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Impact of yoga training on hematological markers in normotensive college students: A randomized controlled trial

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ABSTRACT
Yoga has gained popularity as a holistic practice that promotes physical and mental well-being. Despite its growing popularity, there is a lack of solid evidence regarding the clinical relevance of yoga for various medical conditions. This randomized controlled aimed to investigate the impact of yoga training on hematological markers in normotensive college students. The study participants consisted of twenty normotensive college students who were randomly assigned to either a yoga training group or a control group. Over a 12-week period (6 days/week), the yoga group engaged in 80-minute yoga sessions, focusing on body postures, breathing exercises, and relaxation techniques, while the control group did not receive any specific intervention. The hematological markers of both groups were measured at baseline and at the termination of the intervention period. The results of the study reported that yoga group experienced significant changes in the levels of red blood cell, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin concentration, lymphocyte%, neutrophils, mean distribution width count, platelets, and mean platelet volume as compared to control group ($p<0.05$). No significant differences were found in the mean corpuscular hemoglobin, red cell distribution, white blood cell, lymphocyte, and platelet counts. Considering these results, it can be concluded that yoga practice may be effective in overall physiological health among normotensive college students.

Keywords- Yoga, normotensive, pranayama, hematological, blood

INTRODUCTION

In the past few years, there has been heightened fascination with unconventional and complementary approaches that go beyond the scope of conventional medicine, driven by the desire for complete well-being and the best possible health (Fontanarosa, 1998, Kaur et al. 2022). Among the various techniques, yoga stands out as an age-old tradition originating from ancient India and is attracting considerable interest due to its potential in promoting physical, mental, and emotional health (Varambally & Gangadhar, 2016; Shroff et al., 2017; Stec, 2020;). Yoga is an age-old self-improvement system that deals with a holistic approach to an individual through its set of beliefs and activities aimed at harmonizing both physical and mental aspects (Herrick & Ainsworth, 2000). It integrates a set of bodily postures (referred to as *asanas*) synchronized with techniques for controlled breathing (known as *pranayama*), along with relaxation and meditative practices (Kumar et al. 2023, Pal, 2014,). Some clinical trials have chosen this non-pharmacological treatment for 12 weeks as a therapy for eating disorders (Carei et al., 2010) to improve heart rate variability and depressive symptoms in women (Chu et al., 2017), to enhance mental health status in elderly female inmates of a hospice (Bhavanani et al., 2017), and to improve cardiovascular and cognitive function in post-cardiac rehabilitation (Yeung et al., 2014). In addition to its well-known effects of reducing stress and enhancing flexibility (Polsgrove et al., 2016; Park et al., 2020), recent studies have indicated that yoga could potentially have favorable effects on a range of physiological measures, including parameters related to the blood and its components (Banerjee et al., 2019; Shadiow, 2019).

Blood markers are useful for assessing health status, clinical evaluation of physiological/pathological conditions, and diagnostic and prognostic evaluation of various types of diseases (Dhama et al., 2019). Hematological parameters cover a variety of blood-related elements, such as the number of red blood cells, hemoglobin concentrations, and white blood cell counts, and play a vital role in preserving overall health and physiological balance (Feriel et al., 2021). Some hematological parameters, such as hemoglobin and hematocrit, can serve as important indicators for assessing aerobic capacity development (Das & Chatterjee, 2015). Nevertheless, some meta-analyses have indicated the beneficial effects of yoga interventions and randomized clinical trials, indicating positive effects on pain-associated disability and mental health (Büssing et al., 2012; Holtzman & Beggs, 2013).

However, the hematological benefits of yoga have received little attention, particularly among normotensive female college students aged 21–25 years. This specific group, characterized by distinct experiences involving academic pressures and life transitions, presents an important context for exploring the potential hematological benefits of yoga (Hardin, 2008, Sagre et al., 2023). The majority of the young adult population comprises normotensive individuals, typically considered

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to have healthy blood pressure levels. The impact of yoga on this specific group is of utmost importance, as it may provide an understanding of preventive healthcare methods and improve well-being among college students. Therefore, this study aimed to determine the hematological benefits of yoga training in female normotensive college-going students.

METHODOLOGY

Inclusion and Exclusion criteria

The study comprised healthy, normotensive university students who freely agreed to participate in a 12-week yoga training (1 hour/day). Individuals with any systemic, mental, or physical disabilities, pregnant, those who were on anti-hypertensive medications, as well as those who had received any form of physical or yoga training, were all excluded from the study**.**

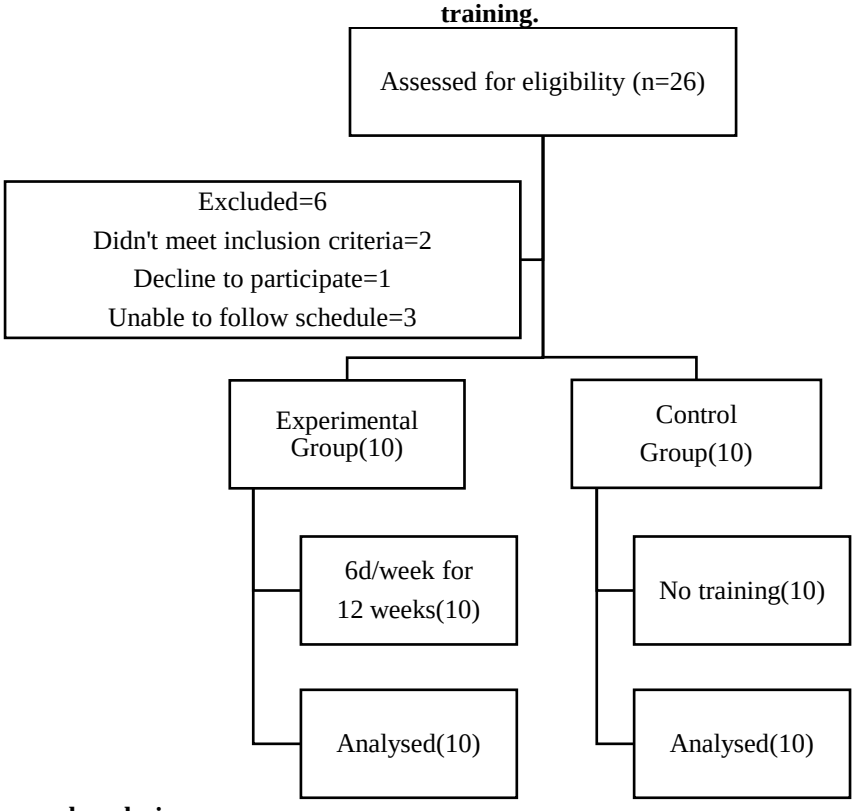
Demographic Profile Questionnaire

Prior to the beginning of the intervention, volunteers were requested to participate in a lifestyle survey. This survey gathered data on their age, height, weight, BMI, alcohol and smoking usage patterns, as well as their medical records.

Participant and Study Design

A randomized controlled methodology was employed in this study, which included 26 female college students (age ranged between 21 to 25), all in good health, non-smokers, and lacking significant medical histories. Among the 26 volunteers, 2 individuals did not meet the eligibility standards, 3 of them could not adhere to the timetable, and 1 chose not to join, leading to a total of 20 participants being included. Following initial measurements, the participants were randomly allocated into two groups (experimental and control group) by using Microsoft Excel randomization routine. Measurements were collected before and after 2-day yoga training program respectively. Prior to testing, the participants provided written informed consent after receiving verbal explanations of the study. Throughout the study, all participants were instructed to abstain from smoking and drinking, and those in the yoga group were advised not to participate in any other physical activity during the trial. Ethical approval for this study was granted by the Institutional Human Ethics Committee of the Central University of Haryana, Mahendragarh, India.

Fig.1 Schematic categorization of control, experimental, and excluded participants and time period of yoga training.



Blood collection and analysis

Blood samples were collected by the phlebotomist at the University Health Center of Maharshi Dayanand University, Rohtak. Under starved condition 5ml blood was drawn in EDTA and serum vials from the left arm of the participants between 7-8 AM. Serum was separated and stored at -80°C in centrifuge tubes. For analysis of total blood cell count 500µl of blood was used by suction method by Erba H360 cell counter machine, cell pack diluents were used for cell washing

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after that within 60 seconds the machine provides the results of the total cell blood count. Later on, the machine was cleaned by stromatolyzer. Plasma was separated from the remaining blood drawn in EDTA vials and stored at -20°C.\

Yoga Training

In the current study, a 12-week yoga training program (6 days/week) was conducted for the experimental group by a yoga trainer, certified by the Ministry of Ayush, Govt of India. Each training session consisted for 80 minutes, beginning with 10 minutes of pranayama (controlled breathing exercises), followed by 15 minutes of warming up activities, 45 minutes of asana (yoga poses) and ending with 10 minutes of relaxation.

Statistical Analysis

SPSS version 27.0 (SPSS Inc.) was used for all the statistical analysis. The normality of data was tested using Shaprio-Wilk test. The data were expressed in mean and standard deviation. To compare between the groups paired t-test was used and within group analysis was done using independent t-test. The level of significance was set at 0.05 for all the analysis.

Results

The study revealed that none of the participants had experienced any injuries or negative incidents. Consequently, all 20 individuals effectively completed the training intervention and underwent the required assessments without encountering any complications. The baseline values of the volunteers are given in the table 1. The mean age of the experimental and control group was 24.329 ± 3.259 and 24.76 ± 1.45 respectively. No significant differences were found in the age gender, height, weight, body mass index (BMI), Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP), confirming that the group allocation was carries out without any biasness. Also, non-significant differences were found in the smoking and alcohol consumption.

Table 1 Baseline characteristics of the subjects. Data represented as mean values (standard deviation).

Variables	Control Group	Experimental Group	p-value
Age (year)	24.76 (1.45)	24.329 (3.259)	0.70
Height (cm)	158.58 (9.02)	159.050 (3.891)	0.88
Weight (kg)	53.50 (5.96)	54.440 (10.491)	0.80
BMI (kg/m^2)	21.36 (2.34)	21.590 (4.380)	0.88
SBP (mmhg)	130.2(9.8)	131.2 (9.8)	0.82
DBP (mmhg)	84.9(6.5)	84.5(6.7)	0.89
Smoker	2	1	-

Table 2 displays the between group analysis of the hematological variables. In between-group analysis, at baseline significant differences were observed in the mean corpuscular volume and percentage. After intervention, significant changes were found in the red cell distribution width and mean corpuscular volume. Nonsignificant changes were observed in rest of the parameters in both groups.

Table 2 Before and after intervention, between-group analysis of the hematological variable.

Variables	Before treatment			After treatment		
	Control Group	Experimental Group	p-value	Control Group	Experimental Group	p-value
RBC (10^6/ uL)	4.38(0.22)	4.34(0.289)	0.757	4.55(0.36)	4.33(0.584)	0.328
Hgb (g/dL)	11.47(2.18)	11.38(1.58)	0.917	11.95(1.68)	12.90(1.46)	0.191
Hct (%)	38.091(3.28)	36.6(2.37)	0.259	40.744(3.65)	40.58(4.76)	0.932
MCV (fL)	83.972(8.41)	84.49(11.89)	0.911	93.19(8.57)	94.95(10.24)	0.682
MCH (pg)	27.23(3.698)	26.52(5.12)	0.723	28.86(8.27)	26.73(3.51)	0.462
MCHC (g/dL)	31.12(2.19)	31.11(1.98)	0.984	28.07(1.10)	28.27(0.80)	0.6496
RDW (%)	14.07(1.15)	14.56(1.91)	0.504	15.74(1.18)	14.66(0.85)	0.032*
WBC (10^3/ uL)	5.83(2.06)	5.53(2.07)	0.749	6.54(1.02)	6.93(1.48)	0.510
Lymphocyte% (%)	61.28(17.72)	61.99(16.33)	0.825	39.76(5.55)	40.60(11.71)	0.839
Lymphocyte# (10^3/ uL)	3.59(1.90)	2.98(0.88)	0.374	2.57(0.33)	2.79(0.91)	0.476
Mid% (%)	7.68(3.36)	20.45(11.13)	0.002**	23.66(11.92)	20.45(11.13)	0.541
Mid# (10^3/ uL)	1.35(0.83)	0.47(0.30)	0.005**	0.48(0.16)	1.26(1.04)	0.031*
Neutrophil% (%)	52.56(8.30)	52.78(14.24)	0.96	15.06(6.69)	20.26(10.65)	0.207
Neutrophil# (10^3/ uL)	3.49(0.96)	3.65(1.23)	0.739	0.88(0.50)	1.28(1.01)	0.281
PLT (10^4/ uL)	23.80(3.31)	23.50(3.21)	0.839	25.07(5.32)	27.47(4.91)	0.309
MPV (fL)	8.16(0.63)	8.56(0.89)	0.261	8.73(0.90)	9.67(0.79)	0.023*
PCT% (%)	0.21(0.04)	0.20(0.02)	0.488	0.19(0.05)	0.22(0.04)	0.155

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Figure 2 displays the within-group analysis of the hematological parameters measured before and after the yoga intervention. The results of the study showed that participants in the yoga group experienced a significant increase in several erythrocyte parameters after the intervention. These parameters include Hemoglobin concentration, Hematocrit level, Mean Corpuscular Volume, Red Blood Cell count, and mean corpuscular hemoglobin concentration [Fig 2 (a)& (b)]. These findings indicate that the yoga intervention had a positive impact on the participants' erythrocyte health and function.

Additionally, the study also observed statistically significant differences in leukocytic parameters in experimental group [Fig 2 (c)]. These changes included Mean distribution width percentage and count, Neutrophil percentage and count, and lymphocyte percentage ($p<0.05$). These changes were observed only after the yoga intervention, suggesting that yoga may have an effect on leukocyte function and count. The study also observed significant changes in thrombocyte parameters including platelets count and mean platelet volume after yoga intervention ($p<0.05$). However, in-within group analysis, control group also reported significant changes in lymphocyte percentage, neutrophil count and percentage and Mean distribution width percentage and count.

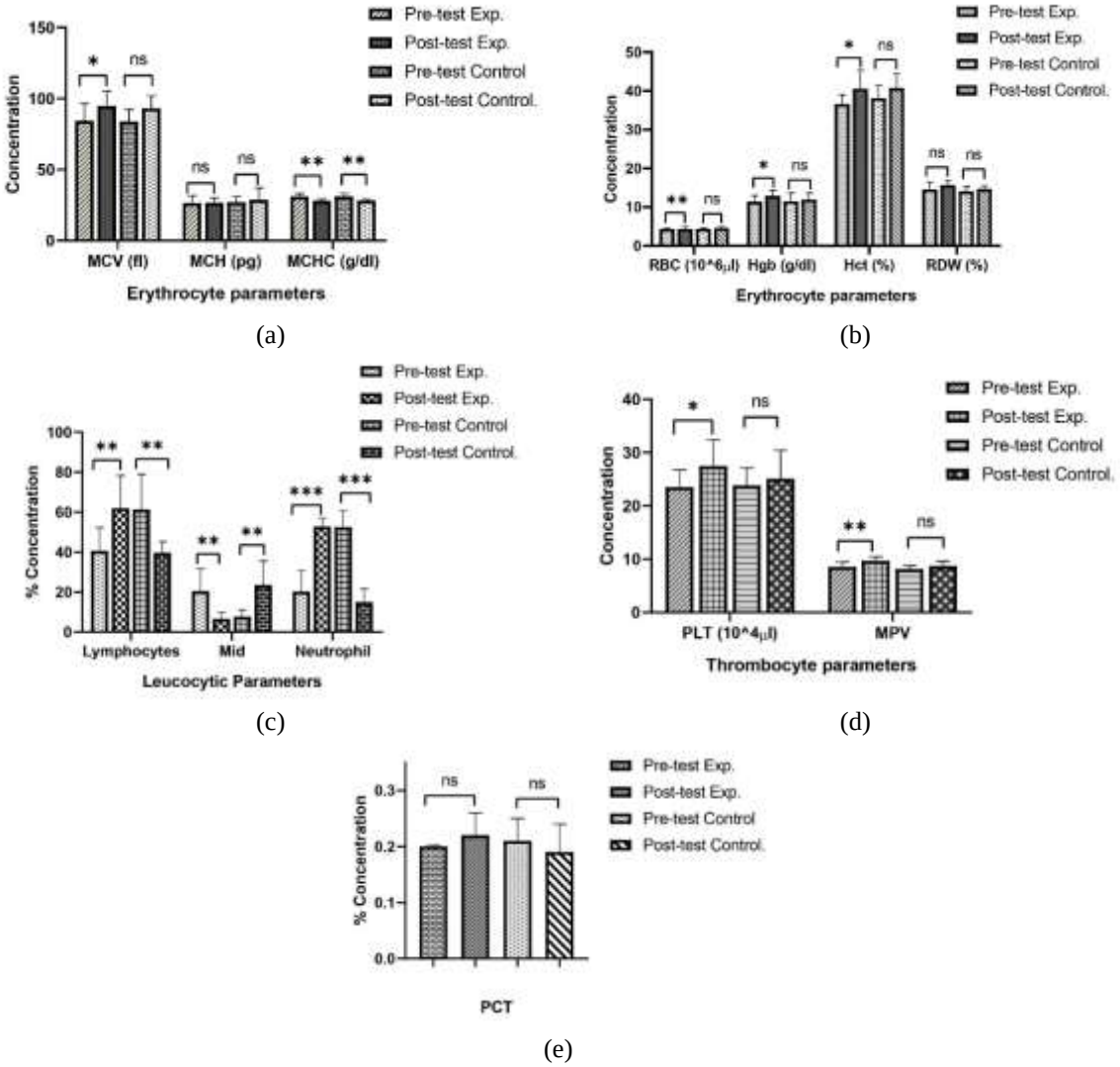

Fig.2. Graphical representation in concentration of (a) erythrocyte parameters MCV (fL), MCH (pg), MCHC (g/dl) (b) RBC, Hgb (g/dl), Hct (%), and RDW (%) (c) leucocyte parameters (Lymphocytes, Mid, Neutrophils) and (d) PLT and MPV and (e) level of PCT in experimental and control group (within-group analysis).

DISCUSSION

In living organisms, physical activity and yoga play crucial roles in numerous systems within the body (Evans et al., 2009; Gard et al., 2014). Engaging in yoga promotes a holistic approach to health, encompassing physical, mental, emotional, and spiritual well-being (Herrick & Ainsworth, 2000). Recent research has focused on uncovering the advantages of

practicing yoga and exploring its effects on individuals with hypertension; however, its underlying effect in normotensive individuals is not well known. Therefore, the present study targeted normotensive young adults to analyze the impact of yoga training on hematological parameters.

Regarding Erythrocyte parameters, the study reported a significant increase in red blood cells and hemoglobin concentration after yoga intervention. These findings are consistent with recent research indicating that yoga increases pulse rate and hemoglobin levels in both healthy male and female individuals (Ramanath et al., 2013). Similar results were observed in a study involving 80 menopausal women aged 40-50 years, in which yoga led to an increase in red blood cells and hemoglobin concentration (Swain et al., 2021). This increase in red blood cells and hemoglobin concentration indicates a potential improvement in oxygen-carrying capacity (Wang et al., 2020). Additionally, the study also reported significant increases in hematocrit and mean corpuscular hemoglobin concentrations, consistent with the findings of previous research conducted on Twenty-six healthy regular yoga practitioners to explore the effects of long-term yoga practice. (Carranque et al., 2012). The hematocrit level indicates that the proportion of red blood cells in the blood volume is crucial for oxygen delivery and blood flow properties (House & Lipowsky, 1987). In sports, athlete may have lower hematocrit levels due to increased blood volume for training known as "sports anemia" (Hu & Lin, 2012, Damian et al., 2021). However, no significant differences were found in the mean corpuscular hemoglobin and red cell distribution width after yogic intervention.

Neutrophils play a vital role in muscle repair and local inflammatory processes following physical activity and yogic asana (Kawanishi et al., 2016). Additionally, the study reported a significant increase in neutrophil value and mean distribution width percentage and concentration along with a significant decrease in lymphocyte concentration. These changes are in accordance with previous research revealing that physical activity improves neutrophil concentration (Mitrotasios et al., 2021). Despite the improvement observed in white blood cell count, there was no statistically significant difference. In thrombocyte parameters, a significant increase was found in platelet count and mean platelet volume in the yoga group compared to their respective baseline values. These changes contradict the findings of previous studies, indicating that Sudarshan kriya and pranayam significantly decrease platelet concentration (Dayalan et al., 2012).

The present study have significant implications for enhancing the overall health and wellness of normotensive students. The potential mechanisms underlying these changes were explored by Lim (2015), who found that regular yoga practice can improve antioxidant status and immune function, which may contribute to the observed hematological changes. This study suggests that engaging in yoga can have a beneficial effect on the oxygen-carrying capacity of the body, which may lead to increased energy levels and enhanced overall well-being. This alteration in the levels of hematological variables is particularly important for college students because of their rigorous lifestyles. College experience often involves various physical and mental stressors that can affect both students' energy levels and academic performance.

This study has certain limitations that should be taken into consideration. Firstly, the training period was short, whereas a longer period may be required to observe greater differences in the experimental group. Secondly, participants were nit blinded to yoga intervention. Thirdly, we did not assess the nutritional status and diet of the participants which may affect the results of blood biomarkers. Finally, although the players were questioned whether they had a typical menstrual cycle, or if they used hormonal contraception, it was not possible to align their training according to their cycles due to the group training. As it was impossible that their cycles ran in tandem with each other, this was not taken into account. Despite these limitations, the findings of this study may account for positive outcomes by adopting yoga as a lifestyle intervention in normotensive individuals. Further larger studies should include with a different age group while considering differences in other variables such as nutritional status, diet and gender.

CONCLUSION

These findings suggest that the yoga training has the potential to positively impact hematological parameters in normotensive college students. The observed increase in RBC, hemoglobin, and platelet levels provides valuable evidence for considering yoga as a complementary approach to support the overall well-being of college students. These changes suggest that yoga being easy, cost-efficient, safe practice for normotensive individuals. Further research is warranted to validate and expand these findings, with the ultimate goal of contributing to the development of effective preventive healthcare strategies tailored to young adults in a college setting.

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DISCLOSURE OF INTEREST

No conflict of interest.

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