Medicine Program
Community Medicine Department

Sleep Quality, Physical Activity, and Academic Performance Among Medical Students in Sudan During Armed Conflict: A Cross-Sectional Study

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Dedication

We dedicate this thesis to our families, whose unwavering support, patience, and encouragement have been our guiding light throughout this academic journey. Their sacrifices, understanding, and belief in our abilities have provided us with the strength and determination to overcome challenges and complete this work.

We also dedicate this work to our teachers, mentors, and all the academic staff who have shared their knowledge, guidance, and inspiration with us. Their dedication to education and commitment to excellence have shaped our learning and motivated us to strive for the highest standards in our research.

Finally, we dedicate this work to our peers and colleagues, whose collaboration, constructive feedback, and shared experiences have enriched our journey and contributed to the successful completion of this thesis.

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List of Abbreviations

Abbreviation	Full Term
PSQI	Pittsburgh Sleep Quality Index
IPAQ-SF	International Physical Activity Questionnaire – Short Form
MET	Metabolic Equivalent of Task
REM	Rapid Eye Movement
NREM	Non-Rapid Eye Movement
EEG	Electroencephalogram
SCN	Suprachiasmatic Nucleus
AASM	American Academy of Sleep Medicine
BDNF	Brain-Derived Neurotrophic Factor
HPA Axis	Hypothalamic–Pituitary–Adrenal Axis
NCDs	Non-Communicable Diseases
GPA	Grade Point Average
WHO	World Health Organization

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Abstract

Background: Medical students are exposed to high academic demands that can negatively affect sleep quality and physical activity, both of which are important for cognitive performance. These challenges may be exacerbated during periods of conflict, such as the ongoing war in Sudan. This study aimed to assess the association between sleep quality, physical activity, and academic performance among medical students in Sudan during the war period (2023–2025).

Methods: A cross-sectional study was conducted among 203 medical students from five Sudanese universities. Data were collected using an online self-administered questionnaire, including the Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality, the short form of the International Physical Activity Questionnaire (IPAQ-SF) for physical activity, and self-reported academic performance. Descriptive and inferential statistics were performed using SPSS to examine associations between sleep quality, physical activity, and academic performance. Ethical approval and informed consent were obtained prior to participation.

Results: A total of 203 medical students participated, with over half reporting declined academic performance during the conflict. The mean PSQI score was 8.15 ± 3.70, indicating poor sleep quality, while 46.8% had high physical activity levels. Sleep quality was significantly associated with age, residency, socioeconomic status, and all academic performance measures ($p < 0.05$). In contrast, physical activity showed no significant association with academic performance. Regression analysis identified sleep quality as a significant predictor of academic performance ($\beta = -0.373$, $p < 0.001$), whereas physical activity was not. A weak positive correlation was observed between physical activity and poorer sleep ($r = 0.166$, $p = 0.018$).

Conclusion: Poor sleep quality was highly prevalent among medical students in this conflict-affected setting and was strongly associated with lower academic performance, while physical activity showed no significant direct effect. These findings underscore the critical role of sleep in supporting cognitive function and academic success, highlighting the need for interventions that promote healthy sleep habits in medical student populations.

المستخلص

خلفية الدراسة: يتعرض طلاب الطب لمتطلبات أكاديمية عالية قد تؤثر سلبًا على جودة النوم والنشاط البدني، وكلاهما مهم للأداء المعرفي. وقد تتفاقم هذه التحديات خلال فترات النزاع، مثل الحرب الدائرة حاليًا في السودان .هدفت هذه الدراسة إلى تقييم العلاقة بين جودة النوم والنشاط البدني والأداء الأكاديمي بين طلاب الطب في السودان خلال فترة الحرب (2023-2025)

المنهجية: أُجريت دراسة مستعرضة شملت 203 من طلاب الطب من خمس جامعات سودانية. تم جمع البيانات باستخدام استبيان ذاتي عبر الإنترنت، بما في ذلك مؤشر بيتسبرغ لجودة النوم (PSQI) لتقييم جودة النوم، والنموذج المختصر للاستبيان الدولي للنشاط البدني (IPAQ-SF) لتقييم النشاط البدني، والأداء الأكاديمي المبلغ عنه ذاتيًا. تم إجراء إحصاءات وصفية واستنتاجية باستخدام برنامج SPSS لفحص الارتباطات بين جودة النوم والنشاط البدني والأداء الأكاديمي. تم الحصول على الموافقة الأخلاقية والموافقة المستنيرة قبل المشاركة.

النتائج: شارك في الدراسة ما مجموعه 203 من طلاب الطب، وأفاد أكثر من نصفهم بتدهور أدائهم الأكاديمي خلال فترة النزاع. وبلغ متوسط درجة مقياس جودة النوم 8.15 ± 3.70 (PSQI)، مما يشير إلى ضعف جودة النوم، في حين أظهر 46.8% منهم مستويات عالية من النشاط البدني. وارتبطت جودة النوم ارتباطًا دلاليًا بالعمر، ومكان الإقامة، والوضع الاجتماعي-الاقتصادي، وجميع مقاييس الأداء الأكاديمي ($p < 0.05$). في المقابل، لم تظهر أي علاقة ذات دلالة إحصائية بين النشاط البدني والأداء الأكاديمي.

حدد تحليل الانحدار جودة النوم كمتنبئ مهم للأداء الأكاديمي ($\beta = -0.373$، $p < 0.001$)، في حين لم يكن النشاط البدني كذلك. ولوحظ ارتباط إيجابي ضعيف بين النشاط البدني وسوء النوم ($r = 0.166$، $p = 0.018$).

الخلاصة: ضعف جودة النوم شائعة بشكل كبير بين طلاب الطب في هذه البيئة المتأثرة بالنزاع، وارتبطت ارتباطًا وثيقًا بانخفاض الأداء الأكاديمي، في حين لم يُظهر النشاط البدني أي تأثير مباشر ذي دلالة إحصائية. وتؤكد هذه النتائج الدور الحاسم للنوم في دعم الوظائف الإدراكية والنجاح الأكاديمي، مما يسلط الضوء على الحاجة إلى تدخلات تعزز عادات النوم الصحية لدى طلاب الطب.

Chapter one

Introduction

1. INTRODUCTION

1.1 Background

Medical education is widely recognized as one of the most academically demanding fields of study [1]. Medical students are required to assimilate large volumes of information, maintain sustained concentration, and perform well in frequent assessments [2]. This intense academic environment often exposes students to high levels of stress, irregular sleep patterns, and reduced engagement in healthy lifestyle behaviors [3,4]. Among the most important lifestyle factors influencing student well-being and performance are sleep quality and physical activity [5].

Sleep is a fundamental biological process essential for cognitive functioning, emotional regulation, and memory consolidation. Adequate sleep supports attention, learning capacity, problem-solving skills, and long-term information retention. Conversely, poor sleep quality and sleep deprivation impair concentration, reduce alertness, and negatively affect academic performance [6]. Medical students are particularly vulnerable to sleep disturbances due to long study hours, night-time studying, examination stress, and clinical responsibilities. Studies conducted in different countries have reported a high prevalence of poor sleep quality among medical students, often associated with psychological distress and reduced academic achievement [3].

Physical activity (PA) is another critical determinant of both physical and mental health. The World Health Organization defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure [7]. In daily life, physical activity may include walking with the purpose of exercise, as well as engaging in moderate or vigorous activities. Vigorous activities include lifting weights, playing football, basketball, and volleyball, while moderate activities

include jogging, calisthenics, table tennis, and similar exercises [8]. Many university students participate in these sports either recreationally or competitively [9].

The benefits of regular physical activity extend beyond physical fitness. Exercise has been consistently associated with improved mental well-being and reduced symptoms of depression and anxiety [10,11]. One of the proposed mechanisms is the release of endorphins, commonly referred to as “feel-good” hormones, which contribute to mood enhancement and a sense of well-being. Additionally, regular physical activity reduces stress hormone levels, including cortisol and adrenaline, thereby alleviating stress and anxiety [12]. Exercise has also been shown to improve sleep quality, shorten sleep onset latency, and enhance overall sleep efficiency [13]. Improved sleep, in turn, supports cognitive performance and academic success.

In individuals diagnosed with major depressive disorder, structured exercise programs have demonstrated significant reductions in depressive symptoms [14]. Even among healthy individuals, regular physical activity contributes to better self-esteem, improved body image, and increased confidence. Many physical activities also involve social interaction, teamwork, and peer engagement, which foster a sense of belonging and social support [15]. These psychosocial benefits may be particularly valuable for medical students, who often experience feelings of isolation due to academic workload.

There is also growing evidence that physical activity positively influences cognitive functioning. Exercise enhances cerebral blood flow, stimulates neuroplasticity, and supports brain health, all of which contribute to improved learning and memory processes [16,17]. Several studies have found a positive association between higher levels of physical activity and better academic performance among university students [17-19]. While the strength of this association varies, the overall evidence suggests that students who engage in regular exercise tend to demonstrate better academic outcomes.

Despite these established benefits, participation in regular physical activity among medical students is often limited. Academic pressure, time constraints, fatigue, and lack of access to recreational facilities are frequently reported barriers [19]. Sleep disturbances are also common, often resulting from academic stress and irregular schedules. The coexistence of poor sleep and reduced physical activity may further compromise students' academic performance.

Since the outbreak of the Sudanese War, higher education institutions in Sudan have experienced significant disruptions. Academic schedules have been interrupted, campuses have been affected, and many students have faced displacement or insecurity [20]. These conditions may further disrupt daily routines, limit access to safe exercise spaces, and negatively affect sleep patterns. Increased psychological stress related to conflict may also contribute to insomnia, reduced physical activity, and decreased academic focus.

1.2. Problem statement:

Medical students are required to maintain high academic performance despite being exposed to intense academic demands and psychological stress [1,2]. Adequate sleep and regular physical activity are essential lifestyle factors that support cognitive functioning, emotional regulation, and academic achievement [5,6,16]. However, evidence indicates that medical students frequently experience poor sleep quality and insufficient physical activity due to heavy workloads and irregular schedules [3,19]. These factors may negatively affect concentration, memory, and overall academic performance.

Since the outbreak of the Sudanese War, higher education institutions in Sudan have experienced major disruptions, including academic interruptions, displacement, and insecurity [20]. Such conditions are likely to disturb sleep patterns, limit

opportunities for safe physical activity, and increase psychological stress among students. These changes may further compromise academic performance during an already challenging period.

Although international studies have demonstrated associations between sleep quality, physical activity, and academic performance [6,10–18], there is limited evidence examining these relationships among medical students in Sudan during the war period. The absence of local data restricts the ability of universities to implement evidence-based strategies to support student well-being and academic success.

1.3. Justification:

Medical students represent the future healthcare workforce of Sudan. Ensuring their academic success and psychological well-being is particularly important during periods of national instability. The ongoing war has created conditions that may disrupt daily routines, increase stress, and negatively affect lifestyle behaviors such as sleep and physical activity. These changes have the potential to influence academic performance at a time when maintaining educational standards is critical.

Sleep quality and physical activity are modifiable lifestyle factors. Unlike many external stressors related to conflict, these behaviors can potentially be improved through awareness programs, institutional support, and student-led initiatives. Identifying whether significant associations exist between these factors and academic performance may help universities design practical interventions aimed at promoting healthy habits and supporting academic achievement.

Furthermore, there is limited local research examining how war-related disruptions affect medical students' lifestyle behaviors and academic outcomes in Sudan. This study will contribute context-specific evidence that can inform university policies, student support services, and future research. Ultimately, the findings may support

strategies that enhance resilience, protect academic performance, and promote the overall well-being of medical students during challenging circumstances.

1.4. Research Questions

1. What is the level of sleep quality among medical students in Sudan during the war period?
2. What is the level of physical activity among medical students in Sudan during the war period
3. What is the academic performance of medical students during the war period?
4. Is there a significant association between sleep quality and academic performance among me dical students?
5. Is there a significant association between physical activity levels and academic performance a mong medical students?

1.5. Research Objective:

1.5.1 General objective:

To assess the association between sleep quality, physical activity, and academic performance among medical students in Sudan during the war period (2023–2025).

1.5.2. Specific objectives:

2. To assess the sleep quality of medical students during the war period
3. To determine the level of physical activity among medical students during the war period.
4. To evaluate the academic performance of medical students during the war period.
5. To examine the association between sleep quality and academic performance among medical students.
6. To examine the association between physical activity levels and academic performance among medical students.

Chapter Two
Literature Review

2. LITERATURE REVIEW

2.1 Introduction

Sleep is defined physiologically as a naturally occurring, reversible state of reduced responsiveness to external stimuli, characterized by specific electroencephalographic (EEG) patterns and distinct metabolic changes [21]. This biological process is primarily governed by the Two-Process Model, which describes the interaction between homeostatic sleep pressure (Process S) and the circadian rhythm (Process C), as established by Borbély et al. (2016) in the Journal of Sleep Research [22]. Process S is driven by the accumulation of adenosine in the basal forebrain; as metabolic activity continues throughout the day, adenosine levels rise, binding to A_1 receptors receptors to inhibit arousal-promoting neurons and increase sleep propensity. Simultaneously, Process C is managed by the Suprachiasmatic Nucleus (SCN) in the hypothalamus, which acts as the body's master clock. The suprachiasmatic nucleus (SCN) synchronizes circadian rhythms with the external light dark cycle by receiving photic input from the retina via the retinohypothalamic tract. This input enables the SCN to regulate pineal melatonin secretion, suppressing its release during daylight and promoting secretion at night. [23,24]

The sleep cycle typically consists of two major states: rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep. NREM sleep is further divided into three stages (N1, N2, and N3) representing a progression from light to deep restorative sleep. During a normal night’s sleep, the body cycles through these stages multiple times, with each cycle lasting approximately 90–120 minutes. Early night sleep is dominated by deep NREM (also known as slow-wave sleep), which supports physical restoration and immune function. The later cycles contain a larger proportion of REM sleep, which is crucial for emotional regulation, memory

consolidation, and cognitive processing. Effective integration of REM and NREM sleep is essential for optimal functioning; disruption of this cycle, through frequent awakenings or altered stage proportions, can degrade overall sleep quality even if total sleep time appears sufficient [25].

The quality of sleep is assessed based on: sleep duration, sleep latency, sleep efficiency, sleep disturbances, and daytime dysfunction. The Sleep duration refers to the total amount of time spent asleep, which varies by age and individual needs. The American Academy of Sleep Medicine (AASM) and the Sleep Research Society consensus recommends a minimum of 9 hours for children 6 to 12 years of age, 8 hours for adolescents, and at least 7 hours for adults [25,26]. Short sleep duration has been linked with cognitive deficits, mood disturbances, and impaired daytime functioning, while excessively long sleep may also predict adverse outcomes. Sleep latency measures how long it takes to transition from wakefulness to sleep; prolonged latency may reflect anxiety, stress, or circadian misalignment. Sleep efficiency is the percentage of time in bed that is actually spent asleep and reflects the degree of sleep consolidation; low efficiency suggests frequent awakenings or difficulty maintaining sleep. Sleep disturbances encompass interruptions such as nocturnal awakenings, environmental disruptions, or sleep-related breathing problems. Finally, daytime dysfunction including excessive sleepiness, impaired concentration, or reduced productivity indicates the functional impact of inadequate sleep. Together, these components provide a comprehensive picture of sleep quality that is more informative than sleep duration alone [25].

Poor sleep is characterized by insufficient sleep duration, prolonged sleep latency, frequent awakenings, reduced sleep efficiency, or non-restorative sleep that fails to support optimal daytime functioning. Importantly, poor sleep reflects both quantitative insufficiency and qualitative disruption of sleep architecture and circadian regulation [27]. Poor sleep quality was linked to adverse outcomes across

cognitive, psychological, and physiological domains. Cognitively, insufficient or fragmented sleep impairs attention, executive function, decision-making, and memory consolidation, leading to slower reaction times, reduced working memory, and poorer problem-solving ability . Psychologically, disturbed sleep is strongly associated with increased anxiety, depression, irritability, and stress reactivity, with longitudinal studies demonstrating a bidirectional relationship between sleep disturbances and mental health problems . Physiologically, chronic poor sleep contributes to metabolic, cardiovascular, and immune dysregulation, including insulin resistance, obesity, hypertension, systemic inflammation, and hormonal imbalance [28-30]

2.2. Physical Activity: Definition, Types, Benefits, Biological Mechanisms, and Consequences of Inactivity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure above resting levels, encompassing a broad range of movements from structured exercise to daily tasks and recreational activities [7]. Physical activity can be categorized according to intensity and purpose. Based on intensity, it is classified as light, moderate, or vigorous. Light physical activity includes slow walking or light household chores, moderate activity includes brisk walking or cycling on flat terrain, and vigorous activity involves running, competitive sports, or high-intensity interval training . According to purpose, physical activity can be occupational (work-related movement), transport (walking or cycling for commuting), domestic (household chores), or leisure-time (planned exercise or sports) [31].

The positive effects of physical activity on human health are well-established. Physiologically, regular movement improves cardiovascular function, muscular

strength, endurance, metabolic regulation, and body composition, while reducing the risk of chronic diseases such as coronary artery disease, type 2 diabetes, hypertension, and some cancers. Physical activity also enhances immune function and reduces systemic inflammation, contributing to overall disease resistance. Beyond physical health, engaging in regular movement has important psychological benefits, including improved mood, decreased symptoms of anxiety and depression, enhanced stress regulation, and better self-esteem. Neurobiological mechanisms, such as increased endorphin release and enhanced neurotransmitter activity, mediate these benefits [32,33].

Physical activity stimulates cardiovascular adaptations such as increased stroke volume, improved endothelial function, and enhanced blood flow, which in turn deliver oxygen and nutrients efficiently to tissues [34]. At the muscular level, activity promotes hypertrophy, mitochondrial biogenesis, and improved metabolic efficiency, enhancing energy production and fatigue resistance [35]. Neurologically, regular exercise increases levels of brain-derived neurotrophic factor (BDNF), which supports neurogenesis, synaptic plasticity, and cognitive performance [36]. It also has Hormonal effects which include modulation of cortisol, insulin, leptin, and ghrelin, which collectively regulate stress response, metabolism, and appetite [37]. These integrated biological mechanisms explain how physical activity contributes simultaneously to physical health, mental resilience, and cognitive function.

Physical activity also positively influences cognitive function and academic performance, particularly in young adults and students. Studies indicate that students who engage in regular moderate to vigorous activity demonstrate enhanced attention, memory, and problem-solving skills, likely due to improved cerebral blood flow and neuroplasticity [38]. These findings highlight the interconnection between lifestyle behaviors and cognitive outcomes, which is particularly relevant

for high-stress populations such as medical students, who often face demanding academic workloads.

Conversely, physical inactivity, insufficient movement or prolonged sedentary behavior is recognized as a major public health concern worldwide. Physical inactivity contributes to an increased risk of non-communicable diseases (NCDs), functional decline, and premature mortality. Meta-analytic study indicates that inactivity accounts for approximately 9% of premature deaths globally and is strongly associated with cardiovascular disease, obesity, and metabolic disorders [39,40]. Physiologically, prolonged inactivity reduces cardiovascular efficiency, increases systemic inflammation, promotes insulin resistance, and leads to muscle atrophy and metabolic dysfunction. In addition, physical inactivity has been linked with poorer mental health outcomes, including elevated risk for mood disorders and cognitive impairments [41,42].

2.3. Challenges of Medical Training and Student Health

Medical school is widely recognized as a high-demand learning environment, combining rigorous academic requirements, clinical responsibilities, and professional skill development. The effects of medical education on students are multi-dimensional, spanning academic, psychological, social, behavioral, and physiological domains.

The demanding curriculum of medical education imposes a heavy cognitive load and huge information volume in medical training that creates substantial academic stress and cognitive burden, reducing learning engagement and memory consolidation. High-stakes exams and performance pressure are linked to heightened test anxiety, which disrupts concentration and working memory [43] . These pressures, coupled with competitive and perfectionistic academic cultures, contribute to burnout and diminished cognitive and emotional well-being among medical students [44].

This chronic stress can also interfere with sleep patterns, increase the risk of mood disorders, and contribute to maladaptive coping strategies, such as substance use or social withdrawal [45]. It also disrupts students' daily routines, affecting sleep, nutrition, and physical activity. Poor sleep quality and irregular sleep schedules are prevalent among medical students, particularly during clinical rotations and exam periods, impairing cognitive performance and overall health [46]. Similarly, insufficient physical activity is common due to time constraints and academic workload, reducing stress resilience and increasing risk for chronic disease. Unhealthy dietary patterns, including skipped meals or reliance on fast food, further exacerbate fatigue, mood disturbances, and cognitive impairments [47,48].

Medical students frequently experience physiological consequences of prolonged stress and lifestyle disruption. Chronic stress and sleep deprivation activate the hypothalamic-pituitary-adrenal (HPA) axis, resulting in elevated cortisol levels, which can impair immune function, increase susceptibility to illness, and negatively affect metabolism [49]. Reduced physical activity contributes to muscle deconditioning, metabolic disturbances, and cardiovascular risk. Cognitive fatigue and sleep deprivation may also impair brain function, reducing neuroplasticity and memory consolidation necessary for effective learning [41,42].

To navigate these challenges, students often rely on structured coping strategies. Effective time management, including prioritization of tasks, goal setting, and scheduled study sessions, is widely reported to reduce cognitive overload and enhance academic efficiency. In addition, strong social support networks from peers, family, and mentors can provide emotional buffering against stress and offer practical strategies for study and clinical work. Institutional interventions, such as mental health counseling, stress management workshops, and wellness programs, have also been shown to improve resilience and promote a positive academic experience [50,51].

Beyond psychological and social strategies, physical activity has emerged as a key factor in promoting mental health and cognitive function among medical students. Multiple studies demonstrate that students who engage in regular activities experience lower levels of perceived stress and anxiety compared with sedentary peers. A systematic review highlighted that exercise improves mood regulation, enhances resilience, and mitigates psychological distress, making it a valuable tool in coping with the demands of medical school [52]. In addition to mental health benefits, physical activity positively influences cognitive function, including memory, attention, and processing speed, which are essential for mastering complex medical knowledge. Interventions involving moderate exercise have also been shown to improve sleep quality, thereby indirectly reducing stress and enhancing academic performance [53].

Medical students can actively improve their physical health through structured lifestyle changes supported by institutional programs implemented worldwide. Many medical schools now integrate formal physical activity and wellness initiatives into their curricula to counteract sedentary behavior and stress. For example, universities in the USA and Canada have adopted curriculum-embedded exercise programs, protected wellness time, and access to on-campus fitness facilities, which have been shown to increase students' physical activity levels and reduce burnout [54,55]. Similarly, medical schools in Ireland and UK have introduced student-led sports clubs, mandatory wellness curricula, and mindfulness-plus-exercise programs, which have demonstrated improvements in physical activity engagement, sleep quality, and perceived health [56,57].These institutional efforts highlight that improving students' physical health is most effective when individual behavior change is reinforced by supportive educational policies, making regular physical

activity an accessible and sustainable component of medical training rather than an optional extracurricular activity.

Closely linked to physical activity is the role of sleep in medical student health and performance. Quality sleep is essential for cognitive processing, memory consolidation, emotional regulation, and overall mental health. Unfortunately, sleep deprivation is prevalent among medical students due to irregular schedules, late-night studying, and clinical rotations. For example, a study among Egyptian medical students found that over 70% reported poor sleep quality, often associated with high academic workload and disrupted sleep patterns [58]. The effects of insufficient sleep on cognitive and academic performance are substantial. Sleep supports the consolidation of short-term learning into long-term memory, and poor sleep impairs both retention and recall of complex information. Furthermore, sleep deprivation reduces attention, problem-solving ability, and clinical reasoning for academic success and patient care [59]. Beyond cognition, inadequate sleep is closely tied to mental health challenges; students with poor sleep often report higher levels of anxiety and depression, creating a cyclical pattern where stress further disrupts sleep [60].

Medical students can improve sleep through consistent schedules, good sleep hygiene, regular physical activity, and stress management techniques. Many medical schools worldwide have implemented wellness programs to support sleep. The UK MED-WELL program combines physical activity with sleep and stress education, improving sleep quality and mental health [56]. In Australia, mindfulness-based interventions have enhanced sleep and psychological well-being among medical students [61]

2.4. Similar Studies:

Numerous studies worldwide have investigated how sleep quality and physical activity influence academic performance, consistently demonstrating that poor sleep and insufficient physical activity are linked to lower academic achievement, reduced concentration, and increased daytime sleepiness.

In European for example , a cross-sectional study conducted at the Faculty of Medicine, University of Ljubljana, Slovenia examined 125 medical students from years 2 to 6 to explore how sleep quality relates to academic performance. Students completed the Pittsburgh Sleep Quality Index (PSQI) and self-reported their GPA; the results showed that about 75.8 % of students were poor sleepers (PSQI > 5), and there was a significant negative correlation between PSQI scores and GPA, indicating poorer sleep was linked to lower academic performance. The use of a validated sleep measure and inclusion of clinical-year students were strengths, but the study's cross-sectional design and reliance on self-reported GPA limited its ability to infer causality and introduced potential reporting bias [62].

In France, Christodoulou and colleagues studied 177 medical students at Paris Diderot University and investigated both sleep quality and knowledge of sleep hygiene along with academic performance. Using PSQI and quizzes about sleep hygiene, The researchers reported that approximately 49.7 % of students experienced poor sleep quality, which was associated with lower average academic scores, and most students demonstrated limited knowledge of basic sleep hygiene. Specifically, 44.6 % of participants took more than 30 minutes to fall asleep at least once per week, 26.5 % slept six hours or less per night, and 42.4 % rated their sleep quality as poor or very poor. Knowledge of fundamental sleep hygiene was generally low, with an average score of 6.61 out of 10 on multiple-choice questions, and only 31 % of students correctly identified basic healthy sleep practices. The study

emphasized the need to optimize medical training schedules and to implement prevention and educational programs focused on sleep hygiene [63].

Another cross sectional study conducted at Rawalpindi Medical University, Pakistan and involving 219 fourth-year MBBS students, evaluated sleep quality using the Pittsburgh Sleep Quality Index (PSQI), physical activity through the Global Physical Activity Questionnaire (GPAQ), and academic performance via recent pathology test scores. The analysis demonstrated that both poor sleep quality and low physical activity were significantly associated with lower test scores, with PSQI showing a negative correlation and GPAQ a positive correlation. Gender differences were observed, as male students reported higher physical activity levels but poorer sleep quality compared to female students. The study recommended that medical school administration implement targeted interventions, routinely monitor these factors, and evaluate the effectiveness of such programs to improve student well-being and academic outcomes [64].

Also, several studies from African countries have examined similar relationships between sleep quality, physical activity, and academic performance among medical students. For example, a cross sectional study among medical students from the Faculty of Medicine of Sfax, Tunisia assessed sleep quality using the PSQI and academic performance using the Study Management and Academic Results Test (SMART). The study included 154 students and found that 55.8 % had poor sleep quality, and poor sleep was significantly associated with lower scores in academic competence and time management domains, though not all academic dimensions were affected. The study emphasized the importance of promoting healthy sleep habits to improve medical students' overall well-being and academic outcomes. It also highlighted that ensuring access to balanced learning resources, providing counseling and psychological support, and implementing effective stress management strategies are essential for supporting students' academic success. The

strength of this work was its multi-dimensional assessment of academic outcomes, but online survey data collection may have led to self-selection bias [65].

In Egypt , also a cross-sectional study at Zagazig University Faculty of Medicine, Egypt, evaluated sleep quality and academic outcomes in 278 fourth-year medical students. Researchers used an Arabic-translated Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality and self-reported GPA as the academic performance measure. The prevalence of poor sleep quality was 25.5 %, and statistically significant differences were observed between poor sleepers and good sleepers in both physical activity levels and academic performance (GPA), suggesting that reduced sleep quality may adversely affect students' grades. The authors called for intervention programmes to improve sleep quality and related academic outcomes among medical students [66].

An institutional cross-sectional study conducted at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia, assessed the magnitude and correlates of sleep quality among 576 undergraduate medical students using the Pittsburgh Sleep Quality Index (PSQI). The researchers found that the prevalence of poor sleep quality was 62 % (95 % CI: 57.9–65.3), indicating that a substantial proportion of students experienced unhealthy sleep patterns. Factors significantly associated with poor sleep quality included depression (adjusted odds ratio [AOR] = 1.92), stress (AOR = 2.04), poor social support (AOR = 5.39), and poor sleep hygiene (AOR = 3.01), all with $p < 0.05$, suggesting these psychosocial and behavioral determinants play a key role in sleep disruption among medical students. Importantly, the analysis also showed that an increase in GPA was associated with a significant decrease in poor sleep quality (AOR = 0.185), implying that better academic performance was linked with better sleep quality among this student population. The authors recommended that routine screening of sleep quality, sleep hygiene behaviours, stress, and depression should be incorporated into student

support systems, and stressed the importance of educating medical students about proper sleep hygiene and the consequences of inadequate sleep to help improve overall well-being and academic outcomes. [67].

In Sudan, several studies have examined the relationship between sleep quality, lifestyle factors, and academic performance among medical students, highlighting the high prevalence of sleep disturbances and their potential impact on learning outcomes. A case–control study involving 165 medical students from two universities compared students with excellent (grade A) and average (grade C) academic performance using the Pittsburgh Sleep Quality Index (PSQI) and a two-week sleep diary. The study found that students with higher academic achievement had better sleep quality, longer sleep duration (7.0 ± 1.9 h vs. 6.3 ± 1.9 h), shorter sleep latency, earlier bedtimes, and less daytime dysfunction compared to average performers.The study emphasized the need for further research to explore underlying causes and recommended implementing suitable preventive strategies and interventions when necessary [68].

Also a cross-sectional study conducted among 199 medical students used PSQI and the Epworth Sleepiness Scale (ESS) to assess sleep quality and daytime sleepiness, alongside semester GPA as a measure of academic performance. Results indicated that 82.5 % of students experienced poor sleep quality and 56.5 % reported severe daytime sleepiness, both of which were significantly associated with lower academic performance. The study also identified other contributing factors, such as age, gender, and year of study.. This study recommends making a policy and tool formation like curriculum revision and counseling to reduce the sleep disorders and increase students academic performance [69].

Another study at the Faculty of Medicine, University of Khartoum, focused on the relationship between perfectionism and sleep quality among 233 medical students using the Frost Multidimensional Perfectionism Scale (F-MPS) and PSQI.

Approximately 60 % of students reported poor sleep quality, and higher perfectionism scores, particularly in the domains of concern over mistakes and parental expectations, were significantly associated with worse sleep outcomes. This study highlighted the influence of personality traits on sleep quality and underscored the importance of addressing psychological stressors alongside sleep hygiene [19].

Regarding physical activities , a cross-sectional study at the Faculty of Medicine, Omdurman Islamic University in Sudan investigated the relationship between physical activity and academic achievement among 295 medical students. Students' physical activity levels were assessed by comparing their weekly exercise against the World Health Organization (WHO) recommendations, while academic performance was measured using official GPA records. The study found that 56.3 % of students met the recommended level of physical activity, with walking being the most common exercise and study load cited as the primary barrier to regular activity. Although students' mean GPA was slightly lower in the physically active group (3.09 ± 0.47) compared to inactive students (3.16 ± 0.44), this difference was not statistically significant ($p = 0.7$), indicating that regular physical activity was not directly associated with academic achievement in this sample.The authors recommended fostering regular physical activity among medical students and conducting larger, multi-institutional studies with robust analytic controls to better understand how exercise may affect academic outcomes [70].

Another important study comes from a study of medical students at the University of Khartoum, which focused on knowledge, practice, and barriers regarding physical activity. In this observational, cross-sectional investigation of 336 students, researchers used the Global Physical Activity Questionnaire (GPAQ) to assess activity levels and reported that only 40.5 % of students achieved the WHO-recommended level of physical activity. The mean time spent in vigorous and moderate intensity activity was relatively low, and the average sedentary time

exceeded 7 hours per day. Although this study did not directly analyze academic performance, it highlights the high prevalence of insufficient physical activity and significant barriers such as lack of time and inadequate facilities, which are likely to influence students' overall health and capacity for sustained academic engagement. Students demonstrated good knowledge of the physical and mental health benefits of exercise, but only 19.4 % correctly identified the recommended levels of activity, indicating a gap between awareness and practice [71].

Chapter three

Methods and Materials

3. METHODS AND MATERIALS

3.1. Study Design

This study employed a cross-sectional design to assess the association between sleep quality, physical activity, and academic performance among medical students in Sudan during the war period (2023–2025).

3.2. Study Area

The study was conducted among medical students enrolled at universities that were originally located in Khartoum, Sudan, before the conflict, including students who were relocated outside Sudan due to the ongoing conflict. The students were enrolled in five higher education institutions in Sudan: Napata College, International University of Africa, Alzaiem Alazhari University, University of Science and Technology, and Hayat University College. These universities represent a diverse student population across both public and private institutions, encompassing different curricula and academic resources. Including multiple universities allows for a broader understanding of sleep quality, physical activity, and academic performance among medical students in Sudan during the war period.

3.3 Study Population

The study population included all medical students enrolled at Napata College, International University of Africa, Alzaiem Alazhari University, University of Science and Technology, and Hayat University College who were actively engaged in academic activities during the study period (2023–2025).

3.4 Eligibility Criteria

3.4.1 Inclusion Criteria:

- Medical students who were enrolled at universities originally located in Khartoum, Sudan, prior to the conflict.
- Students who were studying inside or outside Sudan due to university relocation caused by the ongoing conflict.

3.4.2 Exclusion Criteria:

- Students who were not actively participating in academic activities during the study period.
- Students who were unwilling or unable to complete the questionnaire.

3.5 Study Variables

- **Dependent Variable:** Academic performance was measured by self-reported perception.
- **Independent Variables:**
    - Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) [72].
    - Physical activity was measured using the short version of the International Physical Activity Questionnaire (IPAQ-SF) [73].

- **Background Variables:** Socio-demographic information included age, gender, year of study, displacement status, living arrangements, university, residence, and socio-economic status.

3.6 Sample Technique and Sample Size

3.6.1 Sample size

The sample size was calculated using Cochran's formula to determine the appropriate number of participants:

$$n = \frac{Z^2 \times p(1-p)}{e^2}$$

Where:

- $Z = 1.96$ *(95% confidence level)*
- $p = 0.5$
- $e = 0.05$

$$n_0 = \frac{(1.96)^2 \times 0.5(1-0.5)}{(0.05)^2}$$

$$n_0 = \frac{3.8416 \times 0.25}{0.0025}$$

$$n_0 = \frac{0.9604}{0.0025} = 384.16$$

The required sample size was approximately 384 students. Due to time limitations, the final number of participants in our study was 203.

3.6.2 Sampling Technique

A convenience sampling technique was utilized to recruit participants based on their availability and willingness to participate during the data collection period.

3.7 Data Collection Techniques and Tools

3.7.1 Data Collection

Data were collected using a self-administered questionnaire, which was distributed online to ensure accessibility for students both inside and outside Sudan. The questionnaire was shared via official student social media groups (e.g., WhatsApp or Telegram) and universities' official student contact lists. Students completed the questionnaire independently and anonymously. Researchers were available online to clarify any questions without influencing responses.

3.7.2 Data Collection Tools

The structured questionnaire consisted of four sections:

- **Sociodemographic Information:** Age, gender, year of study, university, residence, socio-economic status, and displacement status.
- **Sleep Quality Assessment:** Measured using the Pittsburgh Sleep Quality Index (PSQI), which evaluated sleep quality over the past month across seven components [72].
- **Physical Activity Assessment:** Measured using the short version of the International Physical Activity Questionnaire (IPAQ-SF), which assessed the frequency and duration of vigorous, moderate, and walking activities over the past 7 days. Physical activity levels were classified as low, moderate, or high [73].

- **Academic Performance:** Self-reported perceived academic performance.

3.7.3 Scoring Procedures

Pittsburgh Sleep Quality Index (PSQI) Scoring

PSQI components were scored according to standard guidelines, with each component ranging from 0 (better) to 3 (worse):

- **Sleep Duration:**
  Based on Q4:
  ≥7 hours = 0; 6–7 hours = 1; 5–6 hours = 2; <5 hours = 3.
- **Sleep Disturbance:**
  Sum of Q5b–Q5j (missing values treated as 0):
  0 = 0; 1–9 = 1; 10–18 = 2; >18 = 3.
- **Sleep Latency:**
  Q2 was recoded (0–3) and added to Q5a, then categorized into 0–3.
- **Daytime Dysfunction:**
  Sum of Q8 + Q9, categorized into 0–3.
- **Sleep Efficiency:**
  Calculated as: (sleep duration ÷ time in bed) × 100
  ≥85% = 0; 75–85% = 1; 65–75% = 2; <65% = 3.
- **Sleep Quality:**
  Based on Q6 (0–3).
- **Use of Sleep Medication:**
  Based on Q7 (0–3).

- **Total PSQI Score:**
  Sum of all seven components (0–21).
  <5 = good sleep quality; >5 = poor sleep quality.

International Physical Activity Questionnaire (IPAQ-SF) Scoring

Physical activity was calculated using MET-minutes per week:

- MET values:
  Walking = 3.3, Moderate = 4.0, Vigorous = 8.0
- **Total MET-min/week:**
  (Walking + Moderate + Vigorous METs × minutes × days)
- **Activity Levels:**
  - **Low:** No or insufficient activity
  - **Moderate:** ≥600 MET-min/week
  - **High:** ≥1500 MET-min/week (vigorous) or ≥3000 MET-min/week (total)

3.8 Data Management and Statistical Analysis

Data were entered into SPSS version 25 for cleaning and analysis. PSQI component scores and the global score were calculated according to standard scoring procedures, and sleep quality was classified as good or poor using the cut-off value (>5 indicating poor sleep quality). IPAQ-SF data were converted into MET-minutes/week and categorized into low, moderate, and high physical activity levels.

Descriptive statistics were used to summarize the data. Frequencies and percentages were calculated for categorical variables such as sociodemographic characteristics, academic performance, sleep quality components, and physical activity levels. Means and standard deviations were computed for continuous variables, including PSQI subscales, total PSQI score, and total MET values.

Inferential statistical analyses were performed to examine associations between study variables. One-way ANOVA tests were used to compare mean PSQI scores and total MET values across multiple groups (e.g., age, residency, socioeconomic status, and academic performance categories), while independent samples t-tests were used to assess differences by gender. Post hoc Tukey tests were conducted for significant ANOVA results to identify group differences.

Pearson correlation analysis was performed to assess the relationship between total PSQI scores and total MET values.

Multiple linear regression analysis was conducted to evaluate the predictive effects of sleep quality (PSQI) and physical activity (total MET) on self-reported academic performance during the conflict. Model fitness was assessed using R^2 and adjusted R^2 values.

A p-value < 0.05 was considered statistically significant throughout the analysis.

3.9 Ethical Considerations

Ethical approval was obtained from the Ethics Committee of Napata College prior to data collection. The purpose, objectives, and voluntary nature of participation were clearly explained to all students, and informed consent was obtained electronically before they completed the questionnaire. Participation was entirely voluntary, confidentiality and privacy were strictly maintained, questionnaires were anonymized, and all data were securely stored in files accessible only to the research team.

Chapter Four

Result

4.1. Descriptive Statistics

4.1.1 Sociodemographic Characteristics

In our study, the majority of participants were aged 22–25 years (49.8%), with smaller proportions in other age groups, indicating a predominantly young adult sample. Gender distribution was nearly equal, with females (50.2%) and males (49.8%). Most participants were in their fifth year of study (35.5%), followed by fourth-year students (24.1%).

Participants were mainly from Napata College (38.9%), with others distributed across different universities. A large proportion were refugees (43.8%) or internally displaced (33.5%), while fewer were not displaced (22.7%). Most respondents were living with their families (69.0%), with smaller groups in other living arrangements.

Regarding socioeconomic status, the majority reported a middle level (60.1%), followed by high (24.6%), while relatively few reported low (13.3%) or very low (2.0%) status. Findings are presented in **Table 1**.

Table 1: Sociodemographic Characteristics of Participants (*n = 203*)

Variable	Category	Frequency (n)	Percentage (%)
Age	18–21 years	44	21.7
	22–25 years	101	49.8
	25–28 years	43	21.2
	≥29 years	15	7.4
Gender	Male	101	49.8
	Female	102	50.2
Year of Study	First year	14	6.9
	Second year	29	14.3
	Third year	23	11.3
	Fourth year	49	24.1
	Fifth year	72	35.5
	Sixth year	16	7.9
University	Napata College	79	38.9
	International University of Africa	35	17.2
	Alzaiem Alazhari University	18	8.9
	University of Science and Technology	43	21.2
	Hayat University College	28	13.8
Displacement Status	Not displaced	46	22.7
	Internally displaced	68	33.5
	Refugee	89	43.8
Residency	Living with family	140	69.0
	Dormitory/student housing	17	8.4
	Renting alone	10	4.9
	Living with relatives	18	8.9
	Staying with friends	18	8.9
Socioeconomic Status	High	50	24.6
	Middle	122	60.1
	Low	27	13.3
	Very low	4	2.0

4.1.2. Academic Performance During the Conflict

A considerable proportion of participants reported a decline in academic performance during the conflict, with 39.9% indicating their performance was worse and 11.3% much worse, while fewer participants reported improvement (**Figure 1**).

Regarding academic productivity, the findings show that many students experienced a reduction, particularly slight (32.0%) and moderate (24.1%), although 32.5% reported no effect on their productivity (Figure 2).

In terms of satisfaction, participants showed mixed responses, with the largest proportion being satisfied (29.1%), followed by dissatisfied (26.6%) and neutral (22.2%), while smaller proportions were very satisfied (14.8%) or very dissatisfied (7.4%) (Figure 3).

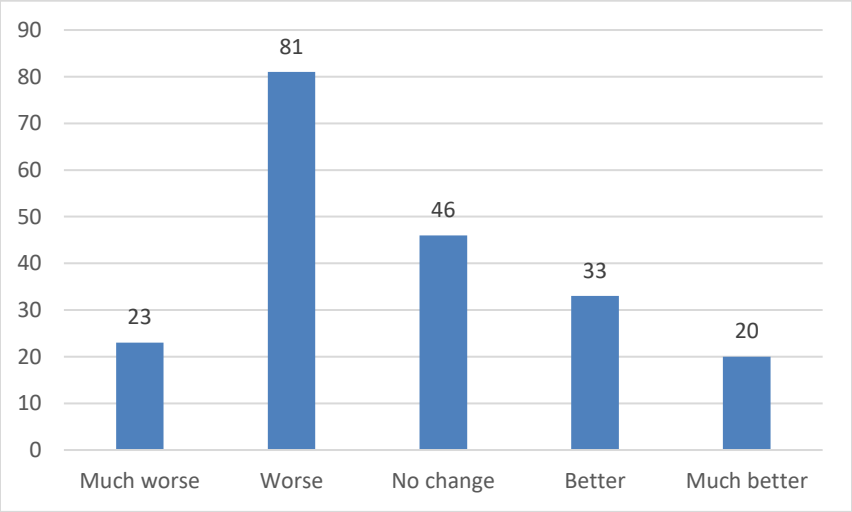


Figure 1: Changes in Academic Performance During the Conflict (*n = 203)*

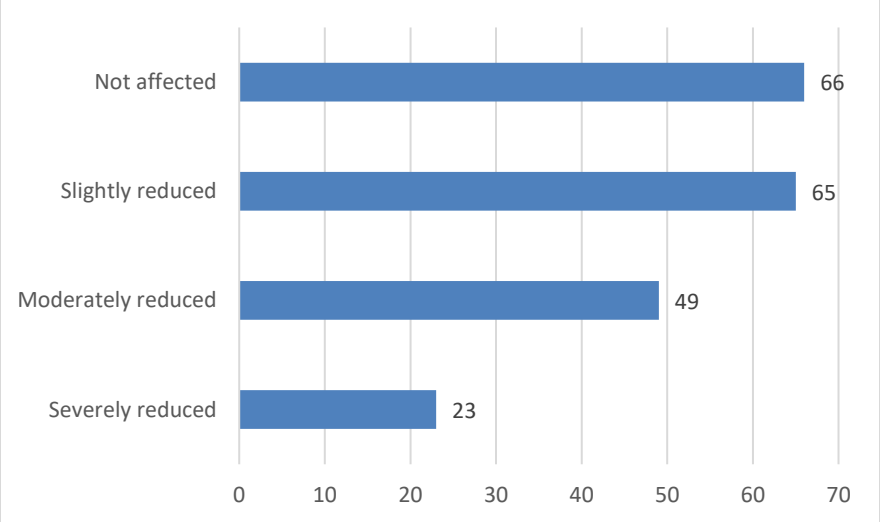


Figure 2: Impact of Conflict on Academic Productivity (*n = 203)*

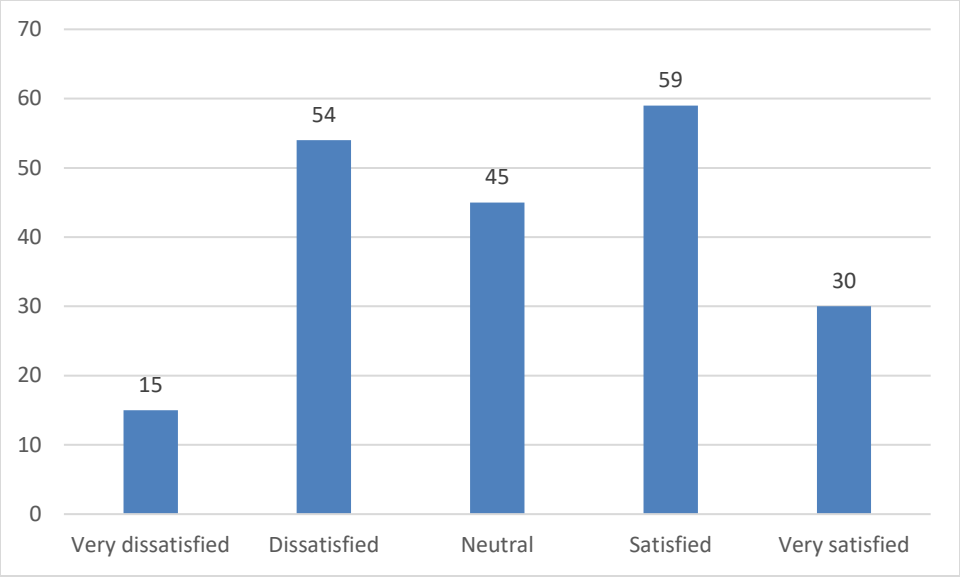


Figure 3: Satisfaction with Academic Performance During the Conflict (*n = 203)*

4.1.3. PSQI:

Sleep Disturbances:

In our study, several sleep disturbances were reported among participants. Difficulty initiating sleep was notable, with equal proportions reporting no difficulty (35.5%) and frequent difficulty (≥3 times/week, 35.5%). Night awakenings were also common, with 25.6% reporting frequent awakenings.

Most participants reported no issues with breathing (52.7%), coughing/snoring (58.1%), or pain (60.6%) during sleep. Similarly, the majority did not experience temperature-related disturbances, including feeling too cold (49.8%) or too hot (53.7%).

However, disturbances such as waking to use the bathroom were relatively common across all frequency levels, while bad dreams were reported by a considerable proportion, with 13.8% experiencing them frequently. Overall, the findings indicate that while some sleep disturbances were not prevalent, others, particularly difficulty initiating sleep and night awakenings, were relatively common among participants. Findings are presented in **Table 2**.

Table 2: Frequency of Sleep Disturbances Among Participants (*n = 203)*

PSQI Component	Not during past month n (%)	<1/week n (%)	1–2/week n (%)	≥3/week n (%)
Cannot get to sleep within 30 minutes	72 (35.5)	38 (18.7)	21 (10.3)	72 (35.5)
Wake up in the night/early morning	63 (31.0)	46 (22.7)	42 (20.7)	52 (25.6)
Get up to use bathroom	64 (31.5)	63 (31.0)	61 (30.0)	15 (7.4)
Cannot breathe comfortably	107 (52.7)	45 (22.2)	37 (18.2)	14 (6.9)
Cough or snore loudly	118 (58.1)	49 (24.1)	27 (13.3)	9 (4.4)
Feel too cold	101 (49.8)	57 (28.1)	38 (18.7)	7 (3.4)
Feel too hot	109 (53.7)	53 (26.1)	32 (15.8)	9 (4.4)
Had bad dreams	82 (40.4)	54 (26.6)	39 (19.2)	28 (13.8)
Have pain	123 (60.6)	55 (27.1)	17 (8.4)	8 (3.9)

Sleep Quality and Daytime Dysfunction

Most participants rated their overall sleep quality as fairly good (41.4%), although a considerable proportion reported fairly bad (30.0%) or very bad (12.8%) sleep quality, indicating variability in perceived sleep health. (**Figure 4**)

The majority of participants (63.5%) reported not using sleep medication during the past month, while smaller proportions used it occasionally or regularly. Regarding daytime functioning, over half (50.7%) reported no trouble staying awake during daily activities, although a notable proportion experienced such difficulties at least occasionally.(**Figure 5)**

In terms of motivation and daily functioning, most participants reported either no problem (32.0%) or only slight difficulty (27.6%) in maintaining enthusiasm, while 29.1% experienced moderate difficulty and 11.3% reported a significant problem. Overall, these findings suggest that although many participants maintained relatively good sleep quality and daytime functioning, a substantial proportion experienced sleep-related and functional impairments. Findings are presented in **Figure 6**.

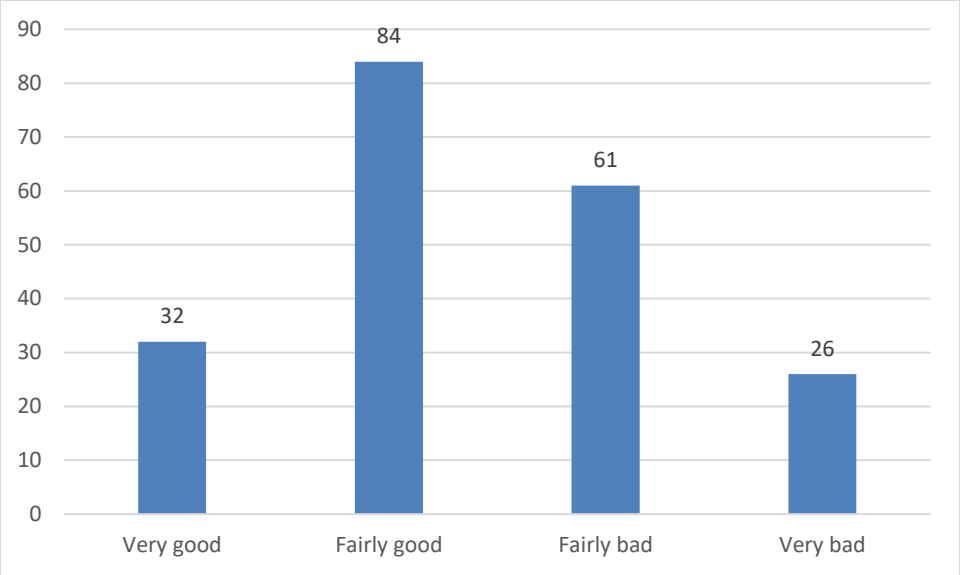


Figure 4: Sleep Quality as Reported by Study Participants (*n = 203)*

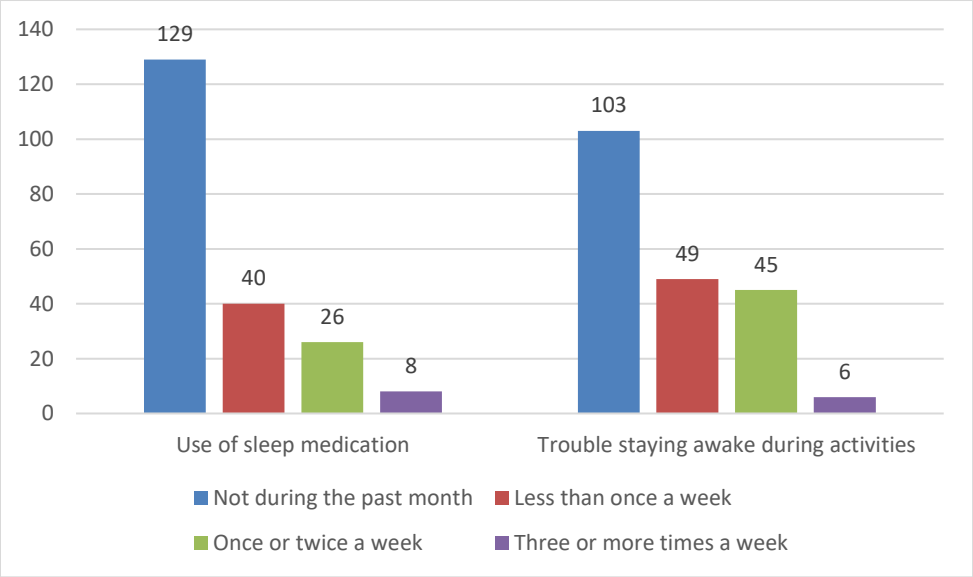


Figure 5: Use of Sleep Medication and Daytime Dysfunction as Reported by Study Participants (*n = 203)*

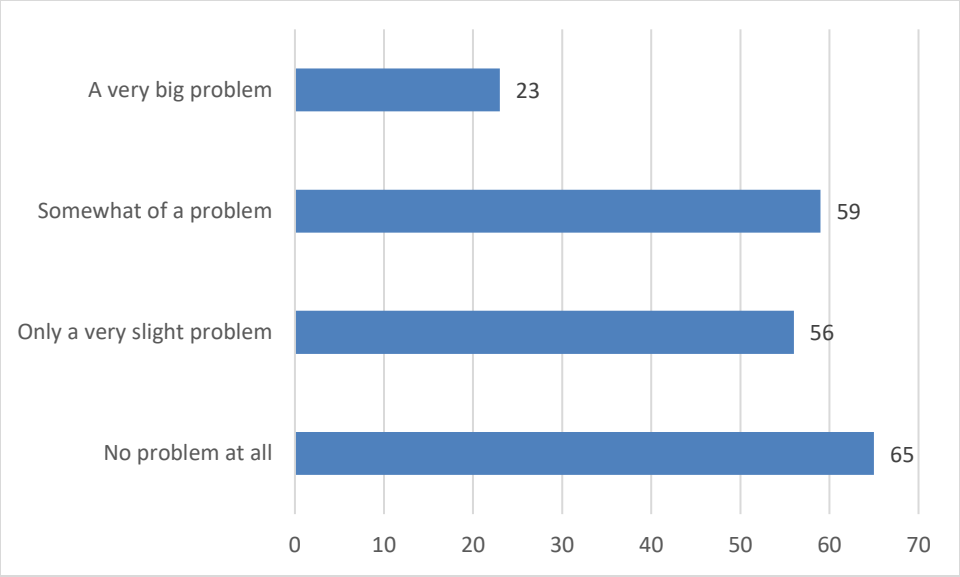


Figure 6: Difficulty in Maintaining Enthusiasm and Daily Functioning (*n = 203)*

Pittsburgh Sleep Quality Index (PSQI) Subscales and Total Score

The mean total PSQI score was 8.15 ± 3.70, indicating overall poor sleep quality among participants. Among the subscales, sleep latency had the highest mean score (1.57 ± 0.98), followed by subjective sleep quality (1.40 ± 0.90).

Moderate scores were observed for sleep disturbances (1.18 ± 0.68), daytime dysfunction (1.16 ± 0.89), sleep duration (1.07 ± 1.16), and habitual sleep efficiency (1.20 ± 1.24), indicating varying levels of sleep-related issues. The lowest mean score was observed for the use of sleep medication (0.57 ± 0.86), suggesting that most participants did not frequently rely on medication for sleep. Findings are presented in **Table 3**.

Table 3: Descriptive Statistics of PSQI Subscales and Total Score (*n = 203)*

PSQI Component (Full Name)	Mean ± SD	Minimum	Maximum
Overall Sleep Quality	1.40 ± 0.90	0	3
Sleep Latency	1.57 ± 0.98	0	3
Sleep Duration	1.07 ± 1.16	0	3
Habitual Sleep Efficiency	1.20 ± 1.24	0	3
Sleep Disturbances	1.18 ± 0.68	0	3
Use of Sleep Medication	0.57 ± 0.86	0	3
Daytime Dysfunction	1.16 ± 0.89	0	3
Total PSQI Score	**8.15 ± 3.70**	0	19

4.1.4. Physical Activity

Physical activity was assessed using the IPAQ short form. In our study, vigorous activity was mostly performed 1 day per week, while moderate activity and walking were distributed across multiple days. Most participants engaged in short bouts of 15–45 minutes per day, with fewer performing longer sessions of 150–180 minutes. Sedentary behavior was high, with many participants reporting ≥150 minutes/day of sitting on weekdays. Findings are presented in **Table 4**.

Table 4: Physical Activity Patterns in the Last 7 Days (IPAQ Short Form, n = 203)

Category / Duration	Vigorous Activity	Moderate Activity	Walking	Sitting (weekday)
0 days	0	27	12	–
1 day	119	56	47	–
2 days	31	41	38	–
3 days	29	37	37	–
4 days	16	23	34	–
5 days	5	14	15	–
6 days	1	4	3	–
7 days	2	1	17	–
15 min/day	99	82	70	41
45 min/day	62	53	55	33
90 min/day	29	32	48	36
150 min/day	9	14	18	43
180 min/day	4	6	6	50

The largest proportion of participants belonged to the high physical activity category (46.8%), followed by low activity (32.0%), and moderate activity (21.2%). The overall mean total physical activity was 2077.8 MET-minutes/week (SD = 2165.0), indicating substantial variability in activity levels among participants. Findings are shown in **Table 5**.

Table 5: Total Physical Activity Levels Based on IPAQ Short Form (*n = 203)*

Physical Activity Category	Frequency (n)	Percent (%)	Mean MET-min/week	SD MET-min/week
Low	65	32.0	—	—
Moderate	43	21.2	—	—
High	95	46.8	—	—
Total / Overall	203	100	**2077.8**	**2165.0**

4.2. Inferential Statistics:

4.2.1. Sleep Quality (PSQI) by Demographic and Academic Factors

Sleep quality, as measured by PSQI, varied significantly across several demographic and socioeconomic factors. Age group was significantly associated with PSQI scores ($F = 2.799$, $p = 0.041$), with participants aged 18–21 years reporting the poorest sleep (Mean = 9.00), significantly higher than those aged 25–28 years (Mean = 6.86) based on post hoc Tukey tests. Residency was also a significant factor ($F = 2.436$, $p = 0.049$), with participants living with relatives (Mean = 10.28) showing poorer sleep compared to those living with family or in university dormitories. Socioeconomic status demonstrated the strongest effect on sleep quality ($F = 11.390$, $p < 0.001$); post hoc comparisons revealed significantly higher PSQI scores among participants with low (Mean = 10.48) and very low socioeconomic status (Mean = 9.75) relative to high SES (Mean = 5.98). No significant differences were observed by year of study ($F = 1.376$, $p = 0.235$),

university affiliation (F = 2.146, p = 0.077), or displacement status (F = 0.671, p = 0.512). Furthermore, PSQI scores did not differ between male and female participants (t = -0.432, p = 0.667). Overall, poorer sleep was observed in younger participants, those with less stable or independent living arrangements, and participants with lower socioeconomic status. Findings are presented in **Table 6-7**.

Table 6: One-Way ANOVA of PSQI Scores by Demographic and Academic Factors (*n = 203*)

Factor	Group / Category	N	Mean PSQI	F	p
Age Group (years)	18–21	44	9.00	2.799	0.041
	22–25	101	8.40		
	25–28	43	6.86		
	≥29	15	7.73		
Year of Study	First year	14	8.71	1.376	0.235
	Second year	29	8.52		
	Third year	23	7.48		
	Fourth year	49	8.90		
	Fifth year	72	7.43		
	Sixth year	16	8.94		
University	Alzaiem Alazhari University	18	7.22	2.146	0.077
	University of Science and Technology	43	7.28		
	International University Of Africa	35	8.20		
	Napata College	79	8.28		
	Hayat University College	28	9.68		
Displacement Status	Refugee (outside country)	89	7.83	0.671	0.512
	Not displaced	46	8.24		
	Internally displaced	68	8.51		
Residency	Living with family	140	7.76	2.436	0.049
	University dormitory / student housing	17	7.76		
	Staying with friends	18	8.72		
	Renting alone	10	9.50		
	Living with relatives (not immediate family)	18	10.28		
Socioeconomic Status	High	50	5.98	11.390	0.000
	Middle	122	8.48		
	Very low	4	9.75		
	Low	27	10.48		

Table 7: Independent Samples T-Test of PSQI Scores by Gender (*n = 203*)

Gender	N	Mean PSQI	SD	t	df	p
Male	98	7.85	3.65	-0.432	201	0.667
Female	105	8.02	3.70			

4.2.2. Sleep Quality (PSQI) by Academic Performance During Conflict

PSQI scores differed significantly across multiple measures of academic performance during the conflict, indicating that poorer sleep was associated with worse academic outcomes. Specifically, PSQI scores varied significantly by how participants rated their academic performance compared to before the conflict ($F = 12.203$, $p < 0.001$), with post hoc Tukey tests revealing that participants reporting "much worse" performance (Mean = 10.00) had significantly poorer sleep than those reporting "much better" (Mean = 4.70), "no change" (Mean = 6.70), or "better" performance (Mean = 7.88). Similarly, sleep quality differed according to the degree to which academic productivity was affected ($F = 20.577$, $p < 0.001$), with "severely reduced" productivity associated with the highest PSQI scores (Mean = 11.57) compared to "not affected" (Mean = 5.91), "slightly reduced" (Mean = 8.48), and "moderately reduced" (Mean = 9.14) groups. Participants' satisfaction with their academic performance during the conflict also varied significantly with sleep quality ($F = 11.950$, $p < 0.001$); post hoc analyses indicated that "very dissatisfied" participants (Mean = 11.73) had significantly poorer sleep than those who were "very satisfied" (Mean = 5.50), "satisfied" (Mean = 7.34), "neutral" (Mean = 8.20), or "dissatisfied" (Mean = 9.48). Overall, poorer sleep quality was strongly linked to worsening academic performance, greater reductions in productivity, and lower satisfaction with academic outcomes during the conflict. Findings are shown in **Table 8**.

Table 8: One-Way ANOVA of PSQI by Academic Performance Measures During Conflict (*n = 203*)

Academic Factor	Groups	N	Mean PSQI	F	p-value
Academic performance compared to before the conflict	Much better	20	4.70	12.203	<0.001
	No change	46	6.70		
	Better	33	7.88		
	Worse	81	9.42		
	Much worse	23	10.00		
Academic productivity affected	Not affected	66	5.91	20.577	<0.001
	Slightly reduced	65	8.48		
	Moderately reduced	49	9.14		
	Severely reduced	23	11.57		
Satisfaction with academic performance during the conflict	Very satisfied	30	5.50	11.950	<0.001
	Satisfied	59	7.34		
	Neutral	45	8.20		
	Dissatisfied	54	9.48		
	Very dissatisfied	15	11.73		

4.2.3. Physical Activity (Total MET) by Demographic and Academic Factors

Physical activity levels, measured by total MET using the IPAQ-SF, differed significantly across several demographic and academic factors. No significant differences were observed by age group ($F = 1.053$, $p = 0.370$), year of study ($F = 0.502$, $p = 0.775$), university affiliation ($F = 1.917$, $p = 0.109$), or displacement status ($F = 1.509$, $p = 0.224$), although post hoc tests suggested slightly higher MET values in older participants (≥29 years) and certain universities. However, residency ($F = 4.653$, $p = 0.001$) and

socioeconomic status (F = 2.866, p = 0.038) were significantly associated with total MET scores. Participants living alone or with relatives had the highest total MET (Mean = 3471.60 and 3569.83, respectively), compared to those living with family or in dormitories (Mean = 1721.99 and 2101.77). Likewise, participants with very low or low socioeconomic status had higher physical activity (Mean = 3872.25 and 2941.83) than those with middle or high socioeconomic status (Mean = 1857.69 and 2004.90). Overall, while age, year, and university affiliation showed no significant effect, living arrangements and socioeconomic status significantly influenced physical activity, with independent living and lower SES associated with higher activity levels. Findings are presented in **Table 9**.

Gender differences were significant, with males showing higher total MET (Mean = 2549.18, SD = 2507.08) than females (Mean = 1611.12, SD = 1646.02), t(201) = 3.154, p = 0.002. (**Table 10**)

Table 9: ANOVA of Total MET by Demographic and Academic Factors (*n = 203*)

Factor	Groups	N	Mean MET	F	p-value
Age group	18–21	44	2113.67	1.053	0.370
	22–25	101	2141.02		
	25–28	43	1658.34		
	≥29	15	2749.90		
Year of Study	First year	14	1921.07	0.502	0.775
	Second year	29	2338.76		
	Third year	23	2190.52		
	Fourth year	49	2298.70		
	Fifth year	72	1778.92		
	Sixth year	16	2248.88		
University	Alzaiem Alazhari University	18	2413.00	1.917	0.109
	The University of Science and Technology	43	1586.20		
	International University of Africa	35	2024.49		
	Napata College	79	1978.46		
	Hayat University College	28	2964.48		
Displacement status	Refugee	89	1783.65	1.509	0.224
	Not displaced	46	2239.53		
	Internally displaced	68	2353.50		
Residency	Living with family	140	1721.99	4.653	0.001
	University dormitory	17	2101.77		
	Staying with friends	18	2556.67		
	Renting alone	10	3471.60		
	Living with relatives	18	3569.83		
Socioeconomic status	High	50	2004.90	2.866	0.038
	Middle	122	1857.69		
	Low	27	2941.83		
	Very low	4	3872.25		

Table 10: Independent Samples T-Test of Total MET by Gender (*n = 203*)

Gender	N	Mean MET	SD	t	df	p-value	95% CI of Difference
Male	101	2549.18	2507.08	3.154	201	0.002	351.65 – 1524.49
Female	102	1611.12	1646.02				

4.2.4. Physical Activity (Total MET) and Academic Performance During Conflict

Analysis of total MET revealed significant differences in physical activity based on academic productivity during the conflict. Participants who rated their academic performance as "much worse" or "severely reduced" showed the highest total MET scores, whereas those reporting "much better" or "not affected" had lower activity levels. ANOVA results indicated significant differences across groups in self-rated academic performance compared to before the conflict ($F = 3.079$, $p = 0.017$) and in perceived productivity during the conflict ($F = 6.366$, $p < 0.001$). Post hoc Tukey tests showed that participants with severely reduced productivity had significantly higher total MET than those with unaffected or slightly reduced productivity. Similarly, participants who rated their performance as "much worse" exhibited higher activity levels than those who rated it as "much better" or "no change." In contrast, self-reported satisfaction with academic performance during the conflict did not significantly affect total MET ($F = 1.749$, $p = 0.141$). Findings are summarized in **Table 11.**

Table 11: One-Way ANOVA of Total MET and Academic Performance During Conflict (*n = 203*)

Factor	Groups	N	Mean MET	F	p-value
Academic performance compared to before	Much better	20	1123.65	3.079	0.017
	No change	46	1827.91		
	Better	33	2433.00		
	Worse	81	1988.82		
	Much worse	23	3211.37		
Academic productivity during conflict	Not affected	66	1476.39	6.366	0.000
	Slightly reduced	65	1992.23		
	Moderately reduced	49	2263.38		
	Severely reduced	23	3650.41		
Satisfaction with academic performance	Very satisfied	30	1571.70	1.749	0.141
	Satisfied	59	1842.69		
	Neutral	45	2190.90		
	Dissatisfied	54	2201.22		
	Very dissatisfied	15	3231.70		

4.2.5. Academic Performance on Sleep Quality and Physical Activity

A multiple linear regression was conducted to examine whether sleep quality (PSQI) and physical activity (Total MET) predicted self-rated academic performance during the conflict compared to before. The overall model was significant, $F(2, 200) = 18.368$, $p < 0.001$, and explained 15.5% of the variance in academic performance ($R^2 = 0.155$, Adjusted $R^2 = 0.147$).

Among the predictors, PSQI was a significant negative predictor of academic performance (β = -0.373, p < 0.001), indicating that poorer sleep quality was associated with lower self-rated academic performance. In contrast, Total MET did not significantly predict academic performance (β = -0.079, p = 0.233). (**Table 12**) The correlation between PSQI and Total MET was weak but significant (r = 0.166, p = 0.018), suggesting that higher physical activity was slightly associated with poorer sleep quality.

Table 12: Multiple Regression Predicting Academic Performance During Conflict (*n = 203*)

Predictor	B	Std. Error	Beta	t	*p*	Tolerance	VIF
(Constant)	2.775	0.188	–	14.773	*0.000*	–	–
PSQI	-0.117	0.021	-0.373	-5.661	*0.000*	0.972	1.028
Total MET	0.000	0.000	-0.079	-1.196	*0.233*	0.972	1.028

4.2.6. Correlation Between Sleep Quality and Physical Activity

Pearson correlation analysis revealed a weak but significant positive correlation between PSQI and Total MET (r = 0.166, p = 0.018). This indicates that participants with higher physical activity levels tended to report slightly worse sleep quality. Findings are shown in **Table 13**.

Table 13: Pearson Correlation Between PSQI and Total MET (*n = 203*)

Variable	PSQI	Total MET
PSQI	1	0.166*
Total MET	0.166*	1
***Correlation is significant at the 0.05 level (2-tailed).**		

Chapter Five: Discussion, Conclusion & Recommendations

5.1. DISCUSSION

This study investigated the relationship between sleep quality, physical activity, and academic performance among medical students during a conflict setting. The findings demonstrate that poor sleep quality, as measured by the Pittsburgh Sleep Quality Index (PSQI), is highly prevalent (mean = 8.15 ± 3.70) and significantly associated with worse academic performance. In contrast, physical activity, assessed using the IPAQ-SF (mean MET = 2077.8 ± 2165), did not significantly predict academic performance, despite showing significant variation across academic productivity groups. Additionally, a weak but significant positive correlation between PSQI and physical activity (r = 0.166) was observed.

The present study clearly demonstrates that poor sleep quality is significantly associated with reduced academic performance, including lower self-rated performance, decreased productivity, and reduced satisfaction with academic outcomes. Students who reported worsening academic performance during the conflict exhibited markedly higher PSQI scores, indicating that sleep disturbances are closely linked to academic decline.

The existing literature strongly supports these findings. A previous study reported that 75.8% of medical students were classified as poor sleepers, with a significant negative relationship between PSQI scores and academic achievement [62]. Similarly, a study conducted in Ethiopia identified a 62% prevalence of poor sleep, with significant associations between sleep quality and academic outcomes [67]. Christodoulou et al. further emphasized that poor sleep, including prolonged sleep latency and shorter sleep duration, was linked to diminished academic performance [63].

The mean PSQI score observed in this study is highly consistent with regional and international data. A study conducted among Saudi medical students reported a mean

PSQI score of 8.13 ± 3.46 among Saudi medical students, with 77% classified as poor sleepers [5], while a large-scale meta-analysis across the MENA region found a mean PSQI score of approximately 8.5, with nearly 60% of students experiencing poor sleep quality [74]. This consistency suggests that poor sleep is a widespread and systemic issue among medical students, regardless of geographical context.

Within Sudan, the findings are particularly relevant. A previous study reported an alarmingly high prevalence of poor sleep (82.5%), accompanied by significant daytime dysfunction and reduced academic performance [69]. Another Sudanese study further demonstrated that students with better academic performance had longer sleep duration, shorter sleep latency, and better overall sleep efficiency, reinforcing the critical role of sleep in academic success [68].

However, it is important to acknowledge that not all studies have found a direct association between sleep quality and academic performance, despite high prevalence of poor sleep [64,65]. These discrepancies may be attributed to differences in study design, measurement tools, or contextual factors such as academic systems, cultural expectations, and coping strategies.

From a mechanistic perspective, the relationship between sleep and academic performance is well-established. Sleep plays a fundamental role in memory consolidation, learning, and cognitive processing, particularly during REM sleep stages [6]. Sleep deprivation impairs attention, working memory, and executive function, all of which are essential for academic success [28]. Furthermore, chronic sleep disruption has been shown to negatively affect emotional regulation and stress resilience [30], potentially exacerbating the challenges faced by students in demanding academic environments.

In the context of our study, the strong association between poor sleep and academic decline may be further intensified by conflict-related stressors, including displacement, instability, and uncertainty [76]. These factors likely contribute to

both sleep disturbances and reduced academic engagement, thereby amplifying the observed relationship.

In contrast to sleep quality, physical activity did not demonstrate a significant independent association with academic performance in the regression analysis, despite showing significant variation across academic performance categories. Notably, students with poorer academic performance and reduced productivity reported higher levels of physical activity, suggesting a non-linear or context-dependent relationship.

This finding aligns closely with Sudanese research; a recent study reported that although 56.3% of students met the recommended physical activity levels, there was no significant association with academic performance ($p = 0.7$) [19]. Similarly, a large-scale study conducted in Jordan found that physical activity was not significantly associated with academic achievement, despite moderate participation levels [77].

Conversely, a substantial body of international literature suggests a positive relationship between physical activity and academic performance. Physical activity has been shown to enhance cognitive function, including memory and executive processing [53], while also promoting neuroplasticity and overall brain health [16]. Furthermore, a significant association has been reported between higher levels of physical activity and improved academic achievement among medical students [18].

Studies utilizing IPAQ-based measurements have also shown that moderate and vigorous physical activity are positively associated with academic performance, although the strength of this association is generally weak [78]. These findings suggest that while physical activity contributes to cognitive and academic outcomes, its effects may be modest and influenced by other variables.

One probable explanation for the lack of a significant association in our study is the influence of contextual and behavioral factors. In a conflict-affected setting, physical activity may not necessarily reflect structured or health-promoting behavior but rather an adaptive coping mechanism, as it is well-established as a protective factor against stress and burnout, with regular physical activity significantly reducing stress levels and improving mental health. [52]. Similarly, a systematic review found that physical activity is associated with reduced burnout and improved quality of life among medical students, with evidence of a dose-response relationship [79].
Therefore, while physical activity may not directly influence academic performance in this study, it likely plays an indirect and supportive role by enhancing psychological well-being and resilience, particularly under stressful conditions.

The combined analysis of sleep quality and physical activity provides valuable insights into their relative contributions to academic performance. In this study, sleep quality emerged as the dominant predictor, while physical activity did not retain significance in the regression model.
This finding is partially consistent with previous research. A study conducted among final year medical students reported that both sleep quality and physical activity were significantly associated with academic performance, with PSQI showing a strong negative correlation ($r = -0.69$) [64]. However, the present study suggests that sleep may play a more critical role than physical activity, particularly in environments characterized by high stress and instability.
The observed weak positive correlation between physical activity and PSQI scores ($r = 0.166$) is particularly noteworthy. Contrary to the general expectation that physical activity improves sleep quality, this finding suggests that higher activity levels were associated with slightly poorer sleep. This may reflect the unique context

of the study, where physical activity occurs under conditions of stress, irregular routines, and disrupted routines.

Although physical activity has been shown to improve sleep quality by reducing sleep latency and enhancing sleep efficiency [13], these benefits may be attenuated in the presence of chronic stress and environmental disruption. Therefore, the relationship between physical activity and sleep in this population appears to be complex and influenced by multiple interacting factors.

A defining characteristic of this study is its focus on a population significantly affected by conflict, with a large proportion of participants being refugees or internally displaced individuals. This context provides important insight into the broader determinants of sleep, physical activity, and academic performance.

Conflict and displacement are known to disrupt daily routines, increase psychological stress, and limit access to stable living conditions. These factors can significantly impair sleep quality, reduce academic engagement, and alter lifestyle behaviors. A study conducted in Sudan after the beginning of the ongoing conflict highlighted that war has profound effects on higher education systems, leading to academic disruption, reduced performance, and compromised student well-being [20].

In the present study, socioeconomic status and residency were significant predictors of sleep quality, with lower SES and less stable living arrangements associated with poorer sleep. These findings are consistent with global evidence indicating that economic hardship and environmental instability negatively affect sleep and academic outcomes [80,81].

The interaction between conflict, stress, and lifestyle factors likely plays a central role in shaping the observed relationships. Students in such environments may

experience chronic stress, uncertainty, and psychological burden, all of which contribute to sleep disturbances and reduced academic performance.

5.2. Study Limitations:

This study encountered several limitations that should be considered when interpreting the findings. The relatively small sample size and inclusion of selected universities may limit generalizability. The cross-sectional design prevents causal inference. Additionally, the use of self-reported data introduces recall and reporting bias.

5.3. Conclusion

This study highlights the significant role of sleep quality in shaping academic performance among medical students in a conflict-affected setting. Poor sleep quality was highly prevalent and strongly associated with worse academic outcomes, including reduced productivity, lower satisfaction, and overall academic decline. These findings reinforce the importance of sleep as a key determinant of cognitive functioning and learning.

In contrast, physical activity did not show a significant independent effect on academic performance, despite variations across groups. This suggests that, in high-stress environments such as conflict settings, the direct academic benefits of physical activity may be less pronounced. However, physical activity may still contribute indirectly by supporting mental health and resilience. The weak positive correlation observed between physical activity and poorer sleep further reflects the complex and context-dependent nature of these relationships.

Overall, sleep quality appears to be a more critical factor than physical activity in influencing academic performance in this population, emphasizing the need to prioritize sleep health in student support strategies.

5.4. Recommendations

Based on the findings of this study, improving sleep quality should be a priority for enhancing academic performance among medical students, particularly in conflict settings.

1. Policy Level

- Integrate student well-being and sleep health into national education and public health policies.
- Develop targeted support strategies for students affected by conflict and displacement.

2. Health Institutions

- Implement screening for sleep problems and psychological stress among students.
- Provide accessible counseling and mental health services.
- Promote sleep hygiene and stress management programs.

3. Universities

- Incorporate wellness and sleep education into curricula.
- Optimize academic schedules to reduce excessive workload.
- Provide supportive and stable learning environments.
- Encourage structured and accessible physical activity programs.

4. Community Support

- Strengthen family and peer support systems.
- Support students facing displacement through community-based initiatives.

5. Future Research

- Conduct longitudinal studies to establish causal relationships.
- Explore the role of stress and environmental factors.
- Include larger and more diverse student populations.

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Appendices:

1: Questionnaire:

Title:

Association Between War-Related Sleep Quality, Physical Activity, and Academic Performance Among Medical Students in Sudan

Introduction

This questionnaire aimed to explore how war-related conditions affected sleep quality, physical activity, and academic performance among medical students in Sudan.

Participation was voluntary, and all responses were kept anonymous and confidential. The collected data were used strictly for research purposes.

The questionnaire required approximately 10–20 minutes to complete.

By completing this questionnaire, participants provided informed consent to take part in the study.

Section 1: Sociodemographic Characteristics

1. **Age**
- 18–21 years
- 22–25 years
- 25–28 years
- ≥29 years
2. **Gender**
- Male
- Female
3. **Year of Study**
- First year
- Second year
- Third year
- Fourth year
- Fifth year
- Sixth year
4. **University**
- Alzaiem Alazhari University
- International University of Africa
- University of Science and Technology
- Napata College
- Hayat University College
5. **Displacement Status**
- Not displaced (living in original residence)
- Internally displaced (within the country)
- Refugee (outside the country)
6. **Residency**
- Living with family

- University dormitory/student housing
- Renting alone
- Living with relatives (not immediate family)
- Staying with friends

7. **Socioeconomic Status**

- High (no financial concerns)
- Middle (meets basic needs)
- Low (difficulty meeting needs)
- Very low (dependent on aid)

Section 2: Academic Performance During the Conflict

1. **How would you rate your academic performance during the conflict compared to before?**

- Much worse
- Worse
- No change
- Better
- Much better

2. **How has your academic productivity been affected? (studying, assignments, exams)**

- Not affected
- Slightly reduced
- Moderately reduced
- Severely reduced

3. **How satisfied are you with your academic performance during the conflict?**

- Very satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very dissatisfied

Section 3: Sleep Quality (PSQI)

1. Usual bedtime during the past month: _____
2. Time taken to fall asleep (minutes): _____
3. Usual wake-up time: _____
4. Hours of actual sleep per night:

- 3–4 hours
- 5 hours
- 6 hours
- 7 hours
- 8 hours
- 9 hours
- 10 hours
- ≥11 hours

5. Sleep Disturbances (During the Past Month)

Item	Not during past month	<1/week	1–2/week	≥3/week
a) Cannot fall asleep within 30 min	☐	☐	☐	☐
b) Wake up at night/early morning	☐	☐	☐	☐
c) Wake to use bathroom	☐	☐	☐	☐
d) Cannot breathe comfortably	☐	☐	☐	☐
e) Cough/snore loudly	☐	☐	☐	☐
f) Feel too cold	☐	☐	☐	☐
g) Feel too hot	☐	☐	☐	☐
h) Have bad dreams	☐	☐	☐	☐
i) Have pain	☐	☐	☐	☐

6. **Overall sleep quality:**
- Very good
- Fairly good
- Fairly bad
- Very bad

7–8. Frequency Questions

Question	Not during past month	<1/week	1–2/week	≥3/week
7. Use of sleep medication	☐	☐	☐	☐
8. Trouble staying awake	☐	☐	☐	☐

9. **Difficulty maintaining enthusiasm:**
- No problem
- Slight problem
- Moderate problem
- Severe problem

10. **Bed partner/roommate:**
- None
- Separate room
- Same room, different bed
- Same bed

Section 4: Additional Sleep Observations (If Applicable)

Item	Not during past month	<1/week	1–2/week	≥3/week
Loud snoring	☐	☐	☐	☐
Breathing pauses	☐	☐	☐	☐
Leg movements	☐	☐	☐	☐

Confusion/disorientation	☐	☐	☐	☐

Section 5: Physical Activity (IPAQ-SF)
Based on the last 7 days:

1. **Days of vigorous activity:**
- 1–7 days
2. **Time spent on vigorous activity/day:**
- <30 min
- 30–60 min
- 1–2 hours
- 2–3 hours
- 3 hours
3. **Days of moderate activity:**
- 1–7 days / None
4. **Time spent on moderate activity/day:**
- <30 min
- 30–60 min
- 1–2 hours
- 2–3 hours
- 3 hours
5. **Days of walking (≥10 minutes):**
- 1–7 days / None
6. **Time spent walking/day:**
- <30 min
- 30–60 min
- 1–2 hours
- 2–3 hours
- 3 hours
7. **Time spent sitting on a weekday:**
- <30 min
- 30–60 min
- 1–2 hours
- 2–3 hours
- 3 hours