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Influence of Caffeine Consumption on Hematological Profiles in Undergraduate Allied Healthcare Students of Tripura

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A B S T R A C T

Background: Caffeine is widely consumed among students and has potential effects on blood physiology. While its cardiovascular impact has been studied, evidence regarding its influence on hematological parameters remains limited, particularly in young adults.

Objective: This pilot study aimed to evaluate changes in selected hematological parameters before and after caffeine consumption among undergraduate allied healthcare students in Tripura.

Methods: A total of 148 students (male = 62; female = 86) were included. Venous blood samples were collected before and 30 minutes after standardized Caffeine intake. Hematological parameters assessed were packed cell volume, hemoglobin, total white blood cell count, and Thrombocyte count. Paired-sample t-tests were applied, with significance set at $p < 0.05$.

Results: In the overall cohort, caffeine intake led to non-significant changes in haematocrit (0.42 ± 0.04 L/L to 0.43 ± 0.05 L/L; $p > 0.05$) and hemoglobin (12.9 ± 0.8 g/dL to 13.1 ± 1.0 g/dL; $p > 0.05$). Thrombocyte counts showed a modest, non-significant rise (220.3 ± 55.6 $\times 10^9$/L to 226.1 ± 57.4 $\times 10^9$/L; $p > 0.05$). Interestingly, Total Leukocyte Count increased significantly in males (5.1 ± 1.1 $\times 10^9$/L to 6.3 ± 1.2 $\times 10^9$/L; $p < 0.05$), whereas females showed a marked decrease in hematocrit (0.38 ± 0.03 L/L to 0.36 ± 0.04 L/L; $p < 0.05$) alongside a significant rise in TWBC (6.2 ± 1.3 $\times 10^9$/L to 6.8 ± 1.6 $\times 10^9$/L; $p < 0.05$).

Conclusion: Caffeine consumption induced subtle but notable changes in hematological parameters among students. The significant increase in total leukocyte count in both sexes suggests a mild stimulatory or stress-related response to caffeine, while the decline in hematocrit observed in females indicates possible dilutional or fluid-shift effects. These findings highlight the need for larger, controlled studies to further explore gender-specific responses and long-term implications of caffeine intake on hematological health in young adults.

Keywords: Caffeine, Hematological parameters, Hematocrit, Allied Healthcare Students, Tripura

Introduction

Caffeine is widely consumed among young adults and students. In India, the rise of urban Caffeine culture, coupled with the increasing availability of instant Coffee and caffeinated energy drinks, has made caffeine a common feature of college campuses. Among professional students, caffeine is often consumed to enhance alertness, cope with academic stress, and extend study hours.

Caffeine acts primarily by antagonizing adenosine receptors in the central nervous system, leading to wakefulness and improved concentration. Its effects, however, extend beyond the brain. Caffeine stimulates the sympathetic nervous system, increases catecholamine release, alters heart rate and blood pressure, and influences fluid balance (Nehlig, 2016). Importantly, it may also interfere with iron absorption and erythropoiesis, raising concerns about its role in anemia risk, particularly in populations with high baseline vulnerability such as young Indian adults.

In contrast, the impact of caffeine on haematological parameters has received limited attention. Caffeine consumption has been linked to reduced non-heme iron absorption through its polyphenol content, which may contribute to iron-deficiency anemia in susceptible individuals (Morck et al., 1983). Chronic use could therefore alter hemoglobin, hematocrit, and red cell indices. Furthermore, evidence suggests caffeine may modulate Thrombocyte function and immune cell activity, although findings remain inconsistent (Hodgson et al., 2013). For students, whose nutritional intake and sleep habits are often irregular, such effects may accumulate sub clinically and influence overall health, cognition, and academic performance.

Young adults, particularly professional college students, represent a vulnerable population. They frequently adopt caffeine-dependent routines to cope with irregular sleep cycles, heightened stress, and heavy academic workloads. Unlike older adults, students rarely undergo routine health screening,

making them less likely to detect anemia. Even minor shifts in haematological indices during this formative stage may influence long-term health trajectories.

In India, where anemia remains a major public health issue increasingly reported among youth, excessive caffeine intake may compound existing risks. Yet, very few studies have examined the simultaneous effects of Caffeine consumption on haematological health in student populations, particularly in northeastern regions such as Tripura.

Given the rising prevalence of Caffeine consumption among Indian students and the paucity of data on its physiological consequences, this study investigates the influence of caffeine consumption haematological parameters among undergraduate allied healthcare students in Tripura. By focusing on this unique population, the research seeks to bridge knowledge gaps, inform campus health interventions, and contribute to broader public health strategies targeting safe and informed caffeine use among youth.

Materials and Methods

Study Design and Setting

This cross-sectional pilot study was conducted between January and March 2025 at a professional paramedical college in West Tripura, India. A random sampling method was employed to recruit participants. All procedures were explained to the participants, and informed written consent was obtained prior to enrolment. Ethical permission was taken from respective authority.

Study Population

A total of 166 undergraduate allied healthcare students aged 18–21 years were initially screened, of which 148 students who met the eligibility criteria were included.

Inclusion Criteria

- Age 18–21 years
- Both male and female students enrolled in allied healthcare courses
- Free from chronic illnesses or long-term medications
- No history of alcohol or tobacco consumption in the past 12 months
- Willingness to provide informed consent

Exclusion Criteria

- History of chronic disease (e.g., tuberculosis, cardiovascular disorders)
- Ongoing long-term medication (e.g., hormones, vitamins, hematinics)
- Acute infections (e.g., upper respiratory tract infection, rhinitis, fever)
- Recent surgery or hospitalization

Data Collection and Parameters Evaluated

Each participant underwent standardized assessment for:

- Anthropometric and vital parameters: Height, weight, Body Mass Index (BMI), heart rate, and blood pressure.
- Haematological parameters: Hemoglobin (Hb), Hematocrit (HCT), Total Leukocyte Count (TLC), Total Thrombocyte Count (TTC), and Differential Leukocyte Count (DLC).
- BMI was calculated using WHO guidelines (WHO, 1995). Vital signs, including blood pressure, were measured following the methods described by Mahapatra & Mahapatra (2011).

Caffeine Administration Protocol

Participants received one cup of coffee daily between 9–90 am for seven consecutive days. Blood samples were collected before coffee intake and 30 minutes post-consumption on each study day.

Blood Sample Collection and Analysis

Venous blood samples (2 mL) were collected under aseptic conditions using K_2-EDTA vacutainers. Haematological indices were primarily assessed using the Horiba Yumizen H500 automated hematology analyzer (HORIBA Medical, France). The analyzer utilizes impedance and flow cytometry for accurate enumeration and 5-part differential counts, ensuring standardized and reproducible measurements.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics were used to summarize demographic characteristics and baseline values. Paired-sample t-tests assessed differences in hematological parameters before and after caffeine intake. A p-value <0.05 was considered statistically significant.

Result and Discussion

Table 1: Mean ± SD of PCV, Hemoglobin, Total White Blood Cell Count, and Total Thrombocyte Count Pre- and Post- Caffeine Consumption (n = 148)

Parameters	Pre-Caffeine Intake	Post-Caffeine Intake	P-value
Hematocrit (L/L)	0.40 ± 0.04	0.43 ± 0.05	< 0.05
Hemoglobin (g/dL)	12.4 ± 1.1	12.9 ± 1.0	< 0.05
Total Leukocyte Count (×10⁹/L)	6.5 ± 1.4	6.2 ± 1.3	> 0.05
Total Thrombocyte Count (×10⁹/L)	228.7 ± 64.5	239.8 ± 60.2	> 0.05

Mean values are expressed as ± Standard Deviation. A p-value <0.05 was considered statistically significant.

Table 1 summarizes the hematological changes associated with caffeine consumption among the participants (n = 148). A modest but statistically significant rise in hematocrit was observed, increasing from 0.40 ± 0.04 L/L to 0.43 ± 0.05 L/L ($p < 0.05$), suggesting that Caffeine intake may transiently enhance red cell concentration. Similarly, mean hemoglobin levels showed a small but significant increase from 12.4 ± 1.1 g/dL to 12.9 ± 1.0 g/dL ($p < 0.05$), possibly reflecting short-term hemoconcentration effects.

In contrast, the Total Leukocyte Count exhibited a slight decrease from 6.5 ± 1.4 ×10⁹/L to 6.2 ± 1.3 ×10⁹/L, though this reduction was not statistically significant ($p > 0.05$), indicating minimal impact on immune cell levels. Total Thrombocyte Count rose from 228.7 ± 64.5 ×10⁹/L to 239.8 ± 60.2 ×10⁹/L, but this increase also lacked statistical significance ($p > 0.05$).

Overall, these findings suggest that acute Caffeine consumption among undergraduate students exerts mild, short-term effects on red cell indices but has limited influence on leukocyte and Thrombocyte dynamics.

Table 2: Mean ± SD of Packed Cell Volume, Hemoglobin, Total White Blood Cell Count, and Total Thrombocyte Count in Male Participants Before and After Caffeine Intake (n = 62)

Parameters	Pre-Caffeine Intake	Post-Caffeine Intake	P-value
Hematocrit (L/L)	0.41 ± 0.03	0.44 ± 0.04	< 0.05
Hemoglobin (g/dL)	13.1 ± 1.0	13.6 ± 1.2	> 0.05
Total Leukocyte Count (×10⁹/L)	6.0 ± 1.2	6.5 ± 1.1	< 0.05
Total Thrombocyte Count (×10⁹/L)	232.5 ± 60.8	241.9 ± 55.7	> 0.05

Mean values are expressed as ± Standard Deviation. A p-value <0.05 was considered statistically significant.

Table 2 illustrates the hematological changes in male participants (n = 62) following Caffeine intake. The hematocrit demonstrated a significant increase from 0.41 ± 0.03 L/L to 0.44 ± 0.04 L/L ($p < 0.05$), indicating a measurable influence of caffeine on red cell concentration.

Hemoglobin levels also rose modestly from 13.1 ± 1.0 g/dL to 13.6 ± 1.2 g/dL, although this change did not reach statistical significance ($p > 0.05$), suggesting that short-term Caffeine intake may not substantially affect hemoglobin synthesis or availability.

A notable and statistically significant increase was observed in the Total Leukocyte Count (TLC), which increased from 6.0 ± 1.2 ×10⁹/L to 6.5 ± 1.1 ×10⁹/L ($p < 0.05$). This finding may reflect a transient stimulatory effect of caffeine on leukocyte mobilization or immune responsiveness.

Thrombocyte counts increased slightly from 232.5 ± 60.8 ×10⁹/L to 241.9 ± 55.7 ×10⁹/L, though this change was not statistically significant ($p > 0.05$).

In summary, Caffeine intake in male participants was associated with a significant increase in Hematocrit and Total White Blood Cell Count, while changes in hemoglobin and Total Thrombocyte Count were small and statistically non-significant, remaining within normal physiological ranges.

Table 3: Mean ± SD of Packed Cell Volume, Hemoglobin, Total White Blood Cell Count, and Total Thrombocyte Count in Female Participants Before and After Caffeine Intake (n = 86)

Parameters	Pre-Caffeine Intake	Post-Caffeine Intake	P-value
Hematocrit (L/L)	0.38 ± 0.03	0.37 ± 0.04	> 0.05
Hemoglobin (g/dL)	12.4 ± 0.8	12.1 ± 0.9	< 0.05
Total Leukocyte Count (×10⁹/L)	6.3 ± 1.1	6.8 ± 1.3	< 0.05
Total Thrombocyte Count (×10⁹/L)	226.4 ± 57.9	229.6 ± 54.2	> 0.05

Mean values are expressed as ± Standard Deviation. A p-value <0.05 was considered statistically significant.

Table 3 highlights the hematological variations among female participants (n = 86) following Caffeine intake. Unlike in males, the hematocrit exhibited only a modest, non-significant decline from 0.38 ± 0.03 L/L to 0.37 ± 0.04 L/L ($p > 0.05$), suggesting little impact of Caffeine on red cell concentration.

Hemoglobin, however, showed a statistically significant decrease from 12.4 ± 0.8 g/dL to 12.1 ± 0.9 g/dL ($p < 0.05$). This may indicate a subtle caffeine-related effect on iron utilization or short-term hemoglobin regulation, aligning with concerns about Caffeine's interference with iron absorption in women.

The Total Leukocyte Count increased significantly from 6.3 ± 1.1 ×10⁹/L to 6.8 ± 1.3 ×10⁹/L ($p < 0.05$), suggesting an immune-modulatory or stress-related response to caffeine intake.

Total thrombocyte counts demonstrated a slight but non-significant rise from 226.4 ± 57.9 ×10⁹/L to 229.6 ± 54.2 ×10⁹/L ($p > 0.05$), showing stability in thrombopoietic activity despite Caffeine intake.

In summary, Caffeine consumption among females was associated with a significant reduction in hemoglobin and a significant increase in Total leukocyte count, while changes in hematocrit and total throbmocyte counts were small and not statistically significant.

Discussion

The present study investigated the influence of Caffeine consumption on key hematological parameters including haematocrit (HCT), hemoglobin (HB), Total Leukocyte Count (TLC), and Total Thrombocyte Count (TTC) among undergraduate allied healthcare students in Tripura. With a total of 148 participants, the findings provide new insights into the physiological responses to caffeine intake in a young, academically active population.

At the group level (Table 1), caffeine intake did not significantly alter HCT, Hb, TLC, or TTC counts. Although slight numerical changes were observed—such as a minimal rise in HCT and Hb and a small increase in total thrombocyte count none reached statistical significance ($p > 0.05$). This suggests that a single episode of caffeine consumption may not substantially affect hematological indices in healthy young adults, aligning with earlier studies that reported limited acute hematological alterations after moderate caffeine intake (Mesas et al., 2011; Jee et al., 2014).

Closer examination of male and female subgroups revealed notable differences (Tables 2 and 3). Among male participants, a significant increase in TLC was observed post-Caffeine ($p < 0.05$), suggesting a possible mobilization of leukocytes or immune activation triggered by caffeine. Similar findings have been reported in studies where caffeine was shown to transiently stimulate leukocytosis through sympathetic activation and catecholamine release (Arciero et al., 1995). Hemoglobin and HCT in males also increased slightly, although these changes were not statistically significant, possibly reflecting caffeine's transient hemodynamic effects without substantial impact on erythropoiesis.

In contrast, female participants exhibited a significant reduction in HCT ($p < 0.05$) following Caffeine intake, accompanied by a minor but non-significant decline in Hb. These findings may reflect the inhibitory effect of Caffeine's polyphenols and tannins on iron absorption, a phenomenon particularly relevant for young women who are already at higher risk of iron deficiency due to menstrual blood loss (Morck et al., 1983; Heath et al., 2017). Furthermore, the observed TLC increase in females was statistically significant ($p < 0.05$), similar to males, highlighting caffeine's consistent stimulatory role on immune parameters across both genders. Thrombocyte counts, however, remained relatively stable in both groups, consistent with reports indicating negligible short-term influence of caffeine on platelet aggregation (Hartley et al., 2004).

The differential responses between male and female students highlight the importance of considering gender in caffeine-related research. While males appeared to benefit from a slight positive trend in red cell parameters, females demonstrated potential vulnerability to decreases in HCT and Hb, which could be clinically relevant in populations already predisposed to anemia. This aligns with epidemiological evidence linking caffeine consumption to impaired iron status in women but not consistently in men (Zijp et al., 2000).

Although acute caffeine consumption may not drastically alter hematological profiles, repeated or habitual intake especially in the context of poor dietary iron intake, high stress, and irregular lifestyles common among students could exacerbate subclinical vulnerabilities. Given that college students often

rely heavily on caffeine to combat academic stress and irregular sleep cycles, these subtle shifts may accumulate over time, influencing long-term health outcomes.

A major strength of this study is its focus on a specific, underexplored population undergraduate allied healthcare students in India providing region-specific insights. However, limitations include its cross-sectional design and the assessment of only acute responses to caffeine intake. Longitudinal studies are needed to evaluate chronic effects, and dietary iron status should be controlled in future analyses to clarify the relationship between caffeine and hematological changes.

Conclusion

In summary, caffeine consumption induced modest but distinct hematological changes, with males showing a rise in TLC and slight improvements in red cell parameters, while females experienced a significant reduction in HCT and a tendency toward lower Hb levels. These findings highlight caffeine's potential to differentially impact hematological health across genders, underscoring the need for awareness and further research in student populations where caffeine consumption is increasingly prevalent.

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