were observed in RBC count, PCV, MCV, MCH, and MCHC in either group.

Conclusions. Significantly improved hemoglobin levels were determined in the EG, indicating potential benefits for oxygen transport and aerobic capacity. The findings demonstrate that enhancing other hematological parameters suggests selective hematological adaptations to yogic practices.

Keywords: hematologic tests, hemoglobins, erythrocyte count, yoga, intervention studies.

Introduction

The role of yogic practices in enhancing human health and well-being has been extensively documented across traditional and contemporary scientific literature (Woodyard, 2011; Chen, 2024). Yoga, a discipline that integrates physical postures (asanas), breath regulation (pranayama), and relaxation techniques, has been recognized for its capacity to improve autonomic function (Shobana et al., 2022), reduce oxidative stress (Patil et al., 2014), and enhance systemic homeostasis (Pratiti, 2022). While a substantial body of research has explored the physiological benefits of yogic practices, its specific influence on hematological parameters remains insufficiently examined. The Complete Blood Count (CBC) is a vital hematological test used to assess overall health, detect deficiencies like anemia, and monitor recovery (Chanda et al., 2025). Hematological variables, including Hb, RBC, PCV, MCV, MCH, and MCHC, are critical indicators of oxygen transport efficiency (Witeska et al., 2022), erythropoiesis (Valent et al., 2018), and overall hematopoietic function (Witeska et al., 2023). These variables are integral to sustaining optimal physiological performance (Brocherie et al., 2015), particularly among populations exposed to stress and sedentary lifestyles, such as students (Alhmoud et al., 2021). Imbalances in hematological parameters, including hemoglobin (Hb), red blood cell (RBC) count, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC), may signify underlying physiological or pathological conditions. A reduction in these indices is often associated with anemia (Johnson-Wimbley & Graham, 2011), leading to impaired oxygen transport and diminished physiological efficiency (Haas & Brownlie, 2001), whereas elevated levels may indicate polycythemia (Lupak et al., 2020), dehydration (Chidozie et al., 2020). Alterations in MCV, MCH, and MCHC reflect morphological variations in erythrocytes (Caimi et al. 2024), commonly linked to nutritional deficiencies or hematological disorders (Deepthi et al., 2018; Zhang et al., 2022). Given their critical role in oxygen delivery and metabolic function, maintaining hematological equilibrium is essential for overall health and optimal physiological performance.

Hematopoiesis, the process of blood cell formation (Jagannathan-Bogdan & Zon, 2013), is intricately regulated by neuroendocrine mechanisms (Maestroni, 1998), physical activity (Vanhie & De Lisio, 2022), and overall systemic health (Carpenter & Maryanovich, 2024). Hemoglobin, a crucial oxygen-carrying protein within erythrocytes (Longeville & Stingaciu, 2017; Mairbäurl & Weber, 2012), plays a fundamental role in sustaining aerobic metabolism (Storz, 2016), and cellular respiration (Sera, 2023). Maintaining adequate hemoglobin levels is crucial for ensuring optimal oxygen transport to tissues and organs, which is fundamental for cellular energy production and overall physiological homeostasis (Billett, 1990; Pittman, 2011). Red blood cells (RBCs) are integral to oxygen transport and the preservation of physiological homeostasis (Kuhn et al., 2017). An adequate RBC count is essential for optimizing oxygen delivery to tissues and muscles, which is crucial for sustaining overall physiological function (Mairbäurl, 2013). RBC count and PCV serve as indicators of blood viscosity and oxygen-carrying capacity (Nader et al., 2019; Roberson & Bennett-Guerrero, 2012), while MCV, MCH, and MCHC provide insights into erythrocyte morphology and functional integrity (Erhabor et al., 2021). Disruptions in these parameters can have profound implications for health, predisposing individuals to fatigue, impaired cognitive function, and diminished immune competence. Given the increasing prevalence of lifestyle-induced hematological imbalances (Agarwal, 2022), identifying holistic, non-invasive interventions such as yogic practice is of paramount scientific and public health significance.

The yogic practice has been postulated to induce favorable hematological adaptations through multiple physiological pathways. The practice of pranayama enhances pulmonary efficiency (Mooventhan & Khode, 2014), optimizes oxygenation (Pandey et al., 2019), and regulates autonomic function (Bhimani et al., 2011), all of which contribute to the improved erythropoietic activity. Additionally, yoga-mediated modulation of endocrine function, particularly in relation to cortisol and erythropoietin levels, plays a pivotal role in maintaining hematological stability (Arora & Bhattacharjee, 2008; Kelly et al., 2000). The cumulative effects of these mechanisms suggest that yogic practices serve as a viable intervention for improving hematological health, yet empirical validation remains limited.

The scientific rationale for exploring yoga's effects on hematological parameters is grounded in its demonstrated impact on physiological homeostasis, autonomic balance, and metabolic efficiency. Prior studies indicate that yogic practices positively influence cardiovascular and pulmonary function, leading to improved tissue oxygenation and metabolic efficiency (Loganathan et al., 2019; Panjeta et al., 2019; Chaya & Nagendra, 2008). These benefits are closely linked to hematopoietic activity, given that enhanced oxygen transport mechanisms stimulate erythropoiesis and improve overall hematological stability.

Furthermore, stress-related hormonal imbalances are known to affect hematological variables (Mischler et al., 2005). Chronic stress, which is prevalent among college students, elevates cortisol levels (Cay et al., 2018), leading to hematopoietic suppression (Gilboa-Geffen et al., 2012), and dysregulated erythrocyte production (Obeagu et al., 2024). Yogic practices reduce cortisol levels (Thirthalli et al., 2013), thereby mitigating stress-induced hematological imbalances. Additionally, yogic practice's impact on nitric oxide bioavailability and endothelial function contributes to improved microcirculation (Singh & Shah, 2024), facilitating more efficient oxygen transport and erythropoiesis.

Existing literature on the relationship between exercise and hematological variables has primarily focused on endurance training (Prommer et al., 2018), resistance exercises (Skouras et al., 2023), and high-intensity interval training (HIIT) (Belviranli et al., 2017). While these modalities demonstrate significant hematopoietic adaptations, they may not be suitable for all populations due to their intensity and potential physical constraints. Yogic practices, as a low-impact, accessible, and holistic practice, offer a viable alternative that warrants systematic exploration in the context of hematological health.

The need for this study is further reinforced by the gap in the literature regarding the direct impact of yogic practices on specific hematological markers. Most studies investigating yogic practice's health benefits focus on its effects on stress reduction, cardiovascular health, and metabolic regulation, while hematological responses remain an under-researched domain. Given that Hb, RBC, PCV, MCV, MCH, and MCHC are crucial indicators of overall physiological resilience, a deeper understanding of yogic practice's influence on these parameters contributes to more comprehensive health recommendations.

This study is designed to generate robust scientific insights into the impact of yogic practices on key hematological parameters, thereby elucidating the physiological underpinnings of yogic practice's influence on hematopoiesis. By addressing the existing research void, it aims to provide a foundation for the integration of yogic practices into evidence-based health interventions. Given the accessibility, cost-effectiveness, and holistic benefits of yogic practices, its potential role in optimizing hematological health warrants further scholarly inquiry and clinical validation. The findings of this study hold substantial implications for educational institutions, healthcare practitioners, and policymakers aiming to enhance holistic well-being among young adults and the broader population. Furthermore, this research contributes meaningfully to public health and preventive healthcare by addressing anemia and hematological deficiencies, which remain prevalent global health concerns (Chaparro & Suchdev, 2019). The identification of non-invasive, lifestyle-based interventions, such as yogic practices, offers a viable alternative or complementary approach to conventional therapeutic strategies, thereby expanding the scope of evidence-based wellness initiatives.

Materials and Methods

A comprehensive literature search was systematically conducted across multiple reputable databases, including MEDLINE, EMBASE, Scopus, Science Direct, the Directory of Open Access Journals (DOAJ), PubMed, and Google Scholar. The search utilized a well-defined set of keywords, including "Yogic practices," "Hemoglobin," "Red Blood Cells," "PCV," "MCV," "MCH," and "MCHC," combined with Boolean operators "AND" and "OR" to optimize both the scope and relevance of the results. The search was confined to studies published in English, with a focused intent to identify research exploring the impact of yogic practices on various hematological parameters. To ensure methodological rigor and the inclusion of high-quality evidence, the search criteria specifically prioritized peer-reviewed articles, clinical trials, and observational studies. This approach was designed to provide a robust and comprehensive evidence base for the ensuing literature review, contributing to a thorough understanding of the potential effects of yogic practices on hematological outcomes.

Study Participants

The present study was conducted at Shyampahari Government Primary Teacher Training Institute, Birbhum, West Bengal, India, and included 20 male participants aged 17 to 22 years. All participants had normal vision and were randomly assigned to either the experimental group (EG) or control group (CG), with each group comprising 10 individuals. The inclusion criteria required participants to be free from smoking and alcohol consumption, have no history of acute or chronic medical conditions, and not be under any form of medication. Furthermore, individuals with any known hematological disorders or conditions that could potentially affect hematological variables were excluded to ensure the validity of the findings. A detailed summary of the participants' demographic and health characteristics is presented in Table 1. Before enrolment, each participant underwent a comprehensive medical evaluation conducted by a qualified physician to confirm eligibility and overall health status. Written informed consent was obtained from all participants following a thorough explanation of the study's objectives, methodology, and potential risks. The study was conducted in strict accordance with established guidelines, prioritizing the safety, well-being, and rights of all participants. This study was approved by the Department of Physical Education and Sports Sciences, University of Delhi, India following clearance from the Department Research Committee and the Board of Research Studies (Ref. no. SF-1/Ph.D/2023/1481, dated 01/02/2023) Informed consent was obtained from all participants after a detailed briefing on the study's objectives, procedures, and their rights, including voluntary participation and the option to withdraw at any stage."

Table 1. Baseline profile of participants (Mean ±SD)

Parameters	Overall Group (N=20)	EG (n=10)	CG (n=10)
Age (years)	20.00 ± 0.97	19.70 ± 0.67	20.30 ± 1.16
Height (cm)	169.95 ± 6.82	170.10 ± 5.24	169.80 ± 8.40
Weight (kg)	63.85 ± 10.94	58.30 ± 5.85	69.40 ± 12.24
BMI (kg/m^2)	22.11 ± 3.42	20.21 ± 2.45	24.00 ± 3.26
WHR	0.86 ± .11	0.87 ± 0.14	0.85 ± 0.06
Systolic Blood Pressure (mmHg)	122.85 ± 3.48	122.00 ± 2.67	123.70 ± 4.11
Diastolic Blood Pressure (mmHg)	80.50 ± 2.93	81.70 ± 2.63	79.30 ± 2.83
Pulse Rate	74.95 ± 3.97	74.60 ± 4.00	75.30 ± 4.10

Randomisation

A computerised randomisation procedure was implemented using Random Allocation Software (version 1.0.0; M. Saghaei, MD, Department of Anesthesia, Isfahan University of Medical Sciences, Isfahan, Iran) to assign 20 eligible participants to either the experimental group (n = 10) or the control group (n = 10). Allocation concealment was ensured through the use of sequentially numbered, opaque, sealed envelopes (SNOSE), thereby minimising selection bias.

Blinding/Masking

Owing to the nature of the yogic intervention, blinding of participants was not practicable. Nevertheless, to uphold methodological rigor and reduce the risk of bias, a single-blind design was employed. The principal investigator remained blinded to group assignments throughout the duration of the study. An independent researcher, not involved in the randomisation procedure or data analysis, was responsible for delivering the intervention and performing all outcome evaluations.

Study Organization

This study adopted a rigorous experimental research design employing a two-group pre-test and post-test framework to examine the effects of a twelve-week yogic intervention on selected hematological parameters. Participants were systematically chosen through probability sampling from the student population to enhance methodological rigor and representativeness. The intervention protocol adhered to standardized yogic practices, ensuring consistency, reliability, and reproducibility. The primary objective was to

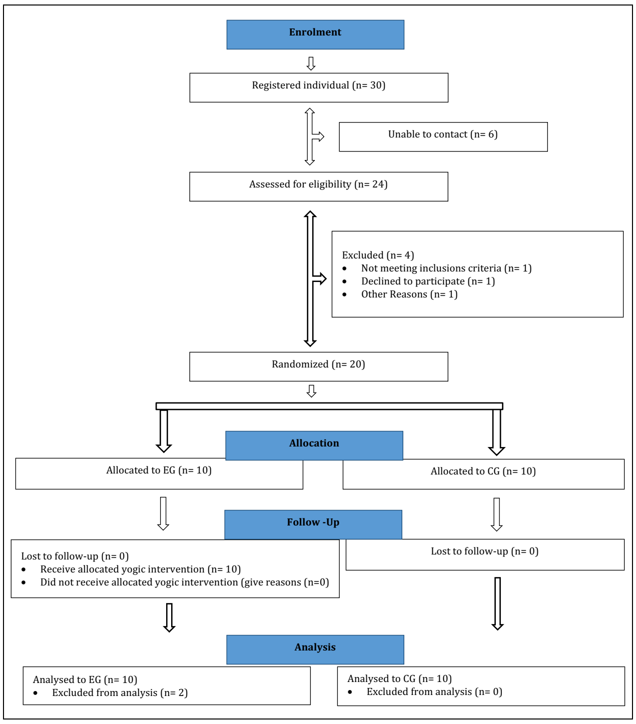

Fig. 1. Participations selection consort flow chart

generate robust empirical evidence on the impact of yogic practices on hematological variables, thereby contributing to the advancement of scholarly research on their potential therapeutic efficacy.

Experimental Protocol

The EG was subjected to a meticulously structured yogic intervention that encompassed suryanamaskar, a systematically sequenced regimen of asanas, pranayama techniques, and relaxation practices. These sessions were conducted six days a week, from Monday to Saturday, between 8:00 and 9:00 AM at the Shyampahari Government Primary Teacher Training Institute ground in Birbhum, West Bengal, India. To ensure methodological rigor and strict adherence to the established protocol, the investigator provided continuous supervision throughout the intervention period. In contrast, the CG maintained their habitual daily activities without any external modifications or structured interventions. To systematically assess the efficacy of the intervention, comprehensive pre- and post-assessments were conducted for all participants. These evaluations, administered at both the commencement and conclusion of the twelve weeks, were designed to objectively quantify changes in the selected hematological variables. A detailed schematic representation of the intervention protocol was provided in Figure 2, illustrating the precise sequencing, duration, and constituent components of the yogic practices integrated into the study.

Outcome Measures.

This study aimed to evaluate the effects of a 12-week yogic intervention on hematological parameters, including Hb, RBC, PCV, MCV, MCH, and MCHC. A pre-test and post-test research design was employed to systematically assess changes in these parameters. Blood samples were collected from the antecubital vein using sterile techniques, ensuring strict adherence to aseptic protocols. Following collection, the samples were promptly transported under controlled conditions to a certified pathology laboratory for analysis. Hematological assessments were performed using the Tulip Coralyzer Smart 200, a high-precision automated analyser recognized for its reliability in clinical diagnostics. To enhance the validity and reproducibility of the findings, the study adhered to rigorous laboratory protocols and implemented comprehensive quality control measures. Regular calibration of equipment, strict compliance with standardized procedural guidelines, and the incorporation of both internal and external quality assurance mechanisms minimized measurement errors. Additionally, all assessments were conducted under continuous supervision by qualified laboratory personnel to ensure methodological rigor, maintain participant safety, and uphold ethical and procedural standards. These methodological safeguards collectively strengthened the accuracy, consistency, and scientific credibility of the results.

Statistical Analysis

The normality of the data distribution was assessed using the Shapiro-Wilk test (Shapiro & Wilk, 1965), while Levene's test was employed to evaluate the homogeneity of variances. Descriptive statistics were utilized to summarize the data. Inferential analysis was conducted using paired t-tests to examine within-group differences and independent t-tests to compare differences between groups. All statistical analyses were performed using IBM SPSS Statistics (version 25), with the significance level set at 0.05. Assumptions underlying the statistical tests were verified to ensure the robustness of the analysis.

Results

Table 2 presented the Shapiro-Wilk test results for hematological parameters in the EG and the CG. The test was conducted to evaluate the normality of data distribution for each parameter within both groups. A p-value greater than 0.05 indicated that the data were normally distributed, whereas a p-value less than 0.05 signified a significant deviation from normality, suggesting the need for non-parametric statistical approaches.

Table 3 presented the results of Levene's test for hematological parameters in the EG and the CG. The test was conducted to assess the homogeneity of variance for each parameter between the groups. All results were statistically significant ($p > 0.05$), confirming that the assumption of equal variances was met across all parameters. Therefore, parametric statistical analyses were deemed appropriate for further comparisons.

The findings of the present study, as detailed in Table 4, indicated differences in hematological parameters between the EG and CG following the intervention. Among the hematological variables, hemoglobin (Hb) levels in the EG increased by 4.28%, from a mean of 14.97 mg/dL (SD = 1.03) in the pre-test to 15.61 mg/dL (SD = 0.99) in the post-test. In contrast, the CG exhibited a reduction of 2.76%, with Hb decreasing from a mean of 15.24 mg/dL (SD = 0.77) to 14.82 mg/

Weeks	Surya Namaskar (Dynamic Warm-up)	Asanas Practiced (In Sequential Order)	Asana Parameters (Holding Time × Repetitions × Rest)	Total Asana Duration	Pranayama (Anulom Vilom and Bhastrika)					Relaxation (Integrative Recovery)
					Breathing Ratio	I	H	E	Cycle × Repetition × Rest between Repetitions	
1–3	1 Round (5 min)	Ardha-Halasana, Sarvangasana, Matsyasana, Halasana, Chakrasana, Naukasana, Bhujangasana, Shalabhasana, Naukasana, Dhanurasana, Ardha Matsyendrasana, Paschimottanasana, Vajrasana, Yogamudra, Ushtrasana, Padmasana, Utkatasana, Trikonasana, Vrikshasana, Tadasana, Shavasana	15 sec × 2 × 5 sec (60 sec rest between sets)	30 (min)	(1:1)	5 (Sec)		5 (Sec)	2×2×60 Sec	Shavasana (5 min)
4–6	2 Rounds (5 min)	Same as above	20 sec × 2 × 5 sec (50 sec rest between sets)	30 (min)	(1:1:1)	5 (Sec)	5 (Sec)	5 (Sec)	2×2×50 Sec	Shavasana (5 min)
7–9	3 Rounds (5 min)	Same as above	25 sec × 2 × 3 sec (40 sec rest between sets)	30 (min)	(1:2:2)	5 (Sec)	10 (Sec)	10 (Sec)	×2×40 Sec	Shavasana (5 min)
10–12	4 Rounds (5 min)	Same as above	30 sec × 2 × 3 sec (30 sec rest between sets)	30 (min)	(1:4:2)	5 (Sec)	20 (Sec)	10 (Sec)	2×2×30 Sec	Shavasana (5 min)

Note: Inhale (I), Hold (H), Exhale (E)

Fig. 2. Yogic intervention module

dL (SD = 0.90). Similarly, red blood cell (RBC) count in the EG increased by 1.08%, from a pre-test mean of 5.57 million/cumm (SD = 0.57) to 5.63 million/cumm (SD = 0.33), while the CG showed a decline of 2.31%, from a mean of 5.20 million/cumm (SD = 0.52) to 5.08 million/cumm (SD = 0.42). Packed cell volume (PCV) in the EG increased by 2.10% from a mean of 45.63% (SD = 3.02) to 46.59% (SD = 5.61). Conversely, the CG experienced a reduction of 4.56%, with PCV decreasing from a mean of 46.05% (SD = 2.09) to 43.95% (SD = 3.73). Mean corpuscular volume (MCV) showed an increase of 5.38% in the EG, from 82.51 fl (SD = 10.15) to 86.95 fl (SD = 9.17), whereas the CG exhibited a decline of 2.60%, from a mean of 88.91 fl (SD = 5.49) to 86.60 fl (SD = 4.10). Further, mean corpuscular hemoglobin (MCH) in the EG increased by 2.51%, from 27.13 pg (SD = 3.22) to 27.81 pg (SD = 2.19), while the CG showed a negligible decline of 0.61%, from 29.42 pg (SD = 1.90) to 29.24 pg (SD = 1.19). The mean corpuscular hemoglobin concentration (MCHC) in the EG, however, exhibited a slight decrease of 2.40%, from 32.90 gm/dL (SD = 0.43) to 32.11 gm/dL (SD = 1.84), whereas the CG showed an increase of 2.21%, from 33.09 gm/dL (SD = 0.61) to 33.82 gm/dL (SD = 1.83).

The observed changes in hematological parameters within the EG suggested that the intervention enhanced oxygen-carrying capacity, hematopoiesis, and overall circulatory efficiency. The decline in hematological values within the CG may have been attributed to the absence of an intervention, emphasizing the impact of the experimental regimen. These findings aligned with previous studies highlighting the role of structured physical activity, particularly yogic practices, in optimizing hematological variables and overall physiological health.

Table 2. Shapiro-Wilk Test Results for Hematological Parameters

Variables	Group	Test	df	Shapiro-wilk (p-value)	Normality assumption
Hb	EG	Pre-test	10	.299	Normal
		Post-test	10	.827	Normal
	CG	Pre-test	10	.537	Normal
		Post-test	10	.982	Normal
RBC	EG	Pre-test	10	.861	Normal
		Post-test	10	.694	Normal
	CG	Pre-test	10	.057	Normal
		Post-test	10	.824	Normal
PCV	EG	Pre-test	10	.862	Normal
		Post-test	10	.494	Normal
	CG	Pre-test	10	.463	Normal
		Post-test	10	.748	Normal
MCV	EG	Pre-test	10	.903	Normal
		Post-test	10	.195	Normal
	CG	Pre-test	10	.692	Normal
		Post-test	10	.330	Normal
MCH	EG	Pre-test	10	.777	Normal
		Post-test	10	.058	Normal
	CG	Pre-test	10	.706	Normal
		Post-test	10	.318	Normal
MCHC	EG	Pre-test	10	.876	Normal
		Post-test	10	.068	Normal
	CG	Pre-test	10	.939	Normal
		Post-test	10	.059	Normal

Table 3. Levene's Test Results for Hematological Parameters

Variables	Test	Group	df	Levene's Test (p-value)	Equality of Variances
Hb	Pre-test	EG CG	18	.385	Equal
	Post-test	EG CG	18	.656	Equal
RBC	Pre-test	EG CG	18	.483	Equal
	Post-test	EG CG	18	.488	Equal
PCV	Pre-test	EG CG	18	.355	Equal
	Post-test	EG CG	18	.171	Equal
MCV	Pre-test	EG CG	18	.089	Equal
	Post-test	EG CG	18	.069	Equal
MCH	Pre-test	EG CG	18	.124	Equal
	Post-test	EG CG	18	.074	Equal
MCHC	Pre-test	EG CG	18	.359	Equal
	Post-test	EG CG	18	.701	Equal

Table 5 presented the paired t-test results, highlighting improvements in hematological variables within the EG following the intervention. The EG demonstrated a statistically significant enhancement in Hb levels, $t_{(9)} = 3.02$, p = .015, indicating a substantial increase in oxygen-carrying capacity, which may have contributed to improved aerobic performance and overall physiological function. Conversely, the CG did not exhibit significant changes in Hb levels, $t_{(9)} = 1.99$, p = .078, suggesting that the intervention played a crucial role in the observed improvement in the EG. Other hematological variables, including RBC count, PCV, MCV, MCH, and MCHC, did not show statistically significant changes in either the EG or CG. Specifically, the RBC count in the EG, $t_{(9)} = 0.35$, p = .740, and CG, $t_{(9)} = 0.98$, p = .353, remained relatively stable. Similarly, PCV levels in the EG, $t_{(9)} = 0.54$, p = .600, and CG, $t_{(9)} = 1.71$, p = .121, did not exhibit significant variation. Furthermore, MCV, $t_{(9)} = 1.16$, p = .280; MCH, $t_{(9)} = 0.68$, p = .513; and MCHC, $t_{(9)} = 1.32$, p = .220, did not demonstrate significant differences post-intervention. The CG also showed no significant changes in MCV, $t_{(9)} = 1.49$, p = .169; MCH, $t_{(9)} = 0.35$, p = .733; and MCHC, $t_{(9)} = 1.16$, p = .275.

The lack of significant changes in these additional hematological parameters suggested that while the intervention effectively improved Hb levels, it did not induce substantial alterations in other erythrocyte-related indices. This may have indicated that the intervention primarily influenced oxygen transport efficiency rather than overall erythropoiesis or red blood cell morphology. Conversely, the CG did not exhibit statistically significant changes in any of the measured hematological parameters, reinforcing the specificity and efficacy of the intervention implemented in the EG. The observed improvements in Hb levels within the EG underscored the potential benefits of structured training programs in optimizing hematological function, which was crucial for endurance and overall athletic performance. These findings provided valuable insights into the impact of targeted interventions on hematological adaptations. Future research may explore the long-term effects of such interventions, particularly in diverse populations, to further elucidate their role in enhancing physiological function and athletic performance.The independent t-test analysis presented in Table 6 revealed notable changes in hematological variables between the EG and CG. The pre-test Hb levels were comparable between the groups (p = 0.512), while post-test values showed an increase in the EG, though the difference was not statistically significant (p = 0.079). A

Table 4. Descriptive Statistics

Variables	Group	Test	N	Mean	Std. Deviation	% Change	Reference Range
Hb	EG	Pre-test	10	14.97	1.03	4.28	12-18 mg/dl
		Post-test	10	15.61	0.99		
	CG	Pre-test	10	15.24	.77	-2.76	
		Post-test	10	14.82	.90		
RBC	EG	Pre-test	10	5.57	.57	1.08	4.5-6.5 millions/cumm
		Post-test	10	5.63	.33		
	CG	Pre-test	10	5.20	.52	-2.31	
		Post-test	10	5.08	.42		
PCV	EG	Pre-test	10	45.63	3.02	2.10	36-46 %
		Post-test	10	46.59	5.61		
	CG	Pre-test	10	46.05	2.09	-4.56	
		Post-test	10	43.95	3.73		
MCV	EG	Pre-test	10	82.51	10.15	5.38	77-93 fl
		Post-test	10	86.95	9.17		
	CG	Pre-test	10	88.91	5.49	-2.60	
		Post-test	10	86.60	4.10		
MCH	EG	Pre-test	10	27.13	3.22	2.51	27-32 pg
		Post-test	10	27.81	2.19		
	CG	Pre-test	10	29.42	1.90	-.61	
		Post-test	10	29.24	1.19		
MCHC	EG	Pre-test	10	32.90	.43	-2.40	31-35 gm/dl
		Post-test	10	32.11	1.84		
	CG	Pre-test	10	33.09	.61	2.21	
		Post-test	10	33.82	1.83		

significant improvement was observed in the RBC count, as the EG had a higher post-test mean compared to the CG ($p = 0.004$), suggesting a positive effect of the intervention. However, PCV did not differ significantly between groups in both pre-test and post-test assessments ($p = 0.722$ and $p = 0.230$, respectively). MCV values remained statistically unchanged after the intervention ($p = 0.913$), indicating minimal impact. Similarly, MCH did not show significant differences in either the pre-test or post-test values ($p = 0.068$ and $p = 0.087$, respectively). MCHC were also comparable between the groups in the pre-test phase ($p = 0.427$), but the post-test values indicated a near-significant difference favoring the CG ($p = 0.051$). These findings, as shown in Table 6, suggested that the intervention was particularly effective in improving RBC count, while other hematological variables exhibited changes that were not statistically significant. The increase in Hb levels in the EG approached significance, highlighting the potential benefits of the intervention, which warranted further research with a larger sample size to establish definitive conclusions.

Discussions

This study examines the effects of yogic practices on select hematological parameters, revealing distinct trends that underscore the potential physiological benefits of yogic practices. The findings suggest that regular engagement in yogic practices contributes to hematological stability and enhancement, particularly in parameters associated with oxygen transport and erythropoiesis. These results align with previous research indicating that mind-body interventions, including yogic practices, play a crucial role in improving hematological health and overall physiological well-being (Banerjee et al., 2019).

The increase in Hb levels in the EG suggests that yogic practices positively influence erythropoiesis and oxygen-carrying capacity. Prior studies report similar findings (Ramanath et al., 2013: Longeville & Stingaciu, 2017), highlighting that pranayama and controlled breathing techniques enhance pulmonary function (Kakkar et al., 2024), leading to increased oxygen diffusion and improved hemoglobin synthesis (Soni et al., 2012). Additionally, yoga's role in reducing physiological stress mitigates cortisol-induced suppression of erythropoietin production, thereby supporting red blood cell proliferation (Arora & Bhattacharjee, 2008; Kelly et al., 2000; Naragatti, 2025). In contrast, the decline in hemoglobin levels in the CG reinforces research indicating that a sedentary lifestyle negatively impacts erythropoiesis and overall hematological stability (Koivula et al., 2022).

Table 5. Paired t-test comparison of pre-test and post-test in EG and CG

Variables	Group	Test	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Hb	EG	Pre-test Post-test	.64	.67	.21	3.02	9	.015
	CG	Pre-test Post-test	.42	.67	.21	1.99	9	.078
RBC	EG	Pre-test Post-test	.06	.54	.17	.35	9	.74
	CG	Pre-test Post-test	.13	.41	.13	.98	9	.353
PCV	EG	Pre-test Post-test	.96	5.58	1.77	.54	9	.60
	CG	Pre-test Post-test	2.10	3.89	1.23	1.71	9	.121
MCV	EG	Pre-test Post-test	4.44	12.11	3.83	1.16	9	.28
	CG	Pre-test Post-test	2.32	4.91	1.55	1.49	9	.169
MCH	EG	Pre-test Post-test	.68	3.15	.99	.68	9	.513
	CG	Pre-test Post-test	.18	1.64	.52	.35	9	.733
MCHC	EG	Pre-test Post-test	.80	1.91	.60	1.32	9	.220
	CG	Pre-test Post-test	.73	1.99	.63	1.16	9	.275

*Significant at 0.05 level

Although the RBC count in the EG exhibits a minor increase, it does not reach statistical significance. Prior studies report similar findings (Chandrashekhar, 2012; Purohit et al., 2013). However, existing literature supports the notion that regular engagement in yogic practice optimizes autonomic function (Jain et al., 2017), and circulation efficiency (Chen, 2024), which contributes to the long-term maintenance of RBC homeostasis. The reduction in RBC count in the CG further corroborates findings from studies emphasizing the detrimental effects of physical inactivity on erythropoiesis (Daniele et al., 2022)

The increase in PCV in the EG highlights the potential benefits of yogic practices in improving blood viscosity and oxygen transport efficiency (Brown & Chevalier, 2015; Puli & Reddy, 2016). Prior studies report similar findings (Sivananda & Srinivasan, 2017). This adaptation likely results from enhanced cardiovascular function and improved metabolic efficiency associated with regular yogic practice (Sharma et al., 2024; Tyagi & Cohen, 2013). Prior research shows that physical activity, including yogic practice, enhances hematological parameters by promoting optimal blood circulation and reducing oxidative stress (Sharma et al., 2024; Patil et al., 2014). The CG decline in packed cell volume further reinforces the importance of physical activity in maintaining optimal blood composition.

The increased MCV observed in the EG suggests improvements in erythrocyte morphology and oxygen-carrying potential (Gowtham et al., 2018). This finding aligns with earlier studies (Bara et al., 2024), indicating that yogic practices improve cellular integrity and hematopoietic efficiency (Chen, 2024; Bhargav et al., 2010). In contrast, the reduction in mean corpuscular volume in the CG supports research showing that sedentary behavior impairs erythrocyte stability and function.

A modest increase in MCH in the EG. This finding aligns with earlier studies (Purohit et al., 2013), and suggests that yogic practice optimizes hemoglobin synthesis within erythrocytes (Ramanath et al., 2013), potentially enhancing oxygen delivery at the cellular level. This improvement likely relates to yogic practice's stress-modulating effects, which mitigate hormonal imbalances that negatively affect erythropoiesis (Arora & Bhattacharjee, 2008; Kelly et al., 2000; Naragatti, 2025). Research suggests that regular yogic practice enhances metabolic efficiency and nutrient absorption (Tyagi & Cohen, 2013; Verma et al., 2017), which contributes to improved hemoglobin synthesis.

Table 6. Independent t-test comparison of pre-test and post-test between EG and CG

Variables	Tests	EG		CG		t	P-value
		Mean	SD	Mean	SD		
Hb	Pre-test	14.97	1.03	15.24	.77	.67	.512
	Post-test	15.61	0.99	14.82	.90	1.86	.079
RBC	Pre-test	5.57	.57	5.20	.52	1.48	.157
	Post-test	5.63	.33	5.08	.42	3.25	.004
PCV	Pre-test	45.63	3.02	46.05	2.09	.36	.722
	Post-test	46.59	5.61	43.95	3.73	1.24	.230
MCV	Pre-test	82.51	10.15	88.91	5.49	1.76	.096
	Post-test	86.95	9.17	86.60	4.10	.11	.913
MCH	Pre-test	27.13	3.22	29.42	1.90	1.94	.068
	Post-test	27.81	2.19	29.24	1.19	1.81	.087
MCHC	Pre-test	32.90	.43	33.09	.61	.81	.427
	Post-test	32.11	1.84	33.82	1.83	2.09	.051

*Significant at 0.05 level

A minor decline in MCHC in the yogic practices group. This finding aligns with earlier studies (Subramanian et al., 2012). Given the role of hydration status and erythrocyte stability in determining mean corpuscular hemoglobin concentration (Pałka et al., 2023), further research is needed to explore the underlying mechanisms influencing this parameter. Studies on yoga's effects on hemodynamics and fluid balance provide additional insights into these findings.

The observed improvements in hematological parameters likely result from multiple physiological adaptations facilitated by yogic practices. Physiological mechanisms underlying these changes may include enhanced oxygenation (Roberson & Bennett-Guerrero, 2012), improved circulation (Chen, 2024), autonomic nervous system modulation (Shobana et al., 2022; Nontakhod et al., 2024), reduced oxidative stress (Patil et al., 2014), and hormonal regulation (Naragatti, 2025), all contributing to hematological balance and efficiency.

The findings of this study provide valuable insights into the role of yogic practices in promoting hematological health. The positive trends observed in hemoglobin and related parameters highlight the potential benefits of yogic practices as a non-invasive and holistic intervention for improving blood composition and oxygen transport capacity. These findings emphasize the significance of integrating yogic practices into lifestyle interventions aimed at enhancing physiological resilience and circulatory efficiency.

Limitations and Future of the Study

Despite yielding promising insights into the influence of yogic practices on hematological responses, this study is not without limitations. The small sample size (n = 20) constrains the statistical power and may limit the generalizability of the findings. The exclusive focus on male college students from a single institution further restricts the applicability of results across different genders, age brackets, and sociocultural contexts. Additionally, extrinsic variables such as nutritional intake, hydration status, sleep quality, and psychosocial stress—which can significantly impact hematological outcomes—were not controlled during the intervention period. The study also lacks follow-up data to determine the long-term sustainability of the observed hematological changes post-intervention.

Future research should consider employing a larger, more heterogeneous sample encompassing diverse demographic profiles. Longitudinal study designs with extended follow-up periods are recommended to assess the durability of hematological adaptations. Integrating biochemical, cardiorespiratory, and psychophysiological markers alongside hematological indices could offer a more comprehensive understanding of the systemic effects of yogic interventions. Inclusion of female participants and assessment of lifestyle variables would further enhance the robustness and translational value of subsequent findings.

Strengths and Implications

The primary strength of this study lies in its well-structured and time-bound yogic intervention, implemented over a twelve-week period with consistent supervision. The use of a randomized controlled design, combined with standardized hematological assessments via a fully automated analyzer, enhances the internal validity and ensures precision in the measurement of key hematological markers. The application of both paired and independent t-tests allowed for rigorous intra- and inter-group comparisons, lending statistical credibility to the observed outcomes.

Another noteworthy strength is the selection of specific hematological parameters—Hb, RBC, PCV, MCV, MCH, and MCHC—which are critical indicators of oxygen transport and erythropoietic activity. By focusing on these indices, the study provides targeted insights into how yogic practices may influence hematopoietic function, particularly among healthy young adults.

From an applied physiological standpoint, the findings underscore the potential role of structured yogic practices—especially combinations of suryanamaskar, asanas, pranayama, and relaxation techniques—in enhancing hemoglobin concentration, a key factor in aerobic performance and oxygen delivery. This suggests that regular yogic practices can contribute to improved cardiovascular efficiency and overall vitality in young populations.

In terms of practical implications, the study supports the integration of yoga into college wellness programs as a cost-effective, non-invasive, and accessible strategy for optimizing hematological health. Although significant changes were observed only in hemoglobin levels, the trend toward improvement in other parameters suggests a broader, gradual hematological adaptation that may become more evident with longer or more intensive interventions. These outcomes provide a compelling rationale for policymakers and educators to promote yoga-based health modules in academic settings as a sustainable method for enhancing physical and mental health without reliance on pharmacological approaches.

Conclusions

This study found that a twelve-week yogic intervention led to notable improvements in hematological parameters within the EG, with Hb levels showing a statistically significant increase, indicating enhanced oxygen-carrying capacity and overall physiological function. Although other hematological variables—RBC count, PCV, MCV, MCH, and MCHC—did not reach statistical significance, the observed trends suggest positive physiological adaptations in response to the yogic intervention. In contrast, the CG exhibited declines or negligible changes across all measured parameters, reinforcing the effectiveness of the intervention.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Йогічні практики та їхній вплив на гематологічні реакції: Фізіологічна перспектива

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 6 табл., 1 рис., 75 джерел.

Історія питання. Йога — стародавня дисципліна, яка поєднує фізичні пози, контроль дихання та медитацію, пов'язана з низкою фізіологічних переваг. Дослідження її впливу на гематологічні показники є надзвичайно важливим, оскільки вони є ключовими індикаторами здоров'я та працездатності.

Мета дослідження. Мета цього дослідження полягала в оцінці впливу йогічних практик на гематологічні показники, а саме: гемоглобін (Hb), кількість еритроцитів (RBC), об'єм осаджених клітин (PCV), середній корпускулярний об'єм (MCV), середній корпускулярний гемоглобін (MCH) та середню корпускулярну концентрацію гемоглобіну (MCHC) серед студентів коледжу.

Матеріали та методи. У дослідженні взяли участь 20 студентів чоловічої статі віком від 17 до 22 років. Вони були розподілені за методом рандомізації на експериментальну групу (n=10), яка проходила інтервенцію із занять йогою, та контрольну групу (n=10), яка не брала участі в жодній структурованій фізичній активності. Експериментальна група (ЕГ) щоденно, шість днів на тиждень, займалася 60-хвилинними сесіями, що включали комплекс вправ Сур'я-намаскара, асани, пранаяму та техніки релаксації. Вимірювання гематологічних показників здійснювалося на початку дослідження та через 12 тижнів за допомогою автоматичного гематологічного аналізатора Tulip Coralyzer Smart 200. Статистичний аналіз проводився із застосуванням t-критеріїв для парних та незалежних вибірок, при цьому рівень значущості встановлено на рівні $p < 0.05$.

Результати. Постінтервенційний аналіз виявив статистично значуще підвищення рівнів гемоглобіну в експериментальній групі ($p = 0.015$), що свідчить про підвищену здатність до перенесення кисню. У жодній з груп не спостерігалося суттєвих змін у показниках кількості еритроцитів, об'єму осаджених клітин, середнього корпускулярного об'єму, середнього корпускулярного гемоглобіну та середньої корпускулярної концентрації гемоглобіну.

Висновки. В експериментальній групі встановлено значне поліпшення рівнів гемоглобіну, що вказує на потенційні переваги для транспорту кисню та аеробної здатності. Результати дослідження показують, що покращення інших гематологічних показників свідчить про наявність селективних гематологічних адаптацій до йогічних практик.

Ключові слова: гематологічні тести, гемоглобіни, кількість еритроцитів, йога, інтервенційні дослідження.

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