International Research Journal of Ayurveda & Yoga Vol. 7(10), pp. 13-19, October, 2024
Available online at http://irjay.com
ISSN: 2581-785X
DOI: 10.48165/IRJAY.2024.71003

ORIGINAL RESEARCH ARTICLE

Study of Yoga Intervention on Hemoglobin, Blood Sugar, Complete Blood Count, and Differential Leukocyte Count Levels in Indo-Tibetan Border Police Personnel for High-Altitude Missions in India

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ARTICLE INFO

Article history:
Received on: 27-08-2024
Accepted on: 19-10-2024
Published on: 31-10-2024

Key words:
Blood Sugar,
Complete Blood Count,
Differential Leukocyte Count,
Hemoglobin,
Indo-Tibetan Border Police Personnel,
Yoga Intervention

ABSTRACT

Background: High-altitude (HA) environments pose significant physiological challenges to the human body, including hypoxia, cold exposure, and increased physical demands. These conditions can lead to fluctuations in vital health parameters such as hemoglobin, blood sugar, and immune function. Yogic practices, including Āsanas (physical postures), Prāṇāyāma (breathing techniques), and meditation, have been shown to improve cardiovascular, immune, and metabolic functions.

Aim: This study investigates the physiological effects of structured Yogic practices on Indo-Tibetan Border Police (ITBP) personnel stationed in HA regions, with a focus on hemoglobin, blood sugar, complete blood count (CBC), and differential leukocyte count (DLC).

Materials and Methods: A randomized case–control design was employed, involving 100 ITBP personnel. Participants were divided into a control group following regular physical activities and an intervention group practicing a comprehensive Yogic regimen for 8 weeks. Pre- and post-intervention measurements of hemoglobin, blood sugar, CBC, and DLC were taken. Statistical analysis was conducted using paired t-tests.

Intervention: The intervention group engaged in structured Yogic practices, including Āsanas, Prāṇāyāma, and meditation, over an 8-week period. The control group maintained their regular physical activities without additional Yogic practices.

Results: The intervention group exhibited significant improvements in key physiological parameters. Hemoglobin levels increased from 12.237 g/dL to 13.103 g/dL, while fasting blood sugar levels decreased from 88.453 mg/dL to 85.056 mg/dL. Total leukocyte count improved from 6789.43 to 6977.04 cells/µL, and neutrophil levels rose from 7163.10 to 7388.04 per mm³, reflecting enhanced immune function.

Conclusion: This study demonstrates that specific Yogic practices positively impact hemoglobin levels, blood sugar regulation, and immune function. The findings suggest that Yoga can promote health and operational readiness among personnel in HA environments, highlighting the value of incorporating Yoga into the routines of individuals exposed to extreme physical and mental conditions, such as ITBP personnel.

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1. INTRODUCTION

High-altitude (HA) environments pose unique physiological challenges, including hypoxia, extreme cold, and increased physical demands, which can adversely affect the health and performance of personnel deployed in such regions. The Indo-Tibetan Border

Police (ITBP) personnel, who operate in these extreme conditions, often experience fluctuations in hemoglobin levels, blood sugar, and immune function, as indicated by changes in complete blood count (CBC) and differential leukocyte count (DLC).

Yogic practices, encompassing *Āsana-s* (physical postures), *Prāṇāyāma* (breathing techniques), and meditation, have been shown to offer various health benefits, including improved cardiovascular function, enhanced immune response, and better overall metabolic regulation.

In this some related research carried out at an elevation of 3445 m in Leh, India, the objective of the investigators was to investigate the impacts of extensive Yogic activities on Indian soldiers stationed in HA areas. The research utilized a prospective, randomized, case–control layout, with soldiers split into a control group participating in regular physical exercises and an intervention group following a complete Yoga regimen. The assessed results encompassed a range of anthropometric, physiological, biochemical, and psychological factors.[1] The increase in HA travel for various reasons has resulted in a rise in hypoxia-related health problems and anxiety. Recent research on *Sudarśana Kriya Yoga* (SKY) emphasizes its effectiveness in reducing stress by recognizing the impact of mental stress on brain and heart functions. This study examines the physiological effects of SKY advanced breathing techniques on lowlanders quickly ascending to HAs, with a focus on stress levels and mental well-being. Following SKY practice, biochemical parameters such as cholesterol, triglycerides, and LDLs showed a significant decrease, alongside enhancements in mental well-being and a reduction in acute mountain sickness. The findings of the study indicate positive results for both biochemical and stress-related factors among SKY practitioners ascending rapidly to HAs.[2] In the pursuit of a simple yet efficient method to train the mind and body, many individuals look to the ancient tradition of Yoga. *Haṭha Yoga,* which involves physical movements through various poses, has its origins in ancient India and offers a wide range of exercises for overall health. With a focus on controlled breathing and meditative practices as outlined in the Yoga Sutras, different styles of Yoga have emerged, including *Haṭha, Aṣṭāṅga, Iyengar*, *Sivananda*, and more. The goal of Yoga is to elevate individuals to higher levels of physical, mental, and spiritual well-being, emphasizing controlled breathing for a stronger cardiopulmonary system and improved posture. In addition to the physical benefits, Yoga serves as a refuge in our fast-paced world, promoting self-awareness and a break from the distractions of everyday life. While certain poses may pose risks, the overall positive impact of Yoga extends to mental, physical, and overall well-being. This research delves into the physiological effects of *Yogāsanas* on young people from various backgrounds, exploring the broader implications of Yoga on diverse populations.[3]

This study aims to explore the potential of a structured Yogic regimen to enhance physiological resilience and optimize health outcomes in ITBP personnel preparing for HA missions. By evaluating key biomarkers such as hemoglobin, blood sugar levels, and CBCs, this research seeks to highlight the role of Yogic practices in maintaining operational fitness and improving the physiological readiness of individuals facing extreme environmental conditions.

1.1. Objective of this Study

The objectives of this study are as follows:

- To study the effects of specific Yogic practices on hemoglobin levels among ITBP personnel
- To study the effects of specific Yogic practices on blood sugar levels among ITBP personnel
- To study the effects of specific Yogic practices on CBC levels among ITBP personnel
- To study the effects of specific Yogic practices on DLC (neutrophils) levels among ITBP personnel.

2. METHODS

2.1. Participants

A total of 100 ITBP personnel were selected for the study from Basic Training Centre, Bhanu, ITBP force, NH 73, Panchkula, Haryana. Participants were randomly assigned to undergo a structured regimen of Yogic practices designed specifically for HA missions. Informed consent was obtained from all participants before their inclusion in the study.

2.2. Study Design

The study employed a pre-test and post-test design to evaluate the effects of Yogic practices on various physiological parameters. Baseline measurements (pre-test) were collected from all participants before the commencement of the Yogic intervention. After the completion of the intervention period, the same participants underwent post-test measurements to assess changes in the physiological parameters. Since this design involved no control or comparison group, the study focused on evaluating within-subject changes over time as a result of the intervention.

2.3. Intervention

The Yogic practices included a combination of *Shatkriyās* (six cleansing techniques), *āsanas* (physical postures), *prāṇāyāma* (breathing exercises), and meditation. The intervention was conducted over a period of 8 weeks, with sessions held 6 days a week. Each session lasted for 60 min and was supervised by certified Yoga instructors. The Yogic intervention spanned 8 weeks, with sessions conducted 6 days a week, each lasting 60 min. The practice regimen was structured as follows:

1. Shatkriyas (6 cleansing techniques) – 5 min: The session began with one of the six Shatkriyas, focusing on techniques such as Jal Neti (nasal cleansing), Kapalbhati (skull-shining breath), or Trataka (concentration on a fixed point), chosen on alternate days. These cleansing techniques aimed to purify the body and prepare the practitioners for further practices.
2. Āsanas (physical postures) – 25 min: A sequence of traditional Yoga postures was included, focusing on flexibility, strength, and balance. Each session targeted different muscle groups, with postures such as Tadasana (Mountain Pose), Trikonasana (Triangle Pose), and Sarvangasana (Shoulder Stand), gradually progressing in intensity throughout the weeks.
3. Prāṇāyāma (breathing exercises) – 15 min: This segment included controlled breathing techniques such as Nadi Shodhana (alternate nostril breathing), Bhastrika (bellows breath), and Ujjayi (victorious breath), which help regulate the flow of prana (life force) and enhance respiratory function.
4. Meditation – 15 min: Each session concluded with a period of guided meditation, focusing on techniques such as mindfulness or mantra repetition to cultivate mental calmness, focus, and emotional balance.

2.4. Data Collection

The data collection for the study was conducted in collaboration with Grecian Hospital, a Super Specialty Hospital located in SAS

Nagar, Mohali. This partnership ensured the accuracy and reliability of the physiological measurements taken before and after the Yogic intervention. Hemoglobin levels were assessed using a standard hemoglobinometer, which provided a precise evaluation of the participants' oxygen-carrying capacity in the blood. Fasting blood sugar levels were measured with a glucometer, offering vital insights into metabolic health.

In addition, a CBC was performed using an automated hematology analyzer. This test yielded comprehensive information on various blood parameters, including red blood cell count, white blood cell count, and platelet levels, essential for assessing overall health. The DLC was conducted manually under a microscope, allowing for the categorization of white blood cells into specific types – neutrophils, lymphocytes, monocytes, eosinophils, and basophils – each crucial for immune function and response. These detailed physiological measurements provided a robust dataset, facilitating the analysis of the effects of Yogic practices on the ITBP personnel. The findings contribute valuable insights into enhancing their readiness for HA missions and overall health.

2.5. Statistical Analysis

The data collected from pre-test and post-test measurements were analyzed using statistical software. Paired t-tests were conducted to compare the mean values of the physiological parameters before and after the intervention. A significance level of $P < 0.05$ was considered to indicate statistical significance.

2.6. Ethical Considerations

The study protocol was reviewed and approved by the Haryana Yog Aayog ethics committee. Participants were briefed on the potential benefits and risks of the study, and their participation was entirely voluntary. All personal data were kept confidential and used solely for research purposes.

3. ANALYSIS AND INTERPRETATION OF THE DATA

3.1. Yogic Practices on Hemoglobin Levels among ITBP Personnel

In order to study, the statistical analysis of specific Yogic practices on hemoglobin among ITBP personnel the specific yogic practice has been conducted and data is collected. The computed statistical measures have been presented in Table 1 and Figure 1 for reference and analysis.

The present study aimed to examine the impact of specific Yogic practices on the hemoglobin levels of ITBP personnel by comparing the pre-test and post-test scores. The data presented in the table highlight a significant increase in hemoglobin levels after the Yoga intervention. The pre-test mean score of hemoglobin among the participants was 12.237 with a standard deviation (SD) of 1.81. Following the Yoga intervention, the post-test mean score increased to 13.103, with a reduced SD of 1.45.

The standard error of difference (SED) between the pre-test and post-test scores was 0.232. The t-value calculated for this comparison was 3.7341, with 189 degrees of freedom (df). This value is statistically significant at a high level of confidence, indicating that the difference observed between the pre-test and post-test hemoglobin levels is not due to random chance. The significant t-value further supports the effectiveness of the specific Yogic practices in improving hemoglobin levels among the ITBP personnel.

The study suggests that the Yoga intervention had a positive and statistically significant effect on hemoglobin levels, demonstrating the potential of Yoga practices in promoting physical health and wellness, particularly in improving blood health parameters such as hemoglobin.

3.2. Yogic Practices on Blood Sugar Levels among ITBP Personnel

In order to study, the statistical analysis of specific Yogic practices on blood sugar level among ITBP personnel the specific yogic practice has been conducted and data is collected for reference and analysis.

The study aimed to assess the impact of specific Yogic practices on blood sugar levels among ITBP personnel by comparing their fasting blood sugar levels before and after a Yoga intervention. A sample of 100 individuals was analyzed, with both pre-test and post-test scores evaluated in terms of mean scores and SD.

The pre-test mean blood sugar level was recorded at 88.453 mg/dL, with a SD of 4.03, while the post-test mean decreased to 85.056 mg/dL, with a lower SD of 2.90. The SED between the two tests was 0.496, with a degree of freedom (df) of 179.

A t-value of 6.8419 was calculated, indicating a highly statistically significant result. This value, being much greater than the critical t-value for a given level of significance, suggests a substantial reduction in fasting blood sugar levels following the Yoga intervention.

The findings clearly demonstrate that specific Yogic practices led to a statistically significant reduction in fasting blood sugar levels among ITBP personnel. The consistency of the post-test scores, as evidenced by the lower SD, further supports the reliability of the intervention's effect. Hence, it can be concluded that Yoga has a beneficial impact on controlling blood sugar levels in this population.

3.3. Yogic practices on CBC – Total Leukocyte Count (TLC) Levels among ITBP Personnel

In order to study, the statistical analysis of specific Yogic practices on CBC level among ITBP personnel the specific yogic practice has been conducted and data is collected. The computed statistical measures have been presented in Table 3 and Figure 3 for reference and analysis.

The study aimed to assess the impact of specific yogic practices on the CBC, particularly the TLC, among ITBP personnel. A pre-test and post-test comparison was conducted, with 100 participants each for both the pre-test and post-test groups. The mean TLC value in the pre-test was 6789.43 cells/μL with a SD of 490.88 cells/μL. After the yoga intervention, the post-test mean TLC value increased to 6977.04 cells/μL, with a corresponding SD of 498.67 cells/μL.

The SED between the pre-test and post-test mean scores was calculated as 69.974, and the degrees of freedom (df) for the study were 197. The computed t-value of 2.6811 indicates a very statistically significant difference between the pre-test and post-test scores at a significant level, confirming that the intervention had a meaningful impact on TLC levels. The analysis demonstrates that the Yoga practices positively influenced the immune function, as reflected by the increased TLC levels among ITBP personnel. This suggests that regular Yoga intervention can contribute to enhanced physiological functioning, including improved immune response, as evidenced by the significant rise in TLC.

3.4. Yogic Practices on DLC (Neutrophils) Levels among ITBP Personnel

In order to study, the statistical analysis of specific Yogic practices on DLC Level among ITBP personnel the specific yogic practice has been conducted and data is collected. The computed statistical

measures have been presented in Table 4 and Figure 4 for reference and analysis.

The study aimed to analyze the effect of specific Yogic practices on DLC, focusing on neutrophil levels among ITBP personnel. The data compared pre-test and post-test mean scores and SDs following a Yoga intervention. The pre-test group, with a sample size of 100, had a mean neutrophil count of 7163.10 per mm^3 and an SD of 398.4. After the Yoga intervention, the post-test group, also with 100 participants, exhibited an increased mean neutrophil count of 7388.04 per mm^3, with a slightly lower SD of 391.55.

The SED was computed to be 55.860, and the degrees of freedom (df) for the study were 197. A t-value of 4.0269 was obtained, indicating an extremely statistically significant difference between the pre-test and post-test neutrophil levels ($P < 0.001$). This suggests that the specific Yogic practices led to a significant increase in neutrophil counts among the personnel.

The increase in mean scores from pre-test to post-test, along with the high t-value, clearly supports the hypothesis that the Yoga intervention had a significant impact on improving neutrophil levels, which could potentially enhance immune function in the participants.

4. DISCUSSION

The present study aimed to assess the impact of specific Yogic practices on the hemoglobin, blood sugar, CBC, and DLC levels among ITBP personnel. The results demonstrate a significant positive effect of Yoga interventions on the aforementioned health parameters, aligning with previous research that supports the benefits of Yoga on various physiological functions.

In terms of hemoglobin levels, the comparison of pre-test and post-test scores revealed a substantial increase. This finding is consistent with prior studies that have documented the role of Yoga in enhancing blood oxygenation and improving hemoglobin concentrations.[4] Similarly, fasting blood sugar levels showed a significant reduction following the Yoga intervention. These results align with existing research highlighting the benefits of Yoga in regulating blood glucose levels, particularly in individuals at risk for diabetes.[5] The reduction in blood sugar levels could be attributed to the enhanced insulin sensitivity and stress reduction effects associated with regular Yoga practice. The TLC also experienced a meaningful improvement, suggesting improved immune function as a result of the Yoga practice. Previous studies have demonstrated the role of Yoga in modulating immune function and increasing TLC levels, which further supports the findings of this research.[6] Finally, the study found a significant increase in neutrophil levels as part of the DLC. This reinforces previous findings that Yoga contributes to immune enhancement by improving neutrophil counts, which play a crucial role in the body's defense mechanism.[7]

The study confirmed that specific Yogic practices have a profound and statistically significant effect on hemoglobin, blood sugar, TLC, and DLC (neutrophil) levels, indicating the potential of Yoga in promoting overall physical health and immune function among ITBP personnel. The holistic nature of Yoga, encompassing *shatkriyas* (six-cleansing technique), *Āsanas* (physical postures), *Prāṇāyāma* (breathing techniques), and meditation, likely contributed to the observed benefits. The reduction in stress and enhancement of physical and mental well-being can lead to better physiological outcomes, as reflected in the improved blood parameters. For ITBP personnel, who face extreme physical and mental demands, the integration of Yoga into their routine could be a valuable strategy for enhancing overall health and performance.

5. CONCLUSION

The analysis of the study indicates a significant positive impact of specific Yogic practices on various health parameters among ITBP personnel. The results demonstrate a substantial increase in hemoglobin levels, reflecting enhanced oxygen-carrying capacity and improved overall blood health. The intervention also led to a notable reduction in fasting blood sugar levels, suggesting that Yoga has a beneficial role in managing blood glucose and promoting metabolic health.

In addition, the study found that specific Yogic practices had a meaningful effect on the immune system, as evidenced by the increase in both TLC and neutrophil levels. These changes point to an enhanced immune response and suggest that regular Yoga practice may contribute to improved physiological functioning, particularly in strengthening the body's defenses.

Overall, the data strongly support the effectiveness of specific Yogic interventions in improving physical health parameters such as hemoglobin, blood sugar levels, and immune function. The statistically significant results highlight Yoga's potential in promoting wellness and preventing illness, particularly among personnel engaged in physically demanding professions like ITBP. This study underscores the value of incorporating Yoga as a regular practice for overall health and well-being.

6. ACKNOWLEDGMENT

Nil.

7. AUTHORS' CONTRIBUTIONS

All the authors contributed equally to the design and execution of the article.

8. FUNDING

Nil.

9. ETHICAL APPROVALS

This study was approved by the Haryana Yog Ayog institutional ethical committee under no-HYA/HRY/2024/374 dated 09/02/2024 Yog Institutional Ethical Committee.

10. CONFLICTS OF INTEREST

Nil.

11. DATA AVAILABILITY

This is an original manuscript and all data are available for only review purposes from principal investigators.

12. PUBLISHERS NOTE

This journal remains neutral with regard to jurisdictional claims in published institutional affiliation.

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How to cite this article:
Arya J, Sharma S, Duhan IS, Chander H, Priyanka, Jaspreet. Study of Yoga Intervention on Hemoglobin, Blood Sugar, Complete Blood Count, and Differential Leukocyte Count Levels in Indo-Tibetan Border Police Personnel for High-Altitude Missions in India. IRJAY. [online] 2024;7(10);13-19.
Available from: https://irjay.com
DOI link- https://doi.org/10.48165/IRJAY.2024.71003

Table 1: Comparison between pre-test and post-test of yoga intervention on hemoglobin among ITBP personnel with respect to mean scores and SD

Groups	*n*	Mean	SD	SED	df	t-value	Level of significance
Pre-test score	100	12.237	1.81	0.232	189	3.7341	Extremely statistically significant.
Post-test score	100	13.103	1.45				

ITBP: Indo-Tibetan Border Police, SED: Standard error of difference, SD: Standard deviation

Table 2: Comparison between pre-test and post-test of yoga intervention on blood sugar (fasting blood sugar) (mg%) among ITBP personnel with respect to mean scores and SD

Groups	*n*	Mean	SD	SED	df	t-value	Level of significance
Pre-test score	100	88.453	4.03	0.496	179	6.8419	Extremely statistically significant
Post-test score	100	85.056	2.90				

ITBP: Indo-Tibetan Border Police, SED: Standard error of difference, SD: Standard deviation

Table 3: Comparison between pre-test and post-test of yoga intervention on CBC (total leukocyte count) level among ITBP personnel with respect to mean scores and SD

Groups	*n*	Mean (cells/µL)	SD (cells/µL)	SED	df	t-value	Level of significance
Pre-test score	100	6789.43	490.88	69.974	197	2.6811	Very statistically significant
Post-test score	100	6977.04	498.67				

ITBP: Indo-Tibetan Border Police, SED: Standard error of difference, SD: Standard deviation, CBC: Complete blood count

Table 4: Comparison between pre-test and post-test of yoga intervention on DLC (Neutrophils) level among ITBP personnel with respect to mean scores and SD

Groups	*n*	Mean (per mm^3)	SD (per mm^3)	SED	df	t-value	Level of significance
Pre-test score	100	7163.10	398.4	55.860	197	4.0269	extremely statistically significant
Post-test score	100	7388.04	391.55				

ITBP: Indo-Tibetan Border Police, SED: Standard error of difference, SD: Standard deviation, DLC: Differential leukocyte count

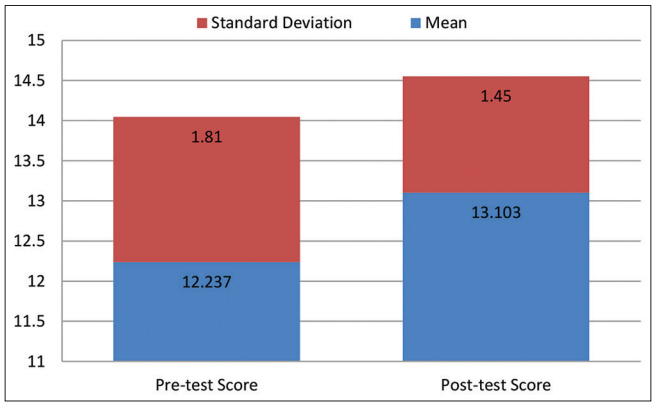

Figure 1: Comparison between pre-test and post-test score of yoga intervention on hemoglobin among Indo-Tibetan Border Police personnel with respect to mean scores and standard deviation

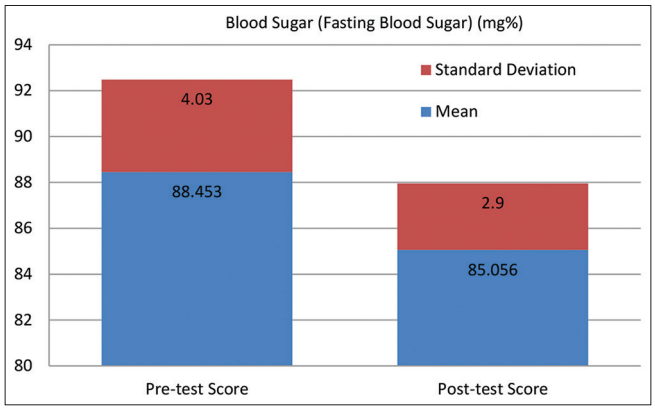

Figure 2: Comparison between pre-test and post-test scores of yoga intervention on blood sugar level among Indo-Tibetan Border Police personnel with respect of mean scores and standard deviation

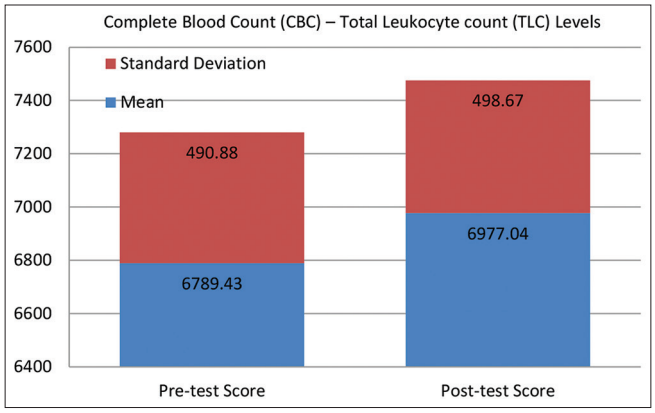

Figure 3: Comparison between pre-test and post-test score of yoga intervention on complete blood count level among Indo-Tibetan Border Police personnel in respect of mean scores and standard deviation

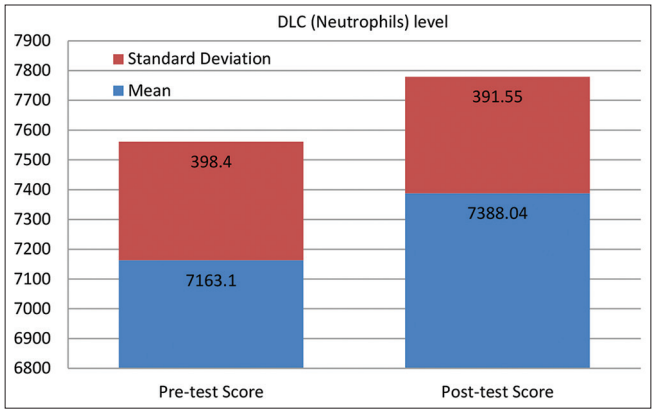

Figure 4: Comparison between pre-test and post-test scores of yoga intervention on differential leukocyte count level among Indo-Tibetan Border Police personnel with respect to mean scores and standard deviation