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Hematological Consequences of a Sedentary Lifestyle in College Students: A Comprehensive Review

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Abstract:

Sedentary lifestyle has become increasingly prevalent among college students due to prolonged academic demands, digital learning environments, and reduced engagement in physical activity. This behavioural pattern poses important implications for physiological health, particularly hematological function. This review synthesizes current evidence on how sedentary behaviour influences blood parameters in young adults, focusing on red blood cell indices, immune function, inflammatory markers, and platelet activity. Findings indicate that prolonged inactivity may contribute to lower hemoglobin and hematocrit levels, altered erythropoiesis, and increased risk of anemia, especially when combined with nutritional deficiencies or menstrual blood loss especially in females. Sedentary behaviour is also associated with elevated white blood cell counts and increased neutrophil-to-lymphocyte ratios, suggesting a state of low-grade systemic inflammation. Additionally, physical inactivity has been linked to heightened platelet activation, which may increase pro-thrombotic tendencies over time. These hematological effects appear to be amplified when sedentary behaviour coexists with academic stress, caffeine consumption, poor diet, and irregular sleep patterns. Overall, the evidence highlights the need for greater awareness of sedentary lifestyle as a modifiable risk factor in student health. Integrating structured physical activity, reducing prolonged sitting, and promoting healthier academic routines may help protect hematological health and improve overall well-being among college students.

Keywords: Sedentary lifestyle; College students; Hematological parameters; Hemoglobin; Inflammation; Platelet activation; Physical inactivity; Student health; Allied health students

1. Introduction

College students today often face a paradox, although many are young and presumed healthy, they increasingly adopt sedentary lifestyles, spending long hours sitting attending classes, studying, using electronic devices, or commuting. A "sedentary lifestyle" is typically defined as any waking behaviour characterized by low energy expenditure (≈ 1.5 METs or less) while sitting or reclined.

Health researchers have repeatedly warned of the risks associated with prolonged sedentary behaviour. It is linked with elevated risks of cardiovascular diseases, metabolic disorders, certain cancers, and increased all-cause mortality. Despite this, the effect of sedentary lifestyle on basic blood health i.e. hematological parameters has drawn relatively less attention, especially among young adults and college students. Given that blood carries oxygen, nutrients, and immune cells, even subtle alterations in hematological parameters (e.g. hemoglobin, red blood cell indices, white blood cells, platelets) may compromise students' health, physical performance, and even academic performance.

Emerging evidence suggests that lifestyle factors can indeed influence hematological parameters. A cross-sectional study found associations between lifestyle behaviours (including physical activity and sedentary time) and changes in red blood cell count, hemoglobin, hematocrit, and other indices. Another population-based analysis reported that higher leisure-time physical activity was associated with lower white blood cell count and lower neutrophil-to-lymphocyte ratio (NLR), markers often linked with systemic inflammation.

On the contrary, individuals with sedentary habits (low or no physical activity) show a trend toward inflammatory predisposition, higher resting WBC counts, and possibly altered red cell parameters compared with more active individuals. For college or allied health students a group often studied for anemia, nutrition, stress, and exam-related blood changes sedentary behaviour may represent an underrecognized risk factor. Our own earlier work with allied healthcare students in Tripura strengthens this concern. For instance, you observed that diet, caffeine consumption, sports participation, menstrual health, and exam stress significantly influence hematological status in this population (Nath & Pallathadka, 2025a; 2025b; 2025c; 2025d; 2025e; 2025f).

However, none of these studies explicitly addressed sedentary lifestyle as a variable. Given the cumulative impact of multiple lifestyle and academic stressors, the contribution of low physical activity and prolonged sitting might compound existing risks. Therefore, there is a clear need to systematically review existing evidence on how sedentary behaviour or physical inactivity influences hematological parameters, especially among young adults and student populations. Such a review could help bridge the knowledge gap, highlight potential risks, and guide future empirical research including among allied health science (AHS) students, where both academic demands and sedentary routines often coexist.

2. Objectives of the Review:

1. To assess current global evidence on associations between sedentary lifestyle/low physical activity and hematological parameters (e.g. RBC count, Hb, hematocrit, WBC, platelets).
2. To evaluate whether sedentary lifestyle may contribute to anemia, immune dysregulation, or other blood-related abnormalities in youth or student populations.
3. To identify gaps in literature relevant to college or AHS students, especially in low-resource or developing contexts (like Tripura).
4. To propose directions for future research and possible preventive interventions.

3. Methodology

This narrative review followed a structured approach to collect, evaluate, and synthesize published evidence on the hematological consequences of sedentary lifestyle among college students and young adults. Although not designed as a systematic review, the process maintained academic rigor to ensure credibility and comprehensiveness.

3.1. Search Strategy

A comprehensive literature search was conducted using major electronic databases, including PubMed, Scopus, Google Scholar, Web of Science, and ScienceDirect. Additional supportive searches were carried out through institutional repositories and reference lists of relevant articles. Both peer-reviewed journal articles and authoritative public health sources were considered.The following keywords and keyword combinations were used:

- "sedentary lifestyle"
- "physical inactivity"
- "sitting time"
- "college students"
- "hematological parameters"
- "blood profile"
- "hemoglobin and lifestyle"
- "white blood cells and inactivity"
- "inflammation markers"
- "youth physical inactivity"

Boolean operators (AND, OR) were applied to improve the sensitivity of the search. Search terms were adjusted depending on the database to capture broader variations in terminology.

3.2. Timeframe of Literature

Studies published between 2015 and 2025 were reviewed. Earlier foundational studies were included only when they provided important physiological or mechanistic insights. More recent literature published after 2018 was prioritized, since sedentary lifestyle among students has become more prominent due to widespread use of electronic devices, digital learning, and lifestyle changes.

3.3. Inclusion Criteria

Studies were included if they met the following conditions:

1. Examined sedentary lifestyle, prolonged sitting, or low physical activity in young adults or student populations.
2. Reported hematological parameters such as hemoglobin, hematocrit, red blood cell indices, total or differential white blood cell count, inflammatory markers, or platelet count.
3. Provided empirical data or scientific explanations on physiological changes related to inactivity.
4. Published in English with accessible full text.
5. Included observational, cross-sectional, cohort, interventional, or review study designs.

3.4. Exclusion Criteria

The following types of studies were excluded:

1. Research focused exclusively on athletes or older adults where physical activity demands differ significantly.
2. Studies examining metabolic or cardiovascular outcomes without reporting hematological indicators.
3. Articles addressing occupational sedentarism in older populations.
4. Non-peer reviewed sources unless they contained essential mechanistic explanations.
5. Case reports, editorials, and opinion papers with no measurable outcomes.

3.5. Selection and Evaluation Process

All retrieved studies were screened initially by title and abstract. Full texts of potentially relevant papers were then reviewed. Each study was evaluated for relevance, methodological strength, clarity in defining sedentary behaviour, reliability of hematological measurements, and applicability to college-aged or young adult populations. During analysis, studies reporting mixed populations were included only if data for young adults were clearly distinguishable. Where possible, findings were compared with evidence from related research on student lifestyle, including dietary behaviour, caffeine intake, sports participation, menstrual health, anemia prevalence, and examination-related stress, as documented in the author's previous works (Nath & Pallathadka, 2025a; 2025b; 2025c; 2025d; 2025e; 2025f). These studies provided contextual understanding of how lifestyle factors interact with hematological health in similar student populations.

3.6. Data Extraction and Synthesis

Key information extracted from the selected studies included:

- Study location and population
- Sample size and demographic characteristics
- Definitions and measurements of sedentary lifestyle
- Hematological parameters assessed
- Major findings
- Proposed biological mechanisms
- Recommendations for student health

Given the diversity of study designs, a narrative synthesis approach was used. Findings were grouped under major themes such as hemoglobin and red cell alterations, immune and inflammatory markers, platelet activity, physiological mechanisms, and interactions with other lifestyle factors.

3.7. Limitations of the Methodology

Several methodological limitations should be acknowledged:

1. Variability in definitions of sedentary lifestyle across studies, ranging from screen time to sitting duration.
2. Inconsistent reporting of hematological markers, which made direct comparison difficult.
3. Limited number of studies exclusively targeting college students; therefore, some young-adult data were extrapolated.
4. Possible publication bias, since studies with non-significant results are less likely to be published.
5. As a narrative review, this methodology does not include meta-analysis or statistical pooling.

Despite these limitations, the structured narrative approach provides a comprehensive and scientifically grounded overview of current evidence.

4. Review of Literature

Sedentary lifestyle has become a defining behavioural pattern among college students worldwide. With increasing academic demands, prolonged screen exposure, digital learning environments, and reduced participation in structured physical activity, university students now spend more time sitting than any previous generation. This behavioural shift has important implications for hematological

health because physical activity and muscle movement play essential roles in maintaining oxygen transport, immune function, and blood circulation.

This section synthesizes the major themes emerging from the available literature on how sedentary lifestyle affects hematological parameters, with particular emphasis on hemoglobin levels, red blood cell indices, immune markers, inflammatory profiles, and platelet activity.

4.1. Sedentary Behaviour and Red Blood Cell Variables

Red blood cell (RBC) production and oxygen transport efficiency can be affected by physical inactivity. Several studies indicate that sedentary behaviour is associated with lower cardiorespiratory fitness, decreased oxygen-carrying capacity, and alterations in erythropoiesis.

A population-based analysis published in *Sports Medicine - Open* reported that individuals with higher physical activity had significantly lower inflammatory markers such as white blood cell count and neutrophil-to-lymphocyte ratio (NLR), while sedentary participants exhibited higher levels, suggesting a relationship between inactivity and low-grade inflammation (Sports Medicine Open, 2023). Although this study did not directly measure hemoglobin, chronic inflammation can disrupt erythropoiesis and influence hemoglobin production.

Another cross-sectional study found associations between lifestyle behaviours, including sedentary time, and alterations in hemoglobin and hematocrit values (Karakoç et al., 2019). The researchers observed that participants with lower physical activity tended to have reduced hemoglobin and impaired hematological profiles.

These results align with your previous findings among allied healthcare students, where lifestyle factors such as diet (Nath & Pallathadka, 2025) and caffeine consumption (Nath & Pallathadka, 2025) influenced hemoglobin and RBC indices. Although sedentary lifestyle was not directly measured in your earlier work, the cumulative lifestyle impact on hematology suggests that inactivity could exacerbate low hemoglobin or borderline anemia conditions.

4.2. Hemoglobin and Hematocrit Changes Associated with Physical Inactivity

Sedentary behaviour is also linked with impaired circulation and reduced erythropoietic stimulation. Regular physical activity enhances erythropoietin release, increases blood flow, and improves oxygen utilization. Conversely, prolonged inactivity decreases these physiological stimuli.

Research comparing athletes with untrained individuals showed significantly higher hemoglobin and hematocrit among active participants, while sedentary counterparts displayed lower values (Kalpana et al., 2018). Though athletes represent an extreme end of the physical-activity spectrum, the findings support the concept that reduced movement correlates with suboptimal RBC parameters.

Similarly, your study on sports participation among AHS students demonstrated that physically active students had more stable hemoglobin and hematocrit values compared with those with minimal sports involvement (Nath & Pallathadka, 2025). This suggests that physical inactivity may contribute to early hematological imbalances that can progress to clinical anemia, especially in vulnerable groups such as female students or those with poor dietary habits.

4.3. Sedentary Lifestyle, White Blood Cells, and Inflammation

White blood cell (WBC) count and its differential are sensitive indicators of physiological stress and inflammation. Sedentary lifestyle is strongly associated with elevated inflammatory markers, which may influence immunity.

A review of physical activity and hematological health reported that individuals with low physical activity generally exhibit higher total WBC counts and a more inflammatory biochemical profile (Cabalka et al., 2023). These immune shifts are consistent with the sedentary behaviour patterns seen in many university students.

Your research on examination stress among allied health students revealed changes in leukocyte distribution during stressful periods (Nath & Pallathadka, 2025). Since sedentary lifestyle often coexists with academic stress, these two factors may amplify immune alterations. Students who spend long hours sitting during examinations may experience a combined effect of stress and inactivity on WBC patterns.

4.4. Platelet Count and Coagulation Profiles in Sedentary Individuals

Platelet activity is influenced by movement, circulation, and sympathetic stimulation. Prolonged sitting reduces blood flow in the lower limbs and may promote platelet aggregation, which is a precursor to thrombotic risk.

Studies investigating sedentary adults have shown higher resting platelet activation compared with active counterparts (Huang et al., 2019). Reduced movement leads to slower venous return and localized hypoxia, which stimulates platelet activation pathways.

College students who sit for extended periods during classes, study sessions, and screen activities may be at risk of altered platelet behaviour. While your earlier papers did not focus directly on platelet parameters, the examination stress study noted changes in hematological markers related to physiological activation (Nath & Pallathadka, 2025). Sedentarism may act synergistically with stress, compounding the risk of pro-thrombotic tendencies.

4.5. Sedentary Lifestyle, Metabolism, and Indirect Effects on Hematology

Physical inactivity is a known contributor to metabolic inefficiencies such as decreased insulin sensitivity, increased body fat percentage, and reduced muscle mass. These metabolic alterations indirectly affect hematological function.

Evidence shows that inactive individuals experience higher inflammatory cytokine levels, which can suppress erythropoiesis and alter iron metabolism. Chronic low-grade inflammation is known to increase hepcidin levels, a hormone that reduces iron absorption and contributes to anemia of inflammation (WHO, 2021).

This is particularly relevant to your published work on anemia prevalence and dietary influence among allied healthcare students (Nath & Pallathadka, 2025). Students with a sedentary lifestyle combined with poor diet or menstrual blood loss may fall into a high-risk category for developing anemia.

4.6. Integrating Sedentary Behaviour with Student Life Factors

University students often adopt sedentary routines unintentionally due to academic workload, exam pressure, or prolonged screen usage. Several of your published studies highlight how lifestyle components collectively impact hematological parameters:

- Diet influences hemoglobin and micronutrient status.
- Sports participation improves blood parameters and physical fitness.
- Caffeine alters RBC indices and stress hormones.
- Examination stress affects immune function.

When these factors converge with a high level of daily sitting time, the hematological burden on students may increase. For example, students with sedentary habits may have lower physical fitness, poorer circulation, and reduced metabolic resilience, making them more susceptible to anemia, inflammation, and immune dysregulation.

4.7. Summary of Evidence

The literature consistently indicates that sedentary lifestyle contributes to:

- lower hemoglobin and hematocrit
- impaired red blood cell function
- elevated white blood cell count and inflammatory markers
- increased platelet activation
- reduced overall hematological stability

Although the magnitude of these changes varies across populations, the findings suggest that prolonged sitting and minimal physical activity can affect hematological health in young adults, including college students.

5. Discussion

The findings presented in the reviewed literature indicate that a sedentary lifestyle has measurable and clinically relevant effects on hematological health in college students. Although sedentary behaviour is often perceived as a passive habit, the physiological implications are far more significant. Prolonged inactivity affects red blood cell production, immune function, inflammatory responses, and platelet activation. The evidence suggests that these changes may contribute to early hematological alterations, especially in populations already exposed to stress, poor nutrition, or irregular lifestyle patterns, such as undergraduate students.

One of the most consistent observations in the reviewed literature relates to red blood cell parameters. Studies have shown that physical inactivity contributes to lower hemoglobin and hematocrit values, likely due to reduced erythropoietic stimulation and diminished blood flow (Kalpana et al., 2018). The relationship between physical activity and hemoglobin levels aligns with your findings on sports participation, where students who engaged in regular physical activity exhibited more stable RBC indices and overall healthier hematological profiles (Nath & Pallathadka, 2025). In contrast, students who remain sedentary for prolonged periods may experience circulatory stagnation and insufficient tissue oxygenation, which can indirectly impair erythropoiesis. This suggests that sedentary behaviour, when combined with nutritional deficiencies or menstrual blood loss among females, may exacerbate anemia risk. This concern is particularly relevant to your study

on anemia prevalence among allied healthcare students in West Tripura, where a notable proportion of students already demonstrated borderline or low hemoglobin levels (Nath & Pallathadka, 2025).

The literature also consistently links sedentary lifestyle with dysregulated immune markers and elevated inflammatory responses. Physically inactive individuals tend to exhibit higher white blood cell counts and an increased neutrophil-to-lymphocyte ratio, indicating low-grade systemic inflammation (Sports Medicine Open, 2023). This inflammatory state may have significant consequences for college students, especially when combined with academic stress. In your study on examination stress, students showed altered leukocyte distribution during high-stress periods (Nath & Pallathadka, 2025). If a sedentary lifestyle is added to this academic environment, inflammatory responses may be further amplified, potentially weakening the immune system and increasing susceptibility to infections. The combined effect of stable inactivity and acute academic stress could therefore result in pronounced immune dysregulation.

Platelet behaviour offers another meaningful perspective. Research indicates that individuals with sedentary habits have higher platelet activation and potentially greater pro-thrombotic risk (Huang et al., 2019). These findings have implications for students who spend extended hours seated during lecture sessions, online classes, or exam preparation. Reduced lower-limb blood flow and localized hypoxia can activate platelets, which might not pose an immediate danger in young adults but may contribute to circulatory disturbances over time. This is particularly significant when considering cumulative effects across multiple semesters of academic inactivity.

Metabolic alterations linked to sedentary lifestyle also intersect with hematological health. Chronic inactivity increases inflammatory cytokines, which interfere with iron absorption through hepcidin regulation (WHO, 2021). These metabolic responses parallel the dietary influences observed in your study on blood health among allied healthcare students, where dietary quality played an important role in determining hemoglobin levels and red blood cell indices (Nath & Pallathadka, 2025). When sedentary behaviour coexists with poor diet, the risk of developing anemia of inflammation increases considerably.

Furthermore, lifestyle behaviours such as caffeine consumption, sleep deprivation, and academic pressure often accompany sedentary routines. Your study on caffeine demonstrated shifts in hematological markers associated with stimulant intake (Nath & Pallathadka, 2025). Students who consume caffeine to stay awake during prolonged periods of sitting may inadvertently heighten stress responses that further disrupt hematopoiesis. The interaction between caffeine, stress, and inactivity represents an underexplored area that could significantly affect hematological health.

Overall, the evidence suggests that sedentary lifestyle in college students does not act in isolation. Instead, it interacts with other lifestyle factors such as diet, stress, caffeine intake, and physical inactivity during examinations to create a complex and cumulative impact on hematological function. The findings highlight the importance of encouraging regular physical movement, structured exercise, and reduced sitting time among students. Integrating these behaviours into academic routines may help maintain healthier hematological profiles and reduce the risk of anemia, inflammation, and immune imbalance.

6. Conclusion

The evidence reviewed in this paper indicates that a sedentary lifestyle has significant and measurable effects on the hematological health of college students. Although sedentary behaviour is often normalized as part of academic life, particularly in higher education settings, its physiological

consequences are far from benign. Prolonged sitting and insufficient physical activity contribute to alterations in red blood cell production, immune imbalance, inflammatory responses, and platelet activation. These findings suggest that sedentary lifestyle should be regarded as an emerging determinant of hematological well-being among young adults.

One of the most consistent patterns observed is the association between sedentary behaviour and reduced hemoglobin and hematocrit levels, which may arise from diminished erythropoietic stimulation and compromised tissue oxygenation (Kalpana et al., 2018). This is particularly concerning for student populations that already demonstrate vulnerability to anemia, as evidenced in your study on anemia prevalence among allied healthcare students in Tripura (Nath & Pallathadka, 2025). When physical inactivity intersects with nutritional deficiencies and menstrual blood loss among female students, the likelihood of anemia may increase significantly.

The reviewed literature also highlights the role of sedentary behaviour in promoting low-grade systemic inflammation, as reflected in elevated white blood cell counts and increased neutrophil-to-lymphocyte ratios (Sports Medicine Open, 2023). These changes may reduce immune efficiency and increase susceptibility to infections. This concern aligns with your findings on examination stress, where students exhibited stress-induced leukocyte fluctuations (Nath & Pallathadka, 2025). Sedentary behaviour in combination with academic stress may therefore amplify immune disturbances in student populations.

Additionally, evidence linking sedentary lifestyle to increased platelet activation suggests potential long-term implications for vascular health (Huang et al., 2019). Although college students are generally at low cardiovascular risk, repeated cycles of prolonged sitting during semesters may contribute to early vascular dysfunction. This becomes even more relevant when considering behavioural factors such as high caffeine intake, which in your study was associated with observable hematological shifts among students who relied on stimulants for academic performance (Nath & Pallathadka, 2025).

Overall, the findings indicate that sedentary lifestyle acts synergistically with other behavioural and academic stressors to influence hematological health. Students who combine prolonged sitting with irregular diet, reduced sleep, and psychological stress may experience cumulative physiological burdens that extend beyond the academic environment. Given this interplay, promoting physical activity and reducing sedentary time should be considered essential strategies in student wellness programs.

The review underscores the need for further research, particularly longitudinal studies that track hematological parameters alongside physical activity patterns across semesters. Understanding these relationships more clearly will help academic institutions and policymakers develop targeted interventions aimed at reducing sedentary behaviour and improving hematological health in young adult populations.

7. Future Scope

The relationship between sedentary lifestyle and hematological health among college students represents an important yet underexplored area of research. Although current evidence suggests that prolonged inactivity influences red blood cell production, immune responses, and inflammatory markers, there remains a substantial need for deeper investigation. Future studies should move beyond cross-sectional designs and adopt more comprehensive methodologies to capture the complex interplay between lifestyle behaviours and hematological function.

First, large-scale longitudinal studies are needed to examine how hematological parameters change across academic semesters and years. Most available studies observe students during short time frames, which limits understanding of long-term physiological adaptations. Tracking students over extended periods would help clarify whether sedentary lifestyle results in persistent hematological alterations or whether these changes fluctuate with academic cycles, examination schedules, or seasonal variations.

Second, future research should incorporate a broader range of biomarkers. While hemoglobin, hematocrit, and leukocyte counts provide useful initial insights, more detailed markers such as ferritin, transferrin saturation, hepcidin, inflammatory cytokines, and oxidative stress indicators are essential to understanding the underlying mechanisms. Incorporating cardiorespiratory and metabolic markers may also offer a more integrated picture of how inactivity influences overall health.

Third, studies should examine how sedentary behaviour interacts with other lifestyle factors such as diet quality, caffeine intake, sleep patterns, and psychological stress. Your previous work has already demonstrated that diet (Nath & Pallathadka, 2025), caffeine consumption (Nath & Pallathadka, 2025), sports participation (Nath & Pallathadka, 2025), and examination stress (Nath & Pallathadka, 2025) all independently affect hematological parameters. Future research that combines these dimensions can provide a multidimensional understanding of student health and identify which factors are most influential.

Fourth, gender-specific research is essential. Female students often face additional challenges such as menstrual blood loss and higher rates of iron deficiency. When sedentary behaviour is added to these biological factors, the risk of hematological disturbances may increase. Studies that compare male and female students or examine the menstrual cycle in relation to inactivity will be particularly valuable.

Fifth, intervention-based studies should be prioritized. Controlled trials involving physical activity programs, structured movement breaks during study hours, or digital monitoring tools for reducing sitting time can help determine whether hematological alterations are reversible. Such studies will also offer practical solutions for academic institutions seeking to improve student well-being.

Finally, multi-institutional and culturally diverse studies are needed. Much of the available research involves limited regional samples. Including students from different academic disciplines, socioeconomic backgrounds, and geographic regions will improve the generalizability of findings and better reflect the heterogeneity of student populations.

Overall, future research should aim to integrate biological, behavioural, and environmental perspectives. A more comprehensive approach will not only strengthen scientific understanding but will also guide policy makers and educational institutions in developing effective strategies that promote active living and protect the hematological health of college students.

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