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HEMOGLOBIN, PHYSICAL ACTIVITY, AND SLEEP QUALITY AS PROTECTIVE FACTORS OF COMMON MENTAL DISORDER AMONG UNIVERSITY STUDENTS

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ABSTRACT

The prevalence of common mental disorders (CMD) among university students is increasing. Globally, one in seven people (1.1 billion) lived with a mental disorder, and 15% of the population including adolescents and adults were affected. These growing burdens highlight the importance of examining lifestyle and hematological factors related to CMD. This study aims to examine the associations of hemoglobin (Hb) levels, physical activity, and sleep quality with CMD. In this cross-sectional study, 105 active students from Tamalatea University, Makassar, were selected through proportional stratified sampling. Data included demographics, anthropometry, total weekly physical activity via the International Physical Activity Questionnaire–Short Form (IPAQ-SF), sleep quality via the Pittsburgh Sleep Quality Index (PSQI), Common Mental Disorder (CMD) symptoms via the Depression, Anxiety and Stress Scales (DASS-42), and hemoglobin (Hb) levels. Multiple logistic regression was used for data analysis. After covariate adjustment, moderate (aOR=0.17; 95%CI: 0.04–0.70; p=0.014) and high physical activity (aOR=0.08; 95%CI: 0.01–0.56; p=0.011) were significantly associated with lower odds of CMD compared with low activity. Good sleep quality was also protective (aOR=0.15; 95%CI: 0.03–0.76; p=0.022). Higher hemoglobin levels showed a borderline protective association (aOR=0.64; 95%CI: 0.41–1.00; p=0.050). The multivariable model demonstrated a Nagelkerke R^2 of 0.286, indicating that the independent variables explained 28.6% of the variance in CMD status. Moderate-to-high physical activity, good sleep quality, and higher hemoglobin levels were protective against CMD among university students. Universities should implement integrated mental health prevention programs, including structured walking and physical activity programs, routine anemia screening with iron supplementation (IFA), and sleep health promotion for students.

INTRODUCTION

Mental disorders are a major global health issue, affecting more than one billion people worldwide [1]. Globally, an estimated 15% of the population is affected by mental disorders, with one in seven people experiencing these conditions most commonly anxiety and depressive disorders [1,2]. The most prevalent conditions across ages and sexes are depressive and anxiety disorders often grouped as common mental disorders (CMD) [3]. Adolescence and emerging adulthood are critical periods for psychosocial development and academic attainment, but also high risk windows for CMD onset [4]. Reports indicate that individuals aged 15–21 years experience poorer mental health including depression and stress than other age groups [5]. Previous studies show high CMD prevalence among university students [4,6]. CMD increases vulnerability to cardiometabolic diseases and premature mortality [7]. CMD not only contributes to disability and a reduced quality of life but also lowers academic performance and productivity [4,8].

A recent meta-analysis shows that lifestyle factors particularly physical activity, sleep quality, and diet are strongly associated with mental health [9]. However, university students often engage in low physical activity levels, irregular sleep patterns, and suboptimal dietary behaviors, placing them at heightened risk for developing CMD. Regular physical activity has consistently been shown to improve emotional well-being and reduce symptoms of depression and anxiety, making it one of the most effective protective factors against CMD [10,11]. Similarly, adequate sleep quality plays a crucial role in the prevention of mental disorders through key biological and psychological mechanisms that are vital for brain health, such as emotional regulation and mood stabilization [12]. These combined lifestyle challenges among university students can significantly increase their vulnerability to CMD.

Hematological status, such as hemoglobin concentration, may influence cognition and emotion regulation through oxygen delivery and neurotransmitter pathways [13,14]. In Indonesia, anemia prevalence among those aged 15–24 years is 15.5% [15]. This high prevalence highlights anemia as a significant public health issue affecting adolescents and young adults. Anemia can impact mental health; fatigue from low hemoglobin levels may precipitate depressive symptoms, while depression may, in turn, exacerbate anemia through altered appetite, inflammation, or poor health-seeking behavior [16]. These physiological and psychological interactions demonstrate how hematological insufficiencies can impair daily functioning and emotional resilience. Young adults, including university students, may be particularly vulnerable due to academic demands and lifestyle-related risks. Therefore, understanding the relationship between hemoglobin status and mental health outcomes is essential for early prevention and targeted interventions.

In Indonesian higher education, many students relocate from rural to urban settings and must gradually adjust from prior living arrangements adapting to different routines, amenities, and the faster pace of city life often alongside dietary changes and heightened academic pressure. While the relationship between lifestyle and mental health is well established globally, in a developing country like Indonesia where iron-deficiency anemia remains a major problem among young adults. how this nutritional challenge intersects with rapid urban transitions is not yet fully understood.

The rapid growth of digitalization in higher education has substantially altered students' lifestyles and behavioral patterns. Increased dependence on online learning platforms, prolonged screen exposure, social media engagement, and technology-based services may contribute to reduced physical activity and increasingly sedentary behaviors among university students. Sedentary behavior has been associated with depression, anxiety, stress, sleep disturbances, and reduced psychological well-being [17]. In urban educational settings such as Makassar, these lifestyle changes may become more pronounced among students adapting from rural and semi-urban environments into digitally oriented academic systems.

Makassar is recognized as one of the educational gateways of Eastern Indonesia, attracting students from diverse sociocultural and rural backgrounds. These transitions may increase students' vulnerability to lifestyle changes, psychosocial stress, and common mental disorders (CMDs), despite having health-related educational exposure. Although several studies have investigated mental health among university students, most have primarily focused on psychosocial and lifestyle-related factors. Limited studies have explored hematological status, particularly hemoglobin levels, in relation to CMDs among university students. This issue may be particularly relevant among students at Tamalatea University Makassar, where students from diverse regions of Eastern Indonesia undergo intense academic, social, and lifestyle transitions while adapting to urban educational environments. Although students in health-related programs are expected to possess better health awareness, they may still remain vulnerable to CMDs due to academic demands and psychosocial adaptation. Therefore, this study aims to analyze the association between hemoglobin (Hb), physical activity, and sleep quality with common mental disorders (CMDs), while controlling for age, sex, body mass index (BMI), and allowance.

Although several studies have investigated mental health among university students, most have primarily focused on psychosocial and lifestyle-related factors. Limited studies have explored hematological status, particularly hemoglobin levels, in relation to common mental disorders (CMDs) among university students. In addition, students in health-related programs are generally expected to possess better health knowledge and awareness; however, they may still remain vulnerable to CMDs due to academic pressure, lifestyle transitions, and psychosocial demands. Therefore, examining the combined role of hemoglobin status, physical activity, and sleep quality as protective factors against CMDs among university students remains important, particularly in the context of Indonesian higher education.

This issue may be particularly relevant among students at Tamalatea University Makassar, a newly transformed institution whose student population is predominantly composed of Public Health students from diverse regions of Eastern Indonesia. Although these students are expected to possess better health awareness, they undergo substantial academic, social, and lifestyle transitions while adapting to Makassar's urban and digital environment, which may increase their vulnerability to common mental disorders (CMDs). Therefore, this study aims to analyze the association between hemoglobin (Hb), physical activity, and sleep quality with CMDs, while controlling for age, sex, body mass index (BMI), and allowance.

METHODS

Study design and setting

We conducted an observational analytical study with a cross-sectional design at the Undergraduate Public Health Program, Tamalatea University Makassar, Indonesia, a newly integrated university in Makassar that attracts students from various regions of Eastern Indonesia. A cross-sectional design was chosen for its efficiency in measuring the prevalence of health outcomes and analyzing multiple determinants at a single point in time. This approach allows for the simultaneous assessment of hemoglobin status, physical activity, sleep quality, and common mental disorders (CMDs) within a relatively short period, making it highly appropriate for identifying associations among variables in a student population [18].

Data collection was carried out from May to July 2025 to ensure adequate participation and prevent academic schedule disruptions to academic activities. However, because exposure and outcome variables were measured simultaneously, causal relationships between variables could not be established, which is a recognized limitation of cross-sectional studies.

Population and Sample

The target population comprised 261 active undergraduate students from the first to third academic year (Year 1–3). Fourth-year students were excluded to maintain a more homogeneous study population, as they typically experience different academic stressors related to thesis completion and final academic requirements that may confound the assessment of routine lifestyle-related factors associated with CMDs. A stratified random sampling technique was applied, with stratification based on academic year to ensure proportional representation and to capture potential variations in academic pressure. Inclusion criteria were active undergraduate students currently enrolled in the Public Health Program, willingness to participate by signing informed consent after receiving study explanations, and ability to complete all study procedures. Students currently taking psychoactive medications were excluded because these medications may influence psychological assessment outcomes.

The sample size was calculated based on Lemeshow's formula for estimating a single proportion. We specified a 95% confidence level (Z = 1.96), an estimated proportion (p) of 13% based on a previous study in youth population [19], and a margin of error (d) of 5%. After applying the finite-population correction, the minimum required sample was 105 students. To enhance representativeness, the planned sample was proportionally allocated across academic years (Year 1, n=34; Year 2, n=36; Year 3, n=35). This sampling approach ensured adequate coverage of students across different academic stages.

Data collection and measurements

Trained enumerators conducted face-to-face interviews using a structured questionnaire to collect demographic (age, sex) and socioeconomic data. This included demographic information (age, sex), family and socioeconomic status. Dietary intake was assessed using a semi-quantitative food frequency questionnaire (SQ-FFQ). Intake was categorized as inadequate if it fell below 80% for energy and protein, or below 77% for iron (Fe).

Intake at or above these respective thresholds was deemed adequate. Physiological and anthropometric assessments were then conducted, including hemoglobin measurement using a HemoCue® Hb 301 system. Capillary blood samples were collected by trained research team members using standardized finger-prick procedures. The participant's fingertip was cleaned with an alcohol swab and allowed to dry before puncture using a sterile lancet. The first drop of blood was wiped away, and the subsequent blood sample was collected into a microcuvette for immediate hemoglobin analysis according to the manufacturer's instructions. The HemoCue® device was routinely checked before use to ensure measurement reliability. Participants completed the questionnaire prior to anthropometric and hemoglobin assessments. Hemoglobin assessment using capillary blood and portable HemoCue systems has been widely applied in field-based epidemiological studies due to its practicality and acceptable validity for anemia screening [20]. Anemia was categorized based on WHO established thresholds (<12 g/dL for females, <13 g/dL for males) that account for biological sex differences. In this study, capillary blood samples were collected by trained research team members using standardized finger-prick procedures.

Additionally, height and weight were measured to calculate Body Mass Index (BMI), which was classified according to Asia-Pacific criteria: Underweight (<18.5), Normal (18.5–22.9), Overweight (23.0–24.9), and Obese (≥25.0). Physical activity levels over the last seven days were evaluated using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), with total MET-minutes/week classified into Low (<600 MET-min/week), Moderate (600–3000 MET-min/week), and High (≥3000 MET-min/week). To minimize recall bias, the IPAQ-SF was administered through face-to-face interviews using standardized instructions by trained enumerators. Sleep quality was evaluated via the Pittsburgh Sleep Quality Index (PSQI), The PSQI is a self-rated questionnaire that evaluates seven components of sleep where a clinically validated global score cutoff of >5 was used to distinguish between 'poor' and 'good' sleep quality.

Common Mental Disorder (CMD) status was determined using the Depression, Anxiety, and Stress Scales (DASS-42). In this study, CMD was operationally defined as the presence of depressive and/or anxiety symptoms at the mild level or higher. Participants were classified as having CMD (case) if they scored ≥10 on the Depression subscale and/or ≥8 on the Anxiety subscale. Participants scoring below both thresholds were classified as non-CMD (non-case). The Stress subscale was not included in the CMD classification.

The Indonesian versions of the Depression Anxiety Stress Scale (DASS-42) and Pittsburgh Sleep Quality Index (PSQI) used in this study have been previously validated and demonstrated good reliability in Indonesian populations. Previous studies reported Cronbach's alpha values above 0.90 for the Indonesian version of DASS [21] and adequate internal consistency for the Indonesian version of the PSQI [22].

Data analysis

Data were analyzed using SPSS software (version 26.0; IBM). Numerical variables were assessed for normality using the Shapiro–Wilk test. Normally distributed data were presented as mean ± standard deviation. Categorical variables were presented as frequencies and percentages.

Bivariate analyses were conducted to examine the association between sociodemographic characteristics, nutritional status, dietary intake, lifestyle factors, and CMD status. The Chi-square test or Fisher's exact test was used for categorical variables, while the independent t-test or Mann–Whitney U test was used for numerical variables, as appropriate.

Variables included in the multivariable logistic regression model were selected based on theoretical relevance, previous literature, and potential confounding effects, regardless of their statistical significance in bivariate analyses. Multivariable logistic regression analysis was performed using the Enter method to examine factors associated with CMDs while controlling for age, sex, body mass index (BMI), and allowance. Dietary intake variables (energy, protein, and iron intake) were excluded from the final model due to potential collinearity with hemoglobin levels. Model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test. Results were reported as adjusted Odds Ratios (aORs) with 95% Confidence Intervals (CIs), and statistical significance was set at $p<0.05$.

Ethical considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee of STIKES Nani Hasanuddin (Reference No. 674/STIKES-NH-KEPK/V/2025; issued on May 25, 2025). Prior to their inclusion, all participants provided written informed consent. Participant confidentiality and anonymity were strictly maintained throughout the study by using coded identifiers, and all data were securely stored and accessible only to the research team.

RESULTS

The study included 105 students; females comprised 80.0% and males 20.0%. The mean age was 20.1 ± 1.24 years. Academic year 1, 2 and 3 were 32.4%, 34.3% and 33.3% respectively (table 1).

Table 1. Descriptive statistics of demographic characteristics (n = 105)

Variable	n / Mean±SD	%
Sex		
Male	21	20.0
Female	84	80.0
Age (years)	20.1 ± 1.24	
Academic Year		
Year 1	34	32.4

Year 2	36	34.3
Year 3	35	33.3

Mean BMI was 21.1 ± 3.3 kg/m^2; most students had normal nutritional status (58.1%), with double-burden features: underweight (18.1%) and overweight/obesity combined (23.8%). Dietary inadequacy was common: Fe (88.6%), energy (62.9%), and protein (48.6%). Poor sleep quality was strikingly prevalent (91.4%). CMD prevalence was 75.2%; anxiety (any severity) was 75.2% versus depression 50.5% (table 2).

Table 2. Nutritional status, dietary intake, lifestyle, and CMD

Variable	n / Mean±SD	%
BMI (kg/m^2)	21.1 ± 3.3	
Underweight	19	18.1
Normal	61	58.1
Overweight	15	14.3
Obese	10	9.5
Energy intake (kcal)	1718.3 ± 545.9	
Inadequate	66	62.9
Adequate	39	37.1
Protein intake (g)	64.6 ± 85.9	
Inadequate	51	48.6
Adequate	54	51.4
Fe intake (mg)	7.9 ± 13.87	
Inadequate	93	88.6
Adequate	12	11.4
Hemoglobin (g/dL)	13.7 ± 1.43	
Physical activity		
Low	36	34.3
Moderate	59	56.2
High	10	9.5
Sleep quality		
Poor	96	91.4
Good	9	8.6
Depression		
Normal	52	49.5
Mild	19	18.1
Moderate	23	21.9
Severe	9	8.6
Extremely severe	2	1.9
Anxiety		
Normal	26	24.8
Mild	12	11.4
Moderate	20	19.0
Severe	23	21.9
Extremely severe	24	22.9
CMD		
Yes	79	75.2
No	26	24.8

SD: standard deviation, CMD: Common Mental Disorder

Table 3 presents the bivariate associations between sociodemographic characteristics, nutritional status, dietary intake, lifestyle factors, and CMD status among university students. The prevalence of CMD was higher among students with low physical activity levels (91.7%) compared to those with moderate (67.8%) and high physical activity levels (60.0%), with a statistically significant association observed (p=0.016). Students with poor sleep quality also showed a significantly higher prevalence of CMD (78.1%) compared to those with good sleep quality (44.4%) (p=0.040).

Mean hemoglobin levels were significantly lower among students with CMD compared to non-CMD students (13.55 ± 1.5 vs. 14.1 ± 1.2 g/dL; p=0.049). Iron intake tended to be lower among students with CMD, although the association did not reach statistical significance (p=0.064). No significant associations were found for enrollment year, allowance, sex, BMI, anemia status, energy intake, or protein intake (p>0.05).

Table 3. Bivariate Analysis of Nutritional Status, Dietary Intake, Lifestyle Factors, and CMDs

Variables	CMD	Non-CMD	p-value
Academic Year			
2022	26 (76.5%)	8 (23.5%)	0.101
2023	23 (63.9%)	13 (36.1%)	
2024	30 (85.7%)	5 (14.3%)	
Monthly Allowance			
Low	40 (76.9%)	12 (23.1%)	0.865
High	39 (73.6%)	14 (26.4%)	
Sex			
Male	14 (66.7%)	7 (33.3%)	0.462
Female	65 (77.4%)	19 (22.6%)	
Age	19.8 ± 1.3	20.3 ± 1.1	0.085
Physical Activity			
Low	33 (91.7%)	3 (8.3%)	0.016
Moderate	40 (67.8%)	19 (32.2%)	
High	6 (60.0%)	4 (40.0%)	
Hemoglobin	13.55 ± 1.5	14.1 ± 1.2	0.049
Anemia Status			
Anemia	10 (83.3%)	2 (16.7%)	0.726
Normal	69 (74.2%)	24 (25.8%)	
Sleep Quality			
Poor	75 (78.1%)	21 (21.9%)	0.040
Good	4 (44.4%)	5 (55.6%)	
Energy Intake	1689.1 ± 504.7	1810.4 ± 658.3	0.323
Low	50 (75.8%)	16 (24.2%)	
Adequate	29 (74.4%)	10 (25.6%)	
Protein Intake	49.1 (21.4–907.0)	61.2 (2.0–182.6)	0.521
Low	40 (75.5%)	13 (24.5%)	
Adequate	39 (72.2%)	15 (27.8%)	
Iron Intake	6.0 (1.8–14.6)	7.1 (2.9–14.4)	0.064
Low	73 (78.5%)	20 (21.5%)	
Adequate	6 (50.0%)	6 (50.0%)	
BMI			
Underweight	13 (68.4%)	6 (31.6%)	0.677
Normal	46 (75.4%)	15 (24.6%)	
Overweight	20 (80.0%)	5 (20.0%)	

Table 4 presents the multivariable logistic regression analysis examining factors associated with CMDs. Variables were entered simultaneously into the model using the Enter method based on theoretical relevance and potential confounding effects. The final model demonstrated a good fit according to the Hosmer–Lemeshow goodness-of-fit test (p > 0.05). Multicollinearity diagnostics confirmed the stability of the model, with Variance Inflation Factor (VIF) values for all independent variables being well below <10, indicating no significant multicollinearity issues. The model yielded a Nagelkerke R^2 of 0.286, suggesting that the included physiological and lifestyle factors collectively explain 28.6% of the variance in CMD status among students.

After controlling for age, sex, BMI, and monthly allowance, physical activity remained significantly associated with CMD. Compared with students reporting low physical activity, those with moderate physical activity (aOR 0.169; 95% CI 0.041–0.696; p=0.014) and high physical activity (aOR 0.084; 95% CI 0.013–0.564; p=0.011) had significantly lower odds of CMD. Good sleep quality was also independently associated with lower odds of CMD compared with poor sleep quality (aOR 0.149; 95% CI 0.029–0.762; p=0.022). In addition, hemoglobin level showed a protective trend, in which each 1 g/dL increase in Hb was associated with lower odds of CMD (aOR 0.637; 95% CI 0.406–1.000; p=0.050).

Table 4. Multiple logistic regression for CMD

Variables in the equation		**B**	**p-value**	**aOR**	**95% CI Lower-Upper**
Hemoglobin (g/dL)	per 1 g/dL	-0.450	0.050	0.637	0.406–1.000
Physical Activity	Low (ref)	-	-	-	-
	Moderate	-1.777	0.014*	0.169	0.041–0.696
	High	-2.472	0.011*	0.084	0.013–0.564
Sleep quality	Poor (ref)	-	-	-	-
	Good	-1.907	0.022*	0.149	0.029–0.762
Age	per 1 year	-0.320	0.182	0.726	0.454–1.162
Sex	Male (ref)	-	-	-	-
	Female	-0.614	0.417	0.541	0.123–2.382
BMI	Underweight	-1.006	0.221	0.366	0.073–1.830
	Normal	-0.762	0.256	0.467	0.125–1.739
	Overweight (ref)	-	-	-	-
Monthly Allowance	Low	0.217	0.685	1.242	0.435–3.547
	High (ref)	-	-	-	-

*Note: aOR: adjusted odds ratio, CI: confidence interval, *p < 0.05, ref = reference category*
**Hosmer–Lemeshow p>0.05; Nagelkerke R^2=0.286; all VIF<10 indicating no multicollinearity*

DISCUSSION

Our findings align with a robust literature linking healthy behaviors to better mental health in students. The university period represents emerging adulthood a critical window where long term lifestyle behaviors are formed and the risk for mental disorder onset peaks. Interventions at this stage hold significant potential to impact lifelong health trajectories. Given the strikingly high prevalence of CMD (75.2%) and poor sleep quality (91.4%) found in our study, this research underscores the urgency of developing targeted mental health prevention strategies for campus environments in developing countries, which often operate with limited mental health resources. Physical activity showed the most stable association with lower CMD risk after covariate adjustment, consistent with evidence that regular, sufficiently intense activity reduces anxiety, depressive symptoms, and academic stress [23,24]. Conversely, physical inactivity is a strong predictor of mood disorders, including depression and anxiety [25].

Our results indicate that one-third of respondents were in the low physical activity category, which corresponded to a smaller reduction in CMD odds compared with the moderate–high activity group. Contextually, many students live close to campus, so daily mobility tends to involve short walking distances or sedentary behavior in academic areas or at home. Meanwhile, the study area is an urban setting with public sports facilities and on-campus amenities that could be utilized. However, there is a mismatch between availability and actual use of these facilities. This suggests the need for physical-activity promotion approaches, such as integrating exercise into student programming. Furthermore, extensive exposure to technology may lead to addictive use of gadgets and gaming, which promotes sedentary behavior and can contribute to symptoms of depression and anxiety. Numerous studies underscore the vital role of physical activity in safeguarding mental health. Evidence shows that physical activity significantly reduces "digital anxiety" and effectively alleviates depressive symptoms when it replaces sedentary behavior [23,26,27].

These efforts are likely to yield physiological and biological benefits, physical activity can enhance emotion regulation through improved neurotransmission and neural function, and by reducing systemic inflammation via increased endorphin production-mechanisms linked to better mood and greater well-being [23]. In addition, several studies report that individuals who are physically active tend to have greater psychological resilience to academic stress and social pressure [25]. Thus, physical activity can be regarded as an effective preventive strategy for preserving mental health in young people [25,28].

Sleep quality is a key variable in determining mental well-being among adolescents and university students. Our findings show that good sleep quality had a strong protective association reducing the odds of CMD by approximately 85% compared with poor sleep quality. In the bivariate analysis, students with poor sleep quality also demonstrated a significantly higher prevalence of CMD than those with good sleep quality. Previous studies have shown that poor sleep not only lowers academic performance but also disrupts emotional regulation and increases the risk of stress and depression among students [29]. Moreover, lifestyle factors such as excessive gadget use reduce sleep quality and contribute to symptoms of neuroticism and depression [30]. Sleep quality is therefore an essential component for maintaining optimal brain function, emotional regulation, and academic performance among university students.

While poor sleep quality was highly prevalent among students in this study (91.4%), the significant difference in CMD prevalence between students with poor and good sleep quality suggests that sleep disturbance may function as a physiological and psychological stressor rather than a sole determinant of mental disorders. This phenomenon may partly reflect bedtime procrastination behavior, in which students delay sleep as a maladaptive self-reward strategy to regain a sense of autonomy after prolonged academic demands and screen exposure [31]. However, the finding that 21.9% of students with poor sleep quality did not experience CMD highlights the potential protective role of psychological resilience and adaptive coping mechanisms. Previous studies have demonstrated that resilience acts as a stress-buffering factor that weakens the association between sleep disturbances and psychological distress [32]. Individuals with higher resilience may maintain emotional stability and better regulate stress despite chronic sleep disruption, thereby reducing vulnerability to CMD. However, these findings should be interpreted cautiously because the proportion of students with good sleep quality was relatively small, which may have resulted in less stable aOR estimates, wider confidence intervals, and possible overestimation of the observed protective effect size

Students with disturbed sleep patterns are more likely to experience depressive symptoms, anxiety, emotional dysregulation, and impaired cognitive performance, particularly under conditions of academic stress [33,34]. Poor sleep quality may impair restorative neurological processes in the prefrontal cortex, a brain region involved in emotional regulation, decision-making, and stress control, thereby increasing vulnerability to psychological distress [29]. In university settings, irregular sleep schedules and inadequate sleep management, often exacerbated by fluctuating academic demands, may further reduce daytime concentration and coping capacity [12]. Evidence from systematic reviews also indicates that persistent sleep disturbances are associated with greater psychological morbidity and increased reliance on psychotropic medications among students with depression [35]. These findings indicate that sleep quality is a critical determinant for optimizing brain neurological function and maturation and for preventing mental health problems [33,36].

Sleep quality may also interact with other protective factors identified in this study. Students with higher physical activity levels generally tend to have better sleep regulation and lower psychological stress, whereas poor sleep may reduce motivation for physical activity and increase sedentary behavior [37,38]. In addition, low hemoglobin levels and fatigue-related symptoms may contribute to poorer sleep quality through reduced physical recovery and impaired physiological functioning [39]. These interactions suggest that sleep quality, physical activity, and hemoglobin status may collectively influence CMD risk through interconnected behavioral and biological pathways.

The relationship between hemoglobin levels and mental health among university students is receiving increasing attention. In our study, higher hemoglobin (Hb) tended to be protective against CMD. Although the multivariate result was of borderline significance ($p=0.05$), clinically, each 1 g/dL increase in Hb was associated with a 36.3% reduction in the odds of CMD. Biologically, low Hb may contribute to CMD through impaired cerebral oxygen delivery and altered neurotransmitter metabolism. Hemoglobin plays a critical role in oxygen transport, and reduced Hb concentrations may lead to chronic cerebral hypoxia, particularly in metabolically active brain regions such as the prefrontal cortex and hippocampus, which are involved in emotional regulation, executive functioning, and stress processing [13]. Inadequate oxygenation may impair mitochondrial energy production, neuronal signaling, and synaptic plasticity, thereby increasing vulnerability to depressive and anxiety-related symptoms.

In addition, iron deficiency associated with low Hb can disrupt the synthesis and regulation of monoamine neurotransmitters, including serotonin and dopamine due to impaired activity of iron-dependent enzymes involved in neurotransmitter biosynthesis which play central roles in mood stability [14,26]. Iron is also essential for myelination, redox regulation, and normal neuronal metabolism; therefore, impaired iron homeostasis may contribute to neurocognitive dysfunction and emotional dysregulation. Severe disturbances in iron metabolism have also been linked to neurodevelopmental disorders, neurodegenerative diseases, stroke, and cancer [14]. Previous studies consistently demonstrate that anemia and low Hb levels are associated with increased risks of depression and anxiety [40,41]. These findings support the hypothesis that adequate Hb and iron status are important neurobiological protective factors against CMD among university students.

Hemoglobin levels may also reflect broader nutritional and inflammatory conditions relevant to mental health. Hb concentrations are influenced by dietary iron intake, protein adequacy, micronutrient status, and systemic inflammation, all of which may indirectly affect psychological well-being [42]. Previous studies suggest that poor dietary quality and nutritional imbalance, including inadequate intake of protein, iron, and other micronutrients, may contribute to depressive symptoms through inflammatory pathways, altered stress responses, and neurotransmitter dysregulation [43]. Therefore, the association between Hb and CMD observed in this study may partly reflect the complex interaction between nutritional status, inflammation, and mental health among university students.

Studies in student populations confirm that iron-deficiency anemia (IDA) adversely affects cognitive function, attention, mood, and academic performance among adolescents and young adults [13,44,45]. Neurotransmitter disturbances and impaired neuronal functioning related to IDA may also contribute to irritability, reduced stress tolerance, and interpersonal emotional conflicts among adolescents [45]. Female adolescents appear to be particularly vulnerable, with several studies reporting higher anxiety levels among females with IDA compared to males [46,47]. Importantly, iron supplementation interventions have been shown to improve mood symptoms and cognitive functioning, suggesting that optimization of Hb and iron status may contribute to better mental health outcomes in young populations [48].

While physical activity and sleep quality demonstrated a clear protective association, the protective effect of higher Hb levels was borderline significant. This may indicate that, in a non-clinical student population, the behavioral predictors such as physical activity and sleep quality exert a stronger, more immediate influence on CMD risk than a subclinical variation in hematological status. Biologically, regular physical activity is known to enhance neuroplasticity, increase hippocampal volume, and stimulate brain-derived neurotrophic factor (BDNF) activity, which may counteract the neurobiological effects of chronic stress and emotional dysregulation associated with CMD. It is crucial, however, not to dismiss this borderline finding, as poor iron status is fundamentally tied to neurotransmitter synthesis. Future longitudinal studies should explore whether clinically categorized anemia (as opposed to a continuous Hb score) has a stronger, delayed predictive relationship with CMD onset.

In Indonesia, anemia prevention program involves iron–folic acid supplementation (IFA), primarily targeting junior and senior high school students. However, coverage remains limited, indicating a need to expand IFA distribution to other young age groups. Accordingly, hemoglobin can be viewed as an important biomarker linked to mental health and a potential target in strategies to prevent and manage psychiatric problems. In the final model, demographic variables (age, sex), economic status (allowance), and nutritional status (BMI) were not significant predictors of CMD. This is likely because their effects are indirect and mediated by behavioral factors such as sleep and physical activity. In addition, within a relatively homogeneous student population, the effects of these variables may be too small to reach statistical significance particularly when between category variation (in BMI) is limited.

This study has several strengths, including standardized assessments of hemoglobin, physical activity, sleep quality, and CMD symptoms. Nonetheless, it has limitations. First, the cross-sectional design precludes causal inference regarding the relationships among variables. Second, the use of self-report questionnaires to assess physical activity and sleep quality may introduce recall bias. Third, because the sample was drawn from a single university, external validity may be limited and generalization to the broader student population should be made cautiously. Fourth, Although dietary intake was assessed descriptively, it was not entered into the multivariable model, which may leave residual confounding if diet independently relates to CMD. Finally, we did not include other relevant psychosocial factors such as social support or academic stressors that may also influence student mental health.

CONCLUSION

This study concludes that moderate-to-high physical activity, good sleep quality, and higher hemoglobin levels are significant independent protective factors against Common Mental Disorders (CMD) among university students). These findings highlight the importance of integrated lifestyle- and health-based mental health prevention strategies in university settings. Institutions are encouraged to implement practical health promotion programs, such as regular anemia screening and iron supplementation (IFA) services for students, as well as structured physical activity initiatives including campus-based “10,000-Step Walk” programs to reduce sedentary behavior and support students’ mental well-being.

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Conflict of Interest

The authors declare that they have no competing interests.

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