

Stress, Cortisol, and Lipid Profiles Among Rwandan Undergraduate Students: A Cross-Sectional Study

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Background: Stress negatively affects mental and physical health globally, with university students in sub-Saharan Africa facing unique challenges that exacerbate psychological distress and academic difficulties. Chronic stress contributes to cardiovascular diseases, yet its physiological effects—such as dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and altered lipid metabolism—remain understudied in this population. There is also a lack of research on the relationship between stress and its physiological impacts among university students in Rwanda. This study aimed to investigate the relationship between serum cortisol levels, lipid profiles, and stress among undergraduate students at the University of Rwanda's Huye Campus.

Methods: A cross-sectional study recruited 247 undergraduate students using stratified sampling. Participants completed a researcher-administered Perceived Stress Scale questionnaire and provided sociodemographic data. Fasting blood samples were collected for cortisol and lipid profile analysis, and data was analyzed using Stata version 15.

Results: The study included 247 students aged 19–25, with 56.7% males. Stress levels were categorized as low (44.9%), moderate (53.9%), and high (1.2%). Morning cortisol levels (median 13.7µg/dL, IQR 10.8–17.2) did not significantly differ by gender ($p > 0.050$). However, moderate stress was linked to higher morning cortisol ($p < 0.001$), total cholesterol (TC), and triglycerides ($p = 0.004$), with TC also varying significantly across stress levels ($p = 0.012$).

Conclusion: This study found significant associations between stress categories, serum cortisol levels, and lipid profiles, particularly total cholesterol and triglycerides, emphasizing the need for stress management strategies to mitigate long-term health risks.

Keywords: stress, cortisol, hypothalamus-pituitary gland axis, lipid profile, cardiovascular diseases, university students

Introduction

Chronic stress is a pervasive and harmful risk factor for psychophysiological morbidity, significantly impacting both mental and physical well-being across diverse populations.¹ The academic environment faced by university students can trigger considerable psychosocial stress, leading to negative effects on their emotional and psychological well-being, academic performance, and overall educational outcomes.^{2,3} The World Health Organization (WHO) acknowledges stress as a major determinant of global morbidity, with estimates suggesting that approximately 450 million people worldwide suffer from stress-related mental health disorders, substantially contributing to the global disease burden measured by disability-adjusted life years and other health indices.⁴ When exposed to stressors, the hypothalamic-pituitary-adrenal (HPA) axis is activated, prompting a neuroendocrine response that includes the release of cortical glucocorticoids, primarily cortisol, and catecholamines, such as adrenaline and noradrenaline, from the adrenal medulla. This triggers a sympatho-adrenal response commonly known as the “fight or flight” response.⁵ While this response is adaptive in the short term, chronic stress can lead to maladaptive changes, such as hypercortisolism, insulin resistance, and dyslipidemia.⁶

Research has consistently shown that stress leads to increased cortisol levels, which negatively affect lipid metabolism. Chronic elevation of cortisol disrupts the body's natural balance, resulting in an atherogenic lipid profile marked by hypertriglyceridemia, hyperbeta-lipoproteinemia, and lower serum high-density lipoprotein cholesterol (HDL-C) levels.⁷ Consequently, people experiencing chronic stress are at a higher risk of developing cardiovascular diseases (CVD) and other metabolic disorders.⁸ A study among Nigerian university students reported that examination stress is linked to notable increases in serum cortisol, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and a decrease in HDL-C.⁹ Similarly, research conducted on Indian university students found that chronic stress is associated with higher serum cortisol levels, higher blood pressure, and dyslipidemia.¹⁰ Furthermore, among Iraqi students, a significant rise in serum cortisol levels and non-HDL-C was observed during the pre-examination phase, likely due to the stress caused by impending exams.¹¹ Additionally, a study conducted on Chinese adolescents found that stress is related to increased cortisol levels, anxiety, and depression.¹²

University students in Sub-Saharan Africa (SSA), including Rwanda, are exposed to a distinct array of stressors that can significantly impact their mental and physical health. The region's socioeconomic, cultural, and environmental factors intersect to create a complex landscape of challenges. Limited access to resources, inadequate infrastructure, and high academic expectations converge to heighten stress levels. Additionally, students may face societal pressures, historical trauma, and economic uncertainty, further exacerbating stress.¹³ These cumulative stressors can have long-term consequences, including anxiety, depression, and cardiometabolic disorders, underscoring the need for context-specific interventions to support the well-being of SSA university students.^{13,14} A study among South African university students found that stress was associated with higher symptoms of anxiety and depression, as well as lower academic performance.¹⁵ Similarly, research on Kenyan university students showed that stress was linked to increased substance abuse and mental health issues.¹⁶

The increasing recognition of stress as a major public health concern underscores the importance of targeted research, particularly in diverse settings. Rwanda, among other regions, remains understudied, with a notable gap in research examining the complex relationships between stress, cortisol levels, lipid profiles, and CVD risk among university students. The intricate interplay between stress, anxiety, and physiological responses is well-documented, with stress impacting multiple bodily systems, including immune function, autonomic nervous system activity, and hormone regulation.¹⁷ Chronic stress can have debilitating effects, including impaired cognitive function, weakened immunity, and increased risk of cardiovascular disease. Furthermore, individual factors, such as character traits, may influence stress responses, although more research is needed to clarify these dynamics.¹⁸ To develop effective stress management interventions and mitigate the risk of stress-related diseases, further investigation is warranted to elucidate the complex mechanisms underlying stress and its physiological consequences. This study therefore aimed to address this knowledge gap by investigating the relationship between stress, cortisol levels, and lipid profiles among undergraduate students at the University of Rwanda's (UR) Huye Campus. By exploring the impact of stress on physiological outcomes, this study seeks to contribute to the development of effective interventions to promote student mental health and well-being.

Materials and Methods

Study Design and Setting

This cross-sectional study was conducted in the 2023 academic year, first semester, from October 2023 to January 2024, at the University of Rwanda's (UR) Huye Campus located in Ngoma Sector, Huye District, Southern Province in Rwanda. This is a public university with students of approximately 10,000 including first-years from various colleges like the College of Arts and Social Sciences (CASS), College of Agriculture and Veterinary Medicine (CAVM), College of Business and Economics (CBE), and College of Medicine and Health Sciences (CMHS).

Study Population and Eligibility Criteria

The study population included undergraduate students enrolled at UR-Huye Campus. To have sufficient coverage in academic disciplines and levels of studies, the stratified selection was employed, which gave an overall picture of the academic program. The participants who were aged over 18 years, residing in university dormitories, and provided written informed consent were included. The exclusion included self-reported unstable psychiatric disorders, diabetes mellitus, thyroid disorder, liver disorder, renal disorder, infectious diseases, or other endocrine disorders. Students experiencing their menstrual cycle or receiving estrogen-based contraceptives also were excluded due to their potential associated hormonal effect on cortisol levels. College affiliations were stratified, with participating students then drawn independently from cluster groups to minimize selection bias. The sample size was calculated using Cochran's formula,¹⁹ based on an estimated prevalence of 54% for perceived stress among Rwandan medical students.²⁰ This calculation yielded a sample size of 247 students, ensuring adequate statistical power to detect significant relationships.

Data Collection

Participant Recruitment

Potential participants were approached and the aims of the research, method, and possible risks were described to facilitate the consenting procedures. Written informed consent was obtained from all participants before the commencement of the research protocol, following ethical guidelines. The structured questionnaire served as a tool to screen the eligibility of participating students. It helped also in collecting stress-related data, dietary habits, physical activity, sleep patterns, cigarette smoking status, and anthropometric measurements such as height and weight, based on research objectives. The use of researcher-administered measurement of stress through the Perceived Stress Scale (PSS) generated scores which were subsequently stratified to facilitate analysis.^{21–23}

Perceived Stress Scale

This is a 10-item instrument measuring how the respondents felt or thought over the past month, with an overall estimate of their levels of perceived stress. Students rate how often in their past month specific feelings and thoughts occurred using a 4-point Likert response. The PSS yields an overall range of 0 to 40 which is categorized into three levels of stress: (1) Low, for scores from 0 to 13; (2) Moderate, for scores from 14 to 26; and (3) High, for scores from 27 to 40. These correspond to experiencing low, moderate, and high levels of perceived stress, respectively.²²

Laboratory Procedures

Following the completion of the questionnaire and consenting procedures, physical assessments were conducted. Height was measured in meters (m) using a stadiometer (Seca, Hamburg, Germany) with students standing upright and barefoot. Weight was measured in kilograms (kg) using a weight scale (Seca, Hamburg, Germany) with students wearing minimal clothing. These measurements were used to calculate the body mass index (BMI), which is determined by dividing the body mass (kg) by the square of the body height (m²). Additionally, the systolic and diastolic blood pressure (BP) were measured using an automated office BP monitor (UM-212BLE, A&D Medical, Abingdon, UK) before blood sample collection.

A 4-milliliter fasting blood sample was collected from each participant via venipuncture between 0800 and 0900 hours to minimize diurnal variations in cortisol and non-fasting effects on lipid profiles. Blood samples were collected into plain red-top tubes and centrifuged at 3000 rpm for 5 minutes to harvest serum. The serum samples were stored at -20°C and thawed only once before performing laboratory assays to ensure accuracy and reliability. Serum lipid profiles, comprising TC (# BXC0261A), triglycerides (TG) (# BXC0271A), and HDL-C (# BXC0421D), were measured using standard colorimetric methods on a semi-automated HumaLyzer-4000 chemistry analyzer (Human Diagnostics, Wiesbaden, Germany). All reagents were bought from Fortress Diagnostics (Fortress Diagnostics, Antrim, Northern Ireland), and were used according to the manufacturer's protocols. These standard lipid panel assays employed chemical/enzymatic principles, culminating in a Trinder reaction. The assays are universally accepted for guiding atherosclerotic CVD risk management.²⁴

Generally, these enzymatic reactions generate hydrogen peroxide, which reacts with 4-aminoantipyrine and phenol to form a colored quinoneimine. The final color intensity is proportional to the analyte concentration. Briefly, TG is hydrolyzed by lipase, resulting in glycerol phosphorylation and hydrogen peroxide generation whilst TC is determined by hydrolyzing cholesterol esters, oxidizing free cholesterol, and measuring hydrogen peroxide using the Trinder method.²⁴ HDL-C was measured using a homogeneous colorimetric assay, directly quantifying it in serum, and eliminating centrifugation or precipitation steps.²⁵ LDL-C concentration was calculated using the Friedewald equation.²⁶ Lipid profile results were interpreted based on the following reference ranges: desirable TC \leq 5.2 mmol/L, normal TG \leq 1.70 mmol/L, optimal LDL-C \leq 2.59 mmol/L, hypoalphalipoproteinemia (low HDL-C): $<$ 1.03 mmol/L for males, $<$ 1.29 mmol/L for females.²⁷ Serum cortisol levels were measured using a competitive enzyme-linked immunosorbent assay (ELISA) (# BXE0831A, Fortress Diagnostics). Good clinical laboratory practice principles were adhered to and normal morning serum cortisol was defined as 5–23 μ g/dL, and hypercortisolism as $>$ 23 μ g/dL, based on kit reference ranges.²⁸

Statistical Analysis

Descriptive statistics were used to summarize the data. Categorical variables were presented as counts and proportions, while numerical variables were summarized using mean \pm standard deviation (SD) or median (interquartile range), depending on the distribution pattern of the data. Data analysis was performed using Stata version 15 (Stata Corp, College Station, Texas, USA). For numerical data, Student's t-tests, Wilcoxon rank-sum tests, or Kruskal–Wallis tests were employed to compare different data strata. The post hoc Dunn test was used for the intergroup comparisons after the Kruskal–Wallis test. Categorical data were compared using z-tests for proportions and the Chi-square test as appropriate. A significance level of 0.05 was used for all statistical comparisons.

Results

Table 1 presents the sociodemographic characteristics of the 247 students recruited from four colleges at UR's Huye Campus: CASS (25.9%, n = 64), CAVM (18.2%, n = 45), CBE (31.2%, n = 77), and CMHS (24.7%, n = 61). The participant pool, aged 19 to 25 years, included 56.7% males (n = 140) and 43.3% females (n = 107). Males participated in physical exercise significantly more frequently than females (p < 0.001), while other sociodemographic characteristics were comparable across genders. The health-related characteristics included an overall median BMI of 22.3, with males exhibiting a slightly higher median BMI (22.4) than females (22.1). Only 1.2% (n = 3) of students were current cigarette

Table 1 Sociodemographic Characteristics of the Study Participants

Variable ^a	Overall (n=247)	Female (n = 107)	Male (n=140)	p-value
Age (mean \pm SD)	21.6 \pm 1.4	21.7 \pm 1.4	21.5 \pm 1.3	0.377
BMI median (IQR)	22.3(21.6–22.8)	22.1(21.2–22.8)	22.4(21.8–22.9)	0.0578
Exercise frequency (times per week)				
1–2	54(21.9)	44(41.1)	10(7.1)	<0.001
3–4	98(39.7)	12(11.2)	86(61.4)	
>5	43(17.4)	1(0.9)	42(30.0)	
Never	52(21.1)	50(46.7)	2(1.4)	
Alcohol drinking status				
Non-drinkers	206(83.4)	89(83.2)	117(83.6)	0.934
Drinkers	41(16.6)	18(16.8)	23(16.4)	

(Continued)

Table 1 (Continued).

Variable ^a	Overall (n=247)	Female (n = 107)	Male (n=140)	p-value
Cigarette smoking status				
Non-smokers	244(98.8)	106(99.1)	138(98.6)	0.725
Smokers	3(1.2)	1(0.9)	2(1.4)	
Year of Study				
Year 1	137(55.5)	60(56.1)	77(55.0)	0.643
Year 2	42(17.0)	14(13.1)	28(20.0)	
Year 3	42(17.0)	20(18.7)	22(15.7)	
Year 4	22(8.9)	11(10.3)	11(7.9)	
Year 5	4(1.6)	2(1.9)	2(1.4)	
College allocation				
CASS	64(25.9)	30(28.0)	34(24.3)	0.723
CAVM	45(18.2)	21(19.6)	24(17.1)	
CBE	77(31.2)	33(30.8)	44(31.4)	
CMHS	61(24.7)	23(21.5)	38(27.1)	
Sleeping duration (hours per day)				
≤5	8(3.2)	4(3.7)	4(2.9)	0.870
>5 to ≤6	115(46.6)	49(45.8)	66(47.1)	
>6 to ≤7	47(19.0)	18(16.8)	29(20.7)	
>7 to ≤8	74(30.0)	35(32.7)	39(27.9)	
>8	3(1.2)	1(0.9)	2(1.4)	

Notes: ^aAll n (%) unless otherwise stated. p<0.05 is bolded to indicate statistical significance.

smokers. Sleep duration varied, with 46.6% (n = 115) sleeping 5–6 hours per day. Nevertheless, only 16.6% (n = 41) were alcohol consumers. These characteristics provide valuable context for interpreting the study findings and their implications.

The clinical and laboratory findings are presented in [Table 2](#). Overall, this study revealed varying stress levels among undergraduate students, with a mean PSS score of 14.3 ± 4.8. There was no significant difference in PSS scores between

Table 2 Clinical and Laboratory Parameters of Undergraduate Students

Variable ^a	Overall (n = 247)	Female (n = 107)	Male (n = 140)	p-value
Systolic BP (mmHg)	114.7±5.6	115.1±5.7	114.5±5.5	0.389
Diastolic BP (mmHg)	74(70–78)	75(70–78)	73(70–77)	0.331
PSS score	14.3±4.8	14.3±4.9	14.3±4.7	0.998
Morning serum Cortisol (µg/dL)	13.7(10.8–17.2)	13.6(10.9–17.4)	13.7(10.7–16.6)	0.576
TC (mmol/L)	3.00(2.59–3.33)	2.89(2.53–3.31)	3.04(2.62–3.34)	0.864

(Continued)

Table 2 (Continued).

Variable ^a	Overall (n = 247)	Female (n = 107)	Male (n = 140)	p-value
TG (mmol/L)	0.66(0.50–0.86)	0.66(0.50–0.87)	0.64(0.49–0.85)	0.604
HDL-C (mmol/L)	1.01(0.81–1.26)	0.95(0.78–1.24)	1.02(0.83–1.31)	0.100
LDL-C (mmol/L)	1.62(1.17–2.13)	1.54(1.17–2.07)	1.64(1.11–2.13)	0.582
TC category				
Normal	244(98.8)	104(97.2)	140(100.0)	0.046
High	3(1.2)	3(2.8)	0	
TG category				
Normal	246(99.6)	106(99.1)	140(100.0)	0.433
High	1(0.4)	1(0.9)	0	
HDL-C category				
Normal	84(34.0)	18(16.8)	66(47.1)	<0.001
Low	163(66.0)	89(83.2)	74(52.9)	
LDL-C Category				
Normal	216(87.5)	92(86.0)	124(88.6)	0.566
High	31(12.6)	15(14.0)	16(11.4)	
Morning serum Cortisol category				
Normal	240(97.2)	104(97.2)	136(97.1)	1.000
High	7(2.8)	3(2.8)	4(2.9)	
PSS category				
Low	111(44.9)	48(44.9)	63(45.0)	0.420
Moderate	133(53.9)	59(55.1)	74(52.9)	
High	3(1.2)	0	3(2.1)	

Note: ^aAll n (%) unless otherwise stated. p<0.05 is bolded to indicate statistical significance.

males and females ($p = 0.998$). Overall, 44.9% ($n = 111$) had low-stress levels, while 53.9% ($n = 133$) experienced moderate stress, and 1.2% (all males, $n = 3$) were highly stressed. Although only 2.8% ($n = 7$) had elevated cortisol levels, the median morning cortisol level was comparable among participants (13.7 $\mu\text{g/dL}$, IQR: 10.8–17.2), with no significant difference between genders ($p = 0.576$). The serum lipid profile parameters (TC, TG, HDL-C, and LDL-C) were also comparable (all $p > 0.050$) although, males had slightly higher median TC, HDL-C, and LDL-C levels. Hypercholesterolemia (High TC) was found in 1.2% of students (all females, $n = 3$), while 12.6% ($n = 31$) had hyperbetalipoproteinemia (High LDL-C). A significantly higher proportion of males (40.5%, $n = 66$) had hypoalphalipoproteinemia (Low HDL-C) compared to females ($p < 0.001$). A significant difference was also observed in the proportions of undergraduates with optimal and elevated serum TC levels ($p = 0.046$).

Students were also categorized by PSS scores into low, moderate, and high-stress groups, with findings detailed in Table 3. Although mean age did not significantly differ across stress categories ($p = 0.238$), those with high stress had the highest median BMI (22.6, IQR: 21.9–23.5), and those with low stress had the lowest (22.1, IQR: 21.4–22.8), though this was not statistically significant ($p = 0.121$). Notably, two-thirds of high-stress students were in their first or second year,

Table 3 Sociodemographic Characteristics Stratified by PSS Score

Variable ^a	Low PSS (n = 111)	Moderate PSS (n = 133)	High PSS (n = 3)	p-value
Age	21.7±1.3	21.5±1.4	20.7±1.2	0.238
BMI	22.1(21.4–22.8)	22.4(21.8–22.9)	22.6(21.9–23.5)	0.121
Exercise frequency (times per week)				
1–2	28(25.2)	25(18.8)	1(33.3)	0.659
3–4	39(35.1)	57(42.9)	2(66.7)	
>5	19(17.1)	24(18.1)	0	
Never	25(22.5)	27(20.3)	0	
Alcohol Drinking Status				
Non-Drinker	94(84.7)	110(82.7)	2(66.7)	0.675
Drinker	17(15.3)	23(17.3)	1(33.3)	
Cigarette Smoking Status				
Non-smokers	110(99.1)	131(98.5)	3(100.0)	0.896
Smokers	1(0.9)	2(1.5)	0	
Level of Study				
Year 1	59(53.2)	76(57.1)	2(66.7)	0.964
Year 2	18(16.2)	23(17.3)	1(33.3)	
Year 3	20(18.0)	22(16.5)	0	
Year 4	12(10.8)	10(7.5)	0	
Year 5	29(1.8)	2(1.5)	0	
College/Faculty				
CASS	30(27.0)	32(24.1)	2(66.7)	0.723
CAVM	21(18.9)	24(18.1)	0	
CBE	33(29.7)	43(32.3)	1(33.3)	
CMHS	27(24.3)	34(25.6)	0	
Sleeping duration (hours per day)				
≤5	3(2.7)	5(3.8)	0	0.987
>5 to ≤6	51(46.0)	62(46.6)	2(66.8)	
>6 to ≤7	22(19.8)	25(18.8)	0	
>7 to ≤8	33(29.7)	40(30.1)	1(33.3)	
>8	2(1.8)	19(0.8)	0	

Note: ^aAll n (%) unless otherwise stated.

while moderate stress levels were most common among first-year students (57.1%, n = 76) and least among fifth-year students (1.5%, n = 2), with no significant variation by year of study (p = 0.964). Lifestyle factors such as exercise frequency, alcohol consumption, cigarette smoking, and sleep duration showed no significant associations with the stress category (p-values ranging from 0.659 to 0.897).

Table 4 Association Between PSS Score Strata, Lipid Profile, and Serum Cortisol Levels

Variable	Low PSS (n = 111)	Moderate PSS (n = 133)	High PSS (n = 3)	p-value
Systolic BP (mmHg)	114.9±5.1	114.5±6.0	115±2.6	0.116
Diastolic BP (mmHg)	74(70–78)	74(70–78)	70(70–76)	0.747
Morning serum Cortisol (µg/dL)	12.2±4.3	15.3±5.2	11.7±4.8	<0.001
TC (mmol/L)	2.80(2.52–3.19)	3.12(2.65–3.43)	3.54(2.51–4.08)	0.012
TG (mmol/L)	0.59(0.44–0.81)	0.69(0.55–0.89)	0.52(0.42–0.65)	0.004
HDL-C (mmol/L)	1.03(0.80–1.31)	0.99(0.81–1.23)	0.89(0.83–1.40)	0.7283
LDL-C (mmol/L)	1.52(1.02–1.94)	1.64(1.26–2.31)	1.95(1.44–2.89)	0.0535

Note: p<0.05 is bolded to indicate statistical significance.

Table 4 illustrates the association between PSS score strata, lipid profile, and serum cortisol levels. Notably, significant differences in morning cortisol levels were observed across stress categories ($p < 0.001$). Students with moderate stress exhibited higher cortisol levels ($15.3 \pm 5.2 \mu\text{g/dL}$) compared to those with low ($12.2 \pm 4.3 \mu\text{g/dL}$) and high stress ($11.7 \pm 4.8 \mu\text{g/dL}$) but significant differences were only observed between the perceived low PSS category and the moderate PSS category ($p < 0.001$). All seven students with elevated morning cortisol were in the moderate stress category, while those with low and high stress maintained normal levels ($p = 0.046$). In addition, lipid profiles also varied significantly across stress categories with high-stressed students having higher TC levels (3.54 mmol/L, IQR: 2.51–4.08) compared to those with moderate (3.12 mmol/L, IQR: 2.65–3.43) and low stress (2.80 mmol/L, IQR: 2.52–3.19) ($p = 0.012$). However, statistically significant differences in serum TC levels were only observed between the low PSS category versus the moderate PSS category ($p = 0.038$). Furthermore, TG levels peaked in the moderate stress group (0.69 mmol/L, IQR: 0.55–0.89), followed by low (0.59 mmol/L, IQR: 0.44–0.81) and high stress (0.52 mmol/L, IQR: 0.42–0.65) categories ($p = 0.004$) with statistically significant differences observed between the low PSS category versus the moderate PSS category ($p = 0.015$). However, no significant differences were found in HDL-C levels ($p = 0.728$) or LDL-C levels ($p = 0.055$) across stress categories.

Discussion

This study elucidates the intricate relationships between stress, serum cortisol levels, and lipid profiles among undergraduate students at the UR's Huye campus. With a substantial sample size of 247 students, our findings offer valuable insights into the physiological and psychological impacts of stress on young adults. Notably, significant variations in morning cortisol levels and lipid profiles were observed across different stress categories, highlighting the complex interplay between stress, cortisol, and lipid metabolism.

The study reports that students with moderate PSS scores were predominantly from the College of Business and Economics, although the PSS score distribution did not significantly differ among colleges. Our study found no significant differences in PSS scores by gender which aligns with a study conducted at the medical faculty of the University of Hamburg but contradicts the case report of Jia YF who found higher stress prevalence in female undergraduate students.^{29–31} While students with low PSS scores tended to be older, this was not statistically significant. Research suggests that aging is linked to a reduced stress response, likely due to broader life experiences and better-coping mechanisms.³² Positive emotions contribute to stress recovery in resilient individuals, suggesting older adults might have higher resilience.³³ Conversely, younger adults often show stronger negative responses to daily stressors.³⁴ First-year students exhibited higher stress levels compared to seniors as reported in many studies.^{29,30} This was attributed to contributing factors including exam pressure, insufficient review time, and adapting to a new environment.^{2,30,35}

Morning serum cortisol levels showed no significant gender differences, with only 2.8% of students exhibiting elevated levels. The normocortisolism and PSS scores may be due to the study's timing, as students were returning from

semester breaks without academic pressures like exams.³⁶ The same findings were reported as shown by the low salivary cortisol in students without academic stress, indicating cortisol increases during stress and decreases in its absence.³⁷

Morning cortisol levels were significantly associated with PSS categories, peaking in the moderate PSS group. The observed association between morning cortisol levels and perceived stress categories is intriguing, particularly the peak in cortisol levels among the moderate stress group. However, the finding of lower cortisol levels in the high-stress group warrants caution due to the notably small sample size of this group (n=3) compared to the moderate and low-stress groups. This disparity in sample sizes may limit the reliability and generalizability of the results for the high-stress group, potentially masking the true relationship between cortisol levels and high stress.

However, our study findings still contribute to the limited body of research on stress and cortisol levels among university students in SSA. In contrast to our results, a South African study at the University of Free State found a positive association between high anxiety levels and cortisol concentrations, while no associations were observed with low to moderate anxiety or stress.³⁸ Conversely, our study's findings align with those of Maduka et al in Nigeria, which reported increased cortisol levels in students under examination stress.⁹ These disparate findings highlight the complexity of stress responses and the need for further research to elucidate the relationships between stress, anxiety, and cortisol levels in diverse African university settings. Despite the discordance, the elevated cortisol observed in moderately stressed students could be due to stress-induced adrenocorticotrophic hormone (ACTH) secretion, triggering cortisol synthesis. Under stress, hypothalamic paraventricular nuclei release corticotropin-releasing hormone (CRH), activating the HPA axis and stimulating pituitary and adrenal activity.⁵

This study faced limitations in exploring associations between lipid profile parameters and serum cortisol variations, as only seven students exhibited abnormal cortisol levels. However, prior research has indicated a significant association between serum cortisol and lipid profile parameters among undergraduate medical students.¹⁰ The observed increases in median TC and median TG with rising perceived stress levels have significant clinical implications. Elevated TC and TG are established risk factors for CVD, and chronic stress may contribute to this risk by disrupting lipid metabolism. The incremental increases in TC and across perceived stress categories suggest a potential dose-response relationship between stress and lipid dysregulation. This association is concerning, as even moderate elevations in lipid profiles can increase the risk of atherosclerosis and CVD over time. Furthermore, young adults, such as the university students in this study, may be particularly vulnerable to the long-term consequences of stress-induced lipid dysregulation. The clinical relevance of these findings highlights the importance of stress management and lipid monitoring in high-risk populations. By identifying individuals with high perceived stress levels and abnormal lipid profiles, healthcare providers can target interventions to mitigate CVD risk and promote cardiovascular health.

In addition, although not statistically significant, BMI was highest among students with high PSS scores and lowest among those with low PSS scores. This observation aligns with previous studies suggesting that greater vulnerability to stress increases exposure to stress-induced hypercortisolism, promoting central fat deposition.³⁹ Notably, morning cortisol levels, as well as elevated serum TG and TC, were significantly associated with PSS categories, peaking in the moderate and high PSS groups, respectively. However, the small proportion of students with abnormally high serum cortisol levels may have masked the expected association between lipid profiles and cortisol levels.

This study boasts several methodological strengths that enhance the reliability and validity of its findings. Notably, stratified sampling was used to ensure a representative sample of undergraduate students from various disciplines and study levels, potentially improving the generalizability of the results. Additionally, fasting blood sampling minimized diurnal variations. However, some limitations were encountered. Firstly, the cross-sectional design may have restricted causal inferences between stress, cortisol, and lipid profiles, hindering the establishment of temporal relationships. Secondly, selection bias may have occurred by limiting participation to students in university residences, potentially excluding a significant segment of the student population. Additionally, excluding students with health conditions and alcohol consumers may limit generalizability. Lastly, assessing cortisol and lipid profiles at a single time point may not capture fluctuations, providing an incomplete picture.

Conclusion

This study provides valuable insights into the complex relationships between stress, cortisol levels, and lipid profiles among Rwandan undergraduate students. The findings reveal significant associations between stress categories and morning cortisol levels, as well as lipid profiles, particularly total cholesterol and triglycerides, highlighting the physiological impact of stress. These results align with existing research demonstrating stress-induced metabolic alterations, while also addressing a critical gap in understanding these dynamics within Sub-Saharan African university students. While the study's cross-sectional design and limited sample size may constrain causal inferences, the results underscore the importance of considering stress management strategies to mitigate potential long-term health consequences. The study's findings have implications for university administrators, policymakers, and healthcare providers, emphasizing the implementation of comprehensive stress-management programs, including counseling services and coping strategy workshops, to support students in navigating academic and emotional challenges. Promoting regular physical activity and healthy nutrition through campus wellness initiatives could also mitigate the metabolic consequences of stress. Future research should focus on longitudinal designs to establish temporal relationships and explore the impact of stress management interventions on cortisol levels and lipid profiles in this population.

Abbreviations

ACTH, adrenocorticotropic hormone; BMI, body mass index; BP, blood pressure; CASS, college of arts and social sciences; CAVM, college of agriculture and veterinary medicine; CBE, college of business and economics; CMHS, college of medicine and health sciences; CRH, corticotropic releasing hormone; CVD, cardiovascular diseases; ELISA, enzyme-linked immunosorbent assay; HDL-C, high-density lipoprotein cholesterol; HPA, hypothalamic-pituitary-adrenal axis; IQR, interquartile range; LDL-C, low-density lipoprotein cholesterol; PSS, perceived stress scale; SSA, sub-saharan Africa; TC, total cholesterol; TG, triglycerides; UR, university of Rwanda; WHO, world health organization.

Data Sharing Statement

All data utilized in this study are included in this manuscript. However, the dataset will be made available by the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

In accordance with the Declaration of Helsinki, this study received ethical approval from the Institutional Review Board of the University of Rwanda (Approval Number: CMHS/IRB/376/2023). Additionally, written informed consent was obtained from all participants, and the completion and submission of the questionnaire by the students served as additional confirmation of their willingness to participate.

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Author Contributions

All authors significantly contributed to the reported work, including its conception, study design, execution, data acquisition, analysis, and interpretation. They participated in drafting, revising, or critically reviewing the article, gave final approval for the version to be published, agreed on the journal to which the article was submitted, and committed to being accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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