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Prevalence and Determinants of Metabolic Risk Factors Among University Students in Dodoma and Morogoro Regions Tanzania

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Abstract: University students often face a multitude of health risks due to the transitional phase they experience. The lifestyles they adopt increase their susceptibility to metabolic issues that are of a public health concern. Metabolic risk factors, encompassing obesity, hypertension, dyslipidemia, and elevated glucose levels pose significant health concerns among this demographic. The cluster of these metabolic risk factors is known as a metabolic syndrome which has the potential to increase the risk of cardiovascular diseases amongst young populations who are linked with the adaptation of health risk behaviours. The objective of this cross-sectional study was to assess the prevalence and determinants of metabolic risk factors of university students in two regions that were purposively selected from mainland Tanzania. The distribution of continuous variables was tested for normality using box plots and-Q plots and the Shapiro-Wilk test. Multivariate linear regression analysis was used to assess the determinants of metabolic risk factors among variables. The metabolic risk factors that were assessed include blood pressure, glucose levels, central obesity, and lipid profiles. The most prevalent metabolic risk factor was the high levels of low-density lipoprotein among university students. The study found Low-density lipoprotein levels that were above optimal, borderline high, high and very high. The low-density lipoprotein levels found in the study were 24 (20.3%), 16 (13.6%), 13 (11%) and 17 (14.4%) for above optimal, borderline high, high, and very high respectively. Significant associations were also found in the determinants of the metabolic risk factors, for central obesity (P=0.000) and for triglyceride levels (P=0.000); (P=0.004). Factors that increase the susceptibility to metabolic risk factors include the location of the university, scholarship status and Individual dietary diversity scores. Saint John's University in Dodoma was associated with low-density lipoprotein and Total cholesterol (β=17.01, SE=10.1, p=0.1) and (β=-0.170, SE=0.0519, p=0.01) respectively. Receiving scholarship and high dietary diversity score was associated with low-density lipoprotein (β=21.83, SE=10.4, p=0.1); (β=5.731, SE=3.14, p=0.1) respectively. University students are living with metabolic risk factors that could have future health implications. Understanding these aspects can help in devising targeted interventions and educational programs to mitigate metabolic risks and promote healthier lifestyles among university students.

Keywords: Metabolic Risk Factors, Metabolic Syndrome, University Students, Determinants, Prevalence, Tanzania

1. Introduction

Metabolic risk factors are conditions that increase the likelihood of developing metabolic syndrome a cluster of interconnected health issues that include abdominal obesity, high blood pressure, prediabetes, high blood glucose and dyslipidaemia [1]. Metabolic risk factors are accelerating rapidly and advancing across countries which results in a substantial morbidity and mortality burden, linked to non-communicable diseases (NCDs) [2].

Young adults are in a transitional period which is critical to the consolidation of health-related behaviours. Engagement of multiple NCD risk behaviours is evident among African youths at the university level [3] Chronic diseases are

becoming more common in Africa due to ongoing demographic changes in various regions [4]. The prevalence of NCDs is rising rapidly and is projected to cause more deaths than communicable, maternal, perinatal, and nutritional diseases combined by 2030 in Africa, which might be a major barrier to attaining Sustainable Development Goals [5]. Several hypotheses have been advanced to explain the explosion of non-communicable diseases, such as the increased and uncontrollable urbanization that is accompanied by lifestyle changes particularly in developing nations that face high and rapid urbanization [6]. The higher prevalence of NCDs among young populations poses a need for emergency interventions to rescue the future generation [7]. Studies have reported metabolic risk factors among young adults including university students [8-10]. It was reported prevalence of diabetes in young adults of Low middle income countries (LMIC) is as high as 11.6% while that of hypertension is up to 36.9%, and up to 36% of young adults have dyslipidaemia [11]. The issue of non-communicable diseases (NCDs) and related risk factors is growing in sub-Saharan Africa (SSA). Lack of appropriate epidemiological data, coexistence of infectious and non-infectious diseases, under-nutrition/over-nutrition, and poor economic status are among the factors that influence CVDs mortality in these countries [12]. In sub-Saharan countries the NCDs levels are expected to rise from 25% since 2004 to 46% in 2030 [13]. Sub-Saharan Africa is facing an epidemiological transition with chronic diseases being prevalent among young adults [2].

Therefore, there is an imperative need to address this so as to avoid future health implications. Early detection of metabolic risk factors in the university context may help reduce the onset of metabolic syndrome which have detrimental impact on overall health. It is important to determine the prevalence of metabolic risk factors among university students in order to take measures from a public health perspective and design strategies for early identification. Therefore, the current study was conducted to determine the prevalence and determinants of metabolic risk factors among university students in Morogoro and Dodoma regions, Tanzania.

2. Materials and Methods

2.1. Study Design and Sample Population

The investigation was a cross-sectional study conducted in university students from Saint John's University in Dodoma region and Mzumbe university in Morogoro region. Morogoro Municipality serves as Morogoro Region's nine districts, serves as the region's capital which represents 0.74% of the region's total land area [14]. The recently estimated population of Morogoro urban is approximate to 440109 with the growth rate of 3.85%. In the case of Morogoro Municipal, linear and nucleated settlements have been the dominant form of urban development, with a few cases of scattered settlements, and population growth go hand in hand with urban expansion and human development, which may take numerous forms [15]. Morogoro experiences bimodal rainfall seasons. Heavy rain seasons are locally called Masika dominating late March to early May and the light rain seasons are locally called Vuli normally between November to December [14].

Dodoma is the region found in the central part of Tanzania mainland. With 41.311 km^2, it has seven districts: Dodoma urban, Chamwino, Bahi, Kondoa, Kongwa, Mpwapwa, and Chemba. It is the 12th largest area in Tanzania. Movement of people to the region as it became the host of the capital city has resulted in increasing population growth, within the Dodoma region, including its metropolitan environment, having 3,085,625 people in 2022 [16]. Dodoma is one of the semi-arid regions with annual rainfall that ranges from 550 to 660 millimetres and a lengthy dry season. The region receives between 550 and 3690 mm of rainfall annually (World Bank) [17]. There is just one rainy season there, which is a crucial climate component for agricultural activity.

A convenience sampling was carried out on the prevalence of the study age group (19.2%) [18] 95%CI, degree of accuracy 5%. The final sample size was 262 university students. A sub-sample of 118 students were drawn from the total cohort. The sampling was drawn randomly but proportion to size of students from each university; 65 students from Mzumbe University and 53 students from Saint Johns' university participated in the study.

The exclusion criteria were: first year students, students in diet or weight management plans, part-time students, disabled students and pregnant individuals.

2.2. Data Collection

Data was collected in university premises under the supervision of responsible private investigator. The data collected include, Waist circumference, Blood pressure, Random blood glucose and lipid profiles. The team that carried out the collection was properly trained and included medical personnel for collecting blood samples and blood pressure.

2.3. Waist Circumference

The waist circumference (WC) was measured using a non-stretchable tape on the upper lateral border of the right ilium in the midaxillary line at the navel level without skin compression to the nearest 0.1 cm. The waist circumference was used to identify individuals with possible health risks based upon threshold values of ≥ 82 cm for women and ≥ 91 cm for men identified from adults in Sub Saharan Africa population [19].

2.4. Blood Pressure

Blood pressure was measured using a fully automatic electronic blood pressure monitor whereby the systolic and diastolic blood pressures were determined. The electronic sphygmomanometer was calibrated before it was used to measure the participants (The blood pressure machine was provided by Morogoro regional Hospital; Model: U-80AH ARI-intellisense). A registered nurse from Morogoro referral

hospital took these readings. Participants were required to be seated in a chair with a backrest and positioned with feet on the floor and legs uncrossed. The right arm was positioned comfortably at the heart level. Blood pressure was measured three times with the appropriate cuff size that covered two-thirds of the upper arm after the participant has rested for at least five minutes and no smoking or caffeine 30 minutes before measurement. Consecutive measurements were taken five-to-ten minutes after the first measurement and the last two BP measurements were calculated to determine the BP status of the participant. Means of the replicate measures were determined and used in the analysis. Participants blood pressure was regarded as low blood pressure <100 mmHg for systolic and 60mmHg for diastolic; normal blood pressure 100-139.9mmHg for systolic and 60-89.9 mmHg for diastolic; High blood pressure ≥140mmHg systolic and ≥90mmHg [20].

2.5. Blood Glucose

Random blood glucose test was measured using the Point of care (POC) digital glucose meter machine. The test was done at a random time of the day by a registered nurse from Morogoro referral hospital. The procedure involved pricking a participant's finger with a lancet and putting the blood on a testing strip. The strip was then inserted into the glucometer, where the results were shown on the screen after few seconds. Participants blood glucose levels were classified as normal (RBG < 7.8 mmol/L), pre-DM (RBG > 7.8– 11.0mmol/L and Hyperglycaemia (RBG ≥ 11.1 mmol/L) as per International Diabetes Federation and national guidelines [21].

2.6. Lipid Profiles

Lipid profile was be measured by determining serum levels of total cholesterol, triglyceride, low density lipoprotein and high-density lipoprotein. Blood sample collection was done by a registered nurse from the Morogoro referral hospital. A venous blood sample was drawn from the antecubital fossa (elbow pit) by using syringes with hypodermic needles for each participant. The blood drawn from the participants were carefully placed in red tubes (PHARMA LAB KIGALI-RWANDA, 4.25°C: 5ml) and arranged in a BD Vacutainer Eclipse™ with iceboxes. The samples were then transported to the Morogoro referral hospital and stored in a refrigerator at temperature of 2°-8°C. After 15 hours of storage, the samples were then transported in the BD Vacutainer Eclipse™ with iceboxes once again to Honest specialized polyclinic Bunju (B) laboratory for analysis of the lipid profiles. On arrival the samples were removed from the vacutainer and were first centrifuged by 800D centrifuge machine to separate the serum and blood at 3,000 RPM. Using a semi-Automated Biochemistry analyzer- CHEM 7 the samples were further analysed. Standard operating procedures instructed by the manufacturer manuals on the machine with its specific reagents for each parameter were used. The machine was washed by distilled water after every sample change and parameter change. For High density lipoprotein Normal ranges for adult's male is 35.3-79.5 mg/dl while normal for adult female is 42.0-88.0 mg/dl. Lipid cut off points of other parameters are depicted in Table 1.

Table 1. *Lipid profile cut-off points.*

Parameter	Low-density lipoprotein	Total Cholesterol	Triglycerides
Optimal	<100mg/dl	<200mg/dl	150-199mg/dl
Above Optimal	100-129mg/dl	<200mg/dl	150-199mg/dl
Borderline high	130-159mg/dl	200-239 mg/dl	150-199mg/dl
High	160-189mg/dl	≥240mg/dl	200-499mg/dl
Very High	≥190 mg/dl	≥240 mg/dl	>499mg/dl

Source Biochemistry analyzer-CHEM 7; ERBA Mannheim

2.7. Statistical Analysis

The data was entered, cleaned and analysed using IBM SPSS Statistics for Windows (Version 26.0. IBM Corp, 2011, Armonk, NY). Within the SPSS software, demographic characteristics of university students were succinctly summarized and presented as frequencies and percentages. The metabolic risk factors were then condensed into frequencies and percentages, depicting the number of students with a risk of the factors. In addition, Chi square (X^2) test at 5% level of significance was used to examine the relationship between dependent variables (metabolic risk factors) and other independent variables such as socio-demographic factors. These were done for the metabolic risk factors that were not normally distributed even after statistical transformation. The metabolic risk factors that were transformed and became normally distributed were further analysed. Multivariate analysis (multiple linear regression) for inferential statistics was performed to identify the determinants of metabolic risk factors in university students. This multivariable model helped to account for confounding variables and elucidated the associations between these factors (independent variables) and the metabolic risk factors in university students.

2.8. Ethical Considerations

The study was approved by the National Institute for Medical research with reference number NIMR/HQ/R.8a/Vol.IX/4363 and from the Sokoine University of Agriculture with reference number SUA/MHN/D/2019/0009. Permission to conduct the study was also sought from respective universities from the administration offices through dean of students. Students were informed about the study and consent forms were given for

signing. Confidentiality of the information was ensured where all participants were identified by numbers.

3. Results

3.1. Characteristics of University Students (n=118)

The socio-demographic characteristics of the University students are presented in Table 2. A total of 118 students was recruited to participate in the study, includes (55.1%, N=65) of Mzumbe university and (44.9%, N=53) from St. John's university. Findings revealed that, the overall proportion of male participant was slightly higher (55.9%) compared to (44.1%) of female participants. Majority (61%) of respondents have the age between 20 to 24 years when compared to students who were 25 years and above (39%). More than half (55.9%) of Second year students participated in the study when compared to students in advanced years (44.1%). Majority (83.1%) of the participants were Christians. A larger proportion (72%) of students in this study stayed off the university premises. More than half (56.8%) of the participants in this study did not receive scholarship.

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Table 2. *Socio-Demographic characteristics of participants (N=118).*

Variable	Overall (%)	Mzumbe University (%)	Saint John's University (%)	P-Value
Sex				
Male	66 (55.9)	30 (46.2)	36 (67.9)	0.018*
Female	52 (44.1)	35 (53.8)	17 (32.1)	
Age				
20-24 Years	72 (61)	42 (64.6)	30 (56.6)	0.375
≥25 Years	46 (39)	23 (35.4)	23 (43.4)	
Study Year				
Second Year	66 (55.9)	28 (43.1)	38 (71.7)	0.002*
Third year and above	52 (44.1)	37 (56.9)	15 (28.3)	
Marital Status				
Single	108(91.5)	59 (90.8)	49 (92.5)	0.774
Married	10 (8.5)	6 (9.2)	4 (7.5)	
Religion				
Christian	98 (83.1)	48 (73.8)	50 (94.3)	0.003*
Muslim	20 (16.9)	17 (26.2)	3 (5.7)	
Chronic disease				
Yes	5 (4.2)	3 (4.6)	2 (3.8)	0.821
No	113(95.8)	62 (95.4)	51 (96.2)	
Sleeping hours				
<8 hours	58 (49.2)	39 (60)	19 (35.8)	0.009
≥8 hours	60 (50.8)	26 (40)	34 (64.2)	
Residence				
Off-campus	85 (72)	36 (55.4)	49 (92.5)	0.000*
In-campus	33 (28)	29 (44.6)	4 (7.5)	
Smoking status				
Non-smoker	113(95.8)	61 (93.8)	52 (98.1)	0.252
Smoker	5 (4.2)	4(6.2)	1 (1.9)	
Nutritional Information				
Offline	38 (32.2)	21 (32.3)	17 (32.1)	0.979
Online	80 (67.8)	44 (67.7)	36 (67.9)	
Scholarship Status				
No	67 (56.8)	43 (66.2)	24 (45.3)	0.023*
Yes	51 (43.2)	22 (33.8)	29 (54.7)	
Type of scholarship				
Partial	13 (25.5)	8 (36.4)	5 (17.2)	0.121
Full	38 (74.5)	14 (63.6)	24 (82.8)	

*Significant at P<0.05

3.2. Prevalence of Metabolic Risk Factors Among University Students

The Metabolic risk factors reported in this section include high blood pressure (systolic and diastolic), central obesity and lipid profile.

3.2.1. High Blood Pressure of University Students

Blood pressure constitutes of systolic and diastolic pressures. The study found that 7(6%) of the university

students had high blood pressure systolic while 4 (3.4%) of university students had high blood pressure (diastolic). Students in Dodoma region showed a higher prevalence 5 (7.5%) of high blood pressure (systolic) when compared to students in Morogoro region 2 (3.1%) Table 3.

Table 3. *Prevalence of Blood pressure among university students.*

	Systolic Blood pressure				Diastolic Blood pressure			
Characteristics	**Normal range (%)**	**Low range (%)**	**High range (%)**	**P-Value**	**Normal range (%)**	**Low range (%)**	**High range (%)**	**P-Value**
Age								
20-24 Years	79 (90.8)	5 (5.7)	3 (3.5)		30 (87.4)	7 (8)	4 (4.6)	
≥ 25 Years	26 (86.7)	1 (3.3)	4 (10.1)	0.339	76 (96.8)	1 (3.2)	0 (0.00)	0.296
Sex								
Male	62 (94)	2 (3)	2 (3%)		47 (89.4)	5 (7.6)	2 (3)	
Female	43 (84.4)	4 (7.8)	5 (7.8)	0.235	59 (90.4)	3 (5.8)	2 (3.8)	0.905
University Location								
Morogoro	59 (90.6)	4 (6.3)	2 (3.1)		59 (90.8)	4 (6.2)	2 (3)	
Dodoma	46 (88.7)	2 (3.8)	5 (7.5)	0.481	47 (88.7)	4 (7.5)	2 (3.8)	0.933
Residence								
Off-campus	78 (60)	2 (8)	6 (32)		30 (89.4)	3 (5.9)	4 (4.7)	
In-campus	27 (55)	4 (41.2)	1 (3.8)	0.076	76 (90.9)	5 (9.1)	0 (0.00)	0.383
Total	105 (88.9)	6 (5.1)	7 (6)		106 (89.8)	8 (6.8)	4 (3.4)	

3.2.2. Lipid Profiles of University Students

Lipid profile discussed in this section include Total Cholesterol (TC), Triglycerides (TG) and Low-density lipoprotein (LDL). The study found that 7 (6%) and 1 (0.8%) of university students had high levels, borderline high and High ranges respectively of Total cholesterol. Students in Morogoro were significantly associated with high levels of Total Cholesterol 7 (10.8%) and 1(1.5%) borderline high and high ranges respectively while students in Dodoma had normal ranges of the factor Table 4 Moreover, the study also found that 15 (12.7%) and 10 (8.5%) were hyper-triglyceridemic and very high ranges of Triglyceride levels respectively. A significant proportion of hyper-triglyceridemic was present in students in Morogoro university and significant high proportion showed high ranges of Triglyceride levels. About 13 (20%) for hyper-triglyceridemic levels were present in Mzumbe students in Morogoro and 2 (3.8%) for students in Saint John's Dodoma. Very high range levels of triglyceride level 10 (15.4%) were present in Mzumbe students in Morogoro and none in Saint John's university students (Dodoma) in the study Table 5.

Furthermore, the study found Low density lipoprotein levels that were above optimal, borderline high, high and very high. The low-density lipoprotein levels found in the study were 24 (20.3%), 16 (13.6%), 13 (11%) and 17 (14.4%) for above optimal, borderline high, high and very high respectively. A significantly higher proportion of above optimal and borderline levels of Triglyceride levels was found in Saint John's university students in Dodoma. A significant higher proportion of high and very high levels of triglycerides levels was found in Mzumbe university students at Morogoro region. For Dodoma region about 17 (32.1%), 9 (17%) and 5 (9.4%) had above optimal, borderline high, high as well as very high levels of triglycerides respectively. Students at Mzumbe in Morogoro university had 7 (10.8%), 8 (12.5%), and 12 (18.4%) above optimal and borderline high, High, and very high levels of Triglycerides Table 6.

Table 1. *Prevalence of Total Cholesterol among University Students.*

Characteristics	**Normal range (%)**	**Borderline high (%)**	**High range (%)**	**P-value**
Age				
20-24 Years	29 (93.1)	2 (5.7)	1 (1.2)	
≥25 Years	81 (93.5)	5 (6.5)	0 (0.00)	0.829
Sex				
Male	63 (95.5)	3 (4.5)	0 (0.00)	
Female	47 (90.4)	4 (7.7)	1 (1.9)	0.400
University Location				
Morogoro	57 (87.7)	7(10.8)	1 (1.5)	
Dodoma	53 (100)	0 (0.00)	0(0.00)	0.030*
Residence				
Off-campus	83 (97.6)	2 (2.4)	0 (0.00)	
In-campus	27 (81.8)	5 (15.2)	1 (3)	0.008
Total	110 (93.2)	7 (6)	1 (0.8)	

*Significant at P<0.05

Table 2. *Prevalence of Triglycerides in University Students.*

Characteristics	Normal range (%)	Hyper triglyceridemic (%)	Very High (%)	P-value
Age				
20-24 Years	69 (79.3)	10 (20.7)	0 (0.00)	
≥25 Years	24 (77.4)	5 (10.6)	10 (12)	0.959
Sex				
Male	55 (83.3)	6 (10.6)	3 (6.1)	
Female	38 (73.1)	9 (15.4)	7 (11.5)	0.379
University location				
Morogoro	42 (64.6)	13 (20)	10 (15.4)	
Dodoma	51 (96.2)	2 (3.8)	0 (0.00)	0.000*
Residence				
Off-campus	69 (81.2)	8 (9.4)	8 (9.4)	
In-campus	24 (72.7)	7 (21.2)	2 (6.1)	0.209
Total	93 (78.8)	15 (12.7)	10 (8.5)	

*Significant at P<0.05

Table 3. *Low-density lipoprotein levels in university students.*

Characteristics	Optimal (%)	Above optimal (%)	Borderline high (%)	High (%)	Very high (%)	P-value
Age						
20-24 Years	36 (41.4)	19 (21.8)	5 (12.6)	10 (11.6)	6 (12.6)	
≥25 Years	12 (38.7)	5 (16.1)	11 (16.1)	3 (9.7)	11 (19.4)	0.845
Sex						
Male	23 (34.8)	17 (25.8)	9 (13.6)	8 (12.2)	8 (13.6)	
Female	25 (48.1)	7 (13.5)	7 (13.5)	5 (9.6)	9 (15.3)	0.457
University Location						
Morogoro	31 (47.7)	7 (10.8)	7 (10.8)	8 (12.3)	12 (18.4)	
Dodoma	17 (32.1)	17 (32.1)	9 (17)	5 (9.4)	5 (9.4)	0.027*
Residence						
Off-campus	33 (45.5)	5 (15.2)	4 (12.1)	2 (6.1)	10 (21.1)	
In-campus	15 (38.8)	19 (22.4)	12 (14.1)	11 (12.9)	7 (11.8)	0.489
Total	48 (40.7)	24 (20.3)	16 (13.6)	13 (11)	17 (14.4)	

*Significant at P<0.05

3.2.3. Central Obesity in University Students

The study found that 13 (11%) of university students had visceral obesity at both Morogoro and Dodoma universities. A significantly higher proportion of females 12 (23.1%) were at risk of morbidity when compared to male counterparts 1 (1.5%). The study also shows a significantly higher proportion of 11 (35.5%) of ≥ 25-year-old students were at a higher risk of morbidity when compared to 20–24-year-old students 2 (2.3%) years of age Table 7.

Table 4. *Prevalence of Central obesity in university students.*

Characteristics	Overall (%)	Risk of morbidity (%)	Non-risk of morbidity (%)	P-Value
Age				
20-24 Years	87 (73.7)	2 (2.3)	85 (97.7)	
≥25 Years	31 (26.3)	11 (35.5)	20 (64.5)	0.000*
Sex				
Male	66 (56)	1 (1.5)	65 (98.5)	
Female	52 (44)	12 (23.1)	40 (76.9)	0.000*
University location				
Morogoro	65 (55)	7 (10.8)	58 (89.2)	
Dodoma	53 (45)	6 (11.3)	47 (88.7)	0.924
Residence				
Off-campus	85 (72)	6(8.2)	78 (91.8)	
In-campus	33 (28)	7 (18.2)	27 (81.8)	0.121
Total	118 (100)	13 (11%)	105 (89)	

*Significant at P< 0.005

3.3. Determinants of Metabolic Risk Factors in University Students

Central obesity was significantly associated with gender (p=0.000) whereby females were at a higher risk of developing central obesity than male counterparts. The study also found that age was significantly associated with central obesity (p=0.000) and students that were ≥25 years old were at more risk compared to participants at a younger age. Nutrition status was also associated with risk of morbidity whereby obese students were at more risk compared to underweight, normal weight and overweight (p=0.000) Table 8.

Triglycerides levels were significantly associated with location of the university (p=0.000) whereby students at Mzumbe were at a risk of having high levels of triglycerides compared to students in Dodoma (Saint John's university). The study found that smoking was significantly associated with high levels of triglycerides (p=0.004). Table 9. Students in Saint John's university (Dodoma) were found to be significantly associated with total cholesterol (mean decrease of 0.17mg/dl, SE = 0.05, p = 0.01) and low-density lipoprotein (mean increase of 17.01mg/dl, SE = 10.1, p = 0.1). Being married was found to be significantly associated with blood pressure (diastolic) (mean decrease of 11.66mmHg, SE=5.222, p=0.05).

University students who received scholarships in the study were found to be significantly associated with low-density lipoprotein (mean increase of 21.83mg/dl, SE=10.40, p=0.1). However, other metabolic risk factors were not significantly associated (p>0.05). Furthermore, the study found that university students who smoked were significantly associated with blood pressure (diastolic) (mean increase of 6.125mmHg, SE=3.451, p=0.1). The study also found that students with a highly diversified diet (≥7 food groups) were significantly associated with low-density lipoprotein (mean increase of 5.731mg/dl, SE=3.143, p=0.1). However, other metabolic risk factors were not significantly associated (p>0.05). Table 10.

Table 5. *Determinants of Central Obesity in University students.*

Characteristics	Risk of morbidity (%)	Non-risk of morbidity (%)	P-value
Sex			
Male	1 (1.5)	65 (98.5)	0.000*
Female	12 (23.1)	40 (76.9)	
Age			
20-24 years	2 (2.3)	85 (97.7)	0.000*
≥ 25 years	11 (35.5)	20 (64.5)	
Nutrition status			
Underweight	0 (0)	7 (100)	0.000*
Normal weight	1 (1.2)	82 (98.8)	
Overweight	6 (27.3)	16 (72.7)	
Obesity	6 (100)	0 (0)	

*Significant at P<0.05

Table 6. *Determinants of Triglycerides levels in university students.*

Characteristics	Normal (%)	Borderline high (%)	Hypertriglyceridemic (%)	P-value
Location of the university				
Morogoro	42 (64.6)	13 (20)	10 (15.4)	0.000*
Dodoma	51 (96.2)	2 (3.8)	0 (0)	
Smoking status				
No	91 (80.5)	12 (10.6)	10 (8.8)	0.004*
Yes	2 (66.7)	3 (14.3)	0 (0)	

*Significant at P<0.05

Table 7. *Determinants of Metabolic risk Factors in University students.*

Characteristics	Blood pressure (Diastolic)	Blood pressure Systolic)	Total cholesterol (TC)	Low-density lipoprotein
Locationof University				
Morogoro	Ref	Ref	Ref	Ref
Dodoma	3.834	4.661	-0.170***	17.01*
	(2.866)	(4.516)	(0.0519)	(10.08)
Sex				
Male	Ref	Ref	Ref	
Female	-0.692	3.221	0.0397	
	(3.223)	(5.004)	(0.0542)	
Marital status				
Single	Ref	Ref		Ref
Married	-11.66**	-10.43		14.78
	(5.222)	(8.115)		(15.99)
Scholarship status				
No	Ref	Ref	Ref	Ref

Characteristics	Blood pressure (Diastolic)	Blood pressure Systolic)	Total cholesterol (TC)	Low-density lipoprotein
Yes	-2.823	-3.576	0.0266	21.83*
	(2.404)	(3.749)	(0.0463)	(10.40)
Smoking Status				
No	Ref	Ref	Ref	Ref
Yes	6.125*	3.892	-0.0566	11.37
	(3.451)	(5.371)	(0.0616)	(14.44)
Dietary Diversity score				
< 7 food groups	Ref	Ref	Ref	Ref
≥ 7 food groups	0.931	1.367	-0.00304	5.731*
	(0.742)	(1.138)	(0.0140)	(3.143)
Constant	72.58**	102.3**	1.872**	-1.269
	(9.434)	(13.75)	(0.168)	(32.64)
Observations	118	118	118	118
R-squared	0.415	0.305	0.384	0.297

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

3.4. Prevalence and Determinants of Other Health Implicated Factors in University Students

The study found other factors such as High-density lipoprotein and Low-levels of blood glucose (hypoglycaemia).

3.4.1. Prevalence of Hypoglycaemia in University Students

The study found that 22 (18.6%) participants had hypoglycaemia in the two regions. A significantly higher proportion 18 (27.7%) of students in Morogoro were found to have hypoglycaemia when compared to the proportion 4 (7.5%) in Dodoma region. Being female was significantly associated with hypoglycaemia 14 (26.9%). Low-levels of blood glucose was associated with residence, whereby the proportion of students in-campus was significantly higher 12 (30.3%) when compared to the proportion 10 (14.1%) of students off-campus. Table 11.

Table 8. *Prevalence of Hypoglycemia levels in university students.*

Characteristics	Overall (%)	Hypoglycaemia (%)	Normal (%)	P-Value
Age				
20-24 Years	77 (73.73)	6(18.4)	71 (81.6)	
≥25 Years	41 (26.27)	16 (19.4)	25 (80.6)	0.906
Sex				
Male	64 (54.24)	8 (12.1)	58 (87.9)	
Female	54 (45.76)	14 (26.9)	38 (73.1)	0.040*
University location				
Morogoro	65 (55.08)	18 (27.7)	47 (72.3)	
Dodoma	53 (44.92)	4 (7.5)	49 (92.5)	0.005*
Residence				
Off-campus	85 (72)	10 (14.1)	73 (85.9)	
In-campus	33 (28)	12 (30.3)	23 (69.7)	0.043*
Total	118 (100%)	22 (18.6)	96 (81.4)	

*Significant at P<0.05

3.4.2. Prevalence of High-Density Lipoprotein in University Students

The study found that 45 (38.2%) of university students had high levels of high-density lipoprotein. Students in Dodoma region had a significantly higher proportion 25 (47.2%) of high-density lipoproteins compared to students in Morogoro region 20 (30.8%). Being female was significantly associated with high levels of high-density lipoprotein in a larger proportion 26 (44.3%) compared to their male counterparts 19 (30.2%). Residency was also significantly associated with high levels of high-density lipoprotein whereby students living off-campus had higher proportion 37 (43.5%) compared to students in-campus 8 (24.2%). Table 12.

Table 9. *Prevalence of High-density lipoprotein levels among university students.*

Characteristics	Normal range (male) (%)	Normal range (female) (%)	High range (%)	P-Value
Age				
20-24 Years	36 (41.4)	9 (20.7)	12 (37.9)	
≥25 Years	10 (32.3)	18 (29)	33 (38.7)	0.552
Sex				
Male	46 (69.8)	0 (0.00)	19 (30.2)	
Female	0 (0.00)	27 (55.7)	26 (44.3)	0.000*

Characteristics	Normal range (male) (%)	Normal range (female) (%)	High range (%)	P-Value
University Location				
Morogoro	25 (38.4)	20 (30.8)	20 (30.8)	
Dodoma	21 (39.6)	7 (13.2)	25 (47.2)	0.050*
Residence				
Off-campus	13 (38.9)	12(17.6)	37 (43.5)	
In-campus	33 (39.4)	15 (36.4)	8 (24.2)	0.051*
Total	46 (39)	27 (22.8)	45 (38.2)	

*Significant at P<0.05

3.4.3. Determinants of High-Density Lipoprotein in University Students

The study found that students at Saint John's University at Dodoma were significantly associated with high-density lipoprotein (mean increase of 0.347mg/dl, SE=0.121, p=0.01). Students who smoked were also significantly associated with high-density lipoprotein (mean increase of 0.446mg/dl/, SE=0.146, p=0.1). Furthermore, students that were Third year and above were associated with high-density lipoprotein (mean increase 0.163mg/dl, SE=0.0924, p=0.1) Table 13.

Table 10. *Determinants of High-density lipoprotein in university students.*

Characteristics	High density lipoprotein (HDL)
Location of University	
Morogoro	Ref
Dodoma	0.347***
	(0.121)
moking status	
No	Ref
Yes	0.446***
	(0.146)
Study year	
Second year	Ref
Third year and above	0.163*
	(0.0924)
Constant	2.718*
	(0.398)
Observations	118
R-squared	0.453

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

3.4.4. Determinants of Hypoglycaemia Among University Students

Being female was significantly associated with blood glucose levels (mean decrease of 1.178mmol/L, SE=0.475, p=0.05). Students who smoked were significantly associated with blood glucose levels (mean increase 1.4440mmol/L, SE=0.510, p=0.01) Table 14.

Table 11. *Determinants of Hypoglycemia in University students.*

Characteristics	Blood glucose
Location of University	
Morogoro	Ref
Dodoma	-0.297
	(0.428)
Sex	
Male	Ref
Female	-1.178**
	(0.475)
Marital status	
Single	Ref
Married	-0.909
	(0.770)
Scholarship	
No	Ref
Yes	0.385
	(0.356)
Smoking status	
No	Ref
Yes	1.4440***
	(0.510)
Dietary Diversity score	
<7 food groups	Ref
≥7 food groups	0.0549
	(0.108)
Constant	5.891***
	(1.305)
Observations	118
R-squared	0.371

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4. Discussion

4.1. Prevalence of Metabolic Risk Factors Among University Students

The primary objective of this study was to assess the metabolic risk factors of university students in Morogoro and Dodoma regions. The metabolic risk factors in this study included blood glucose levels, blood-pressure, central obesity and lipid profiles. These metabolic risk factors are consistent with studies done at the global level as well as across African countries.

According to the findings of these study, students in Dodoma region showed a higher prevalence of elevated systolic blood pressure (7.5%) compared to students in Morogoro region. This is due to the differences in agro-ecological zones, economic activities and overall population. Dodoma region has recently experienced an influx of people and led to the increase of the metropolitan environment. The findings of this study are in line with [22] that showed differences in the prevalence of hypertension between urban and rural settings. A Malagasy study also found high prevalence rates of hypertension that were similar to observed rates in urban settings of different African countries and lower prevalence rates that were reported in many rural communities on mainland Africa [23]. Rashid, N., & Dika, H. I. [24] reported differences in diastolic blood pressures among individuals living in shores of lake Nyasa where by the diastolic blood pressure was higher compared to

individuals living in the hills around lake Nyasa. Furthermore Wang, C., *et al* [25] found that the prevalence of hypertension was significantly higher in rural areas compared with urban an area (25.93% versus 22.73%, respectively) which was contrary to this study since it did not show significant differences.

Prevalence of high levels of the lipid profiles among university students in the study (Total cholesterol, Triglycerides and low-density lipoprotein levels) were found to be significantly associated with location of the universities. The imbalance of lipid levels (in most cases above optimal/high levels) in the blood is known as dyslipidaemia. Students in Mzumbe university in Morogoro had a higher prevalence of elevated total cholesterol, hypertriglyceridemia and very high levels of triglycerides in their blood (10.8%, 20% and 15.4% respectively) compared to students in Saint John's University. This could be due to difference in the location of the two universities, it could also be due to the fact that students in Saint John's university were found to have no to little elevated levels of cholesterol and triglycerides in their blood. Moreover, due to the fact that Saint John's university some courses offered at the institution are science based which might make the students aware on NCD-risk behaviours, this is contrary to Mzumbe university whereby the courses offered are entirely business and administrative oriented. This might also be related to the small number of participants enrolled for the study in Saint John's university (n=53) when compared to Mzumbe university (n=65). Similarly, it was reported that medical college students (n=100) had a lower prevalence of total cholesterol and triglyceride levels due to some differences in food habits and small number of participants enrolled from a single institution [26].

Furthermore, de Groot, R., *et al* [27] reported differences in Total cholesterol levels among adults who are located in different environmental contexts whereby Total cholesterol levels were higher in urban areas compared to rural areas. Moreover, Sarfo, F. S., & Ovbiagele, B. [28] reported that dyslipidaemia prevalence was higher among urban dwellers than rural residents which is consistent with the notion that suburbanization and adoption of occidentalized lifestyles could lead to the rise of lipid levels.

This is also due to the different foods available in these regions, in Morogoro there are vast food crops and cash crops grown which is not the same for Dodoma region. Examples of food crops grown in Morogoro include rice, millet, sorghum and cassava. Similarly, a study done by Davis, E. F.*, et al* [29] amongst adolescents reported elevated lipid levels in participants that had different food sources.

The prevalence of low-density-lipoprotein levels among university students were found to be elevated in this study compared to other metabolic risk factors. The categories were defined as above optimal, Borderline high, high and very high (20.3%, 13.6%, 11% and 14.4% respectively). The reason for this is due to the increase in independence amongst the university students that can lead to risky behaviours which have healthy implications. It has been suggested that both lifestyle and biological factors are associated with elevated levels of LDL-C components [26]. This study showed a significant increase in Low-density lipoproteins levels for high and very high (12.3% and 18.4% respectively) among Mzumbe university students compared to the levels in Saint John's university students. The study also showed a significant increase in Low-density lipoprotein levels for above optimal and borderline high (32.1% and 17% respectively) among Saint John's University students compared to the levels in Mzumbe University students. These findings are similar to Al-Duais, M. A., & Al-Awthan, Y. S. [30] whereby, it was reported that there was a significant increase of High LDL among urban university students compared to the levels in rural university students. In contrast to our study Kasia, B. E.*, et al* [31] reported a significant difference amongst female and male university students at Niger Delta mean plasma LDL-c values for males were significantly lower than females value 2.38 ± 0.49 versus 2.64 ± 0.64 P= 0.023.

Moreover, the prevalence of visceral obesity in this study was found to be 11% and was significantly associated (P=0.000) with age and sex of the university students. The prevalence in this study is lower when compared to a study done among university students in Nairobi whereby the prevalence was 27.8% [32]. This could be due to the total numbers of participants that participated in the study. Female students had a higher prevalence (23.1%) compared to male counterparts. Similarly, Mitić, N. R., & Popović, L. [33] reported a significant difference between genders however, male university students had a higher prevalence of central obesity (12.2%) compared to their female counterparts (11.4%). The higher prevalence of central obesity in this study for females is due to the fact that females often have less lean mass and more fat mass compared to male and the biological factors that account for the gender differences. This study corroborates with Maila, G., *et al* [34] who reported a study done in Verulam, South Africa that indicated 68.4% of women and 25% of men were at risk of central obesity.

Furthermore, the study found that prevalence of visceral obesity in students aged ≥25 years was (35.5%). The reason could be due to difference of eating habits and overall food choices that lead to risky behaviours. The reasons could be due to metabolic changes that happen across different age groups and life factors that are accompanied as age progresses such as increased stress, changes in sleep patterns and exposure to risk behaviours. The findings of this study are in line with Molla, M. D., *et al* [35] that found an increase in age was statistically associated with central obesity. Similarly, a study by Munyogwa, M. J., *et al* [36] in Dodoma City reported respondents with an increased age were associated with development of abdominal obesity.

An interesting finding in the current study was the absence of Hyperglycaemia among the University students. The findings are inconsistent with those of other studies. Many regional and international studies reported high blood sugar to be a significant risk factor amongst university students [37-39, 40] The absence of high blood sugar levels in this study is likely related to the method used to assess for the blood

glucose levels (Random blood glucose) and the number of participants that were enrolled in the study.

4.2. Determinants of Metabolic Risk Factors Among University Students

In our study location of the university, gender, age, nutrition status, marital status, Scholarship status, Smoking status and dietary diversity were all significant determinants of metabolic risk factors. Females were more susceptible in developing central obesity compared to their male counterparts. The probable cause of this could be due to the sociocultural dynamics, different contextual factors that drive gender differences in food consumption and the biological factors. The findings of this study are in line with Israel, E., *et al* [41] who reported that being female was associated with central obesity. Female students are less likely to perform physical activities and more prone to sedentary behaviours this could be a possible explanation for the risk of morbidity. Students who were ≥25 years old in this study were more inclined to have central obesity compared to younger students. The probable cause for this might be due to differences in food habits and increase metabolic needs as age progresses. These results were consistent with a study conducted in Ethiopia whereby the odds of being abdominally obese by waist circumference increased by age [42]. The study also found that being obese was associated with central obesity. Central obesity is often associated with sedentary lifestyles, poor dietary choices, high consumption of energy dense foods as well as a number of factors such as hormonal imbalances and metabolic disorders which may lead to general obesity. The findings of this study are in line with Tegegne, K. D., *et al[*43] that reported central obesity to be associated with overall obesity.

In our study we found that location of the university and smoking status was significantly associated with increased levels of triglycerides whereby students at Mzumbe university and students who smoked were at a higher risk of having high triglyceride levels. The possible reason could be due to the toxic chemicals present in cigarette smoke which may impair lipid metabolism and lead to higher triglyceride levels. However, this could be bias due to the fact that the study reported few participants who were smokers. The findings of this study are in line with van der Plas, A., *et al* [44] who reported triglyceride levels to be higher in smokers than non-smokers by 0.50 mmol/L (95% confidence interval: 0.49–0.50 mmol/L). Agro-ecological zones across regions have differences which can have a health implication to the residents, the differences include food stuffs grown, rainfall pattern, land fertility and overall food security. This study found that triglyceride levels differed between Morogoro and Dodoma region in the university students the findings corroborate with de Groot, R., *et al* [27] who reported differences in triglyceride levels to be higher in urban than in and rural areas among adults (mean difference 0.09, 95%CI 0.03 to 0.14). Furthermore, the urban/rural differences of low-density lipoprotein levels were reported to be higher in urban than in rural areas (mean difference 0.28, 95%CI 0.17 to 0.39) [27]. Total cholesterol levels were associated with location of the university in contrast with Studziński, K.*, et al* [45] who reported no association of total cholesterol levels between urban and rural areas.

The study also reported Marital status and smoking to be associated with Blood pressure (Diastolic). Marital life comes with a lot of challenges that are economic, social and physical. These factors can lead to changes in the body metabolism that results into metabolic disorders. For the case of smoking the chemical substances such as nicotine causes vasoconstriction leading to increase of blood pressure, moreover smoking is associated with increased heartbeat through adrenaline secretion. Li, K., *et al* [46] reported that marital status was associated with higher odds of hypertension. Chen, Q., *et al* [47] reported an association between smoking and hypertension in adults. Furthermore, the study reported receiving scholarship and students with a diversified diet to be associated with low density lipoprotein. The possible reason for this could be because the students have a financial capacity to engage in vast risky behaviours and food habits that could lead to elevated levels of low-density lipoproteins. Rong, S., *et al* [48] reported Low-density lipoprotein to be associated with socio-economic status that results to high risks of all-cause mortality.

4.3. Prevalence and Determinants of Other Health Implicated Factors Among University Students

The study found that the overall prevalence of low-blood sugar levels among the participants was 18.6%. A significant higher prevalence was found to be in females (26.9%), Morogoro university (27.7%), and students in campus (30.3%). The probable reason could be because of the methodology used to collect the blood samples which is random blood glucose. The measurements were taken during normal class routine and in between breaks from one lecture to another. It is known that university students tend to skip their meals therefore this could have been among the factors that resulted to low levels of blood glucose, another factor could be stress on studies and keeping up with school activities. The findings in this study are inconsistent with other studies done in university students that show high prevalence of hyperglycaemia among adults. Metta, E. [49] reported the prevalence of diabetes to be 10.3% which is higher than the 9.1% prevalence reported in 2012 and is a massive increase from the 2.5% prevalence reported in 1984 among people of the same population group. The International diabetes Federation reported that 2,888,000 Tanzanians are living with diabetes (International Diabetes Federation) [50].

Additionally, the overall prevalence of high-density lipoprotein among the university students was (38.2%). A significant higher prevalence was found to be in females (44.3%), Saint Johns's university students (47.2%) and Off-campus students (43.5%). The possible reason could be due to inconsistent cut off points for high-density lipoprotein and the number of participants present in the study. The findings of this study vary with other studies that report low levels of high-density lipoprotein which is among the metabolic risk factors. High density lipoprotein is inversely

associated with cardiovascular disease whereby low levels of HDL-cholesterol are strong predictors atherosclerosis, cardiovascular disease and mortality [51]. Hamooya, B. M., *et al* [52] reported low HDL-concentration to be highly prevalent among young adults in Sub-Saharan Africa.

The determinants for the health implicated risk factors in the study were found to be significantly associated with Location university, smoking status, study year and sex. The possible reason for this is due to difference in agro-ecological zones, biological factors accompanied with gender differences, peer pressure, food choices and eating behaviour.

5. Conclusions

The study emphasizes that university students are living with metabolic risk factors that could have future health implications. Low-density lipoprotein levels were the most prevalent metabolic risk factor. The study revealed that location of the university, gender, age, nutrition status, marital status, scholarship status, smoking status and dietary diversity were all significant determinants of metabolic risk factors. However, other health related factors were found in this study such as low-blood glucose levels and high-density lipoprotein. The results highlight that the prevalence of metabolic risk factors that result to metabolic syndrome amongst the study population can have health implications. Therefore, health and university policymakers must consider the predisposing factors among this vulnerable population in order to prepare preventive and health promotion strategies for controlling Cardio Vascular Diseases risk. Likewise, university environment should be a platform where nutrition programs are administered and actively participation of the university students as influencers and agents of change. Nutrition policies and programs aiming to tackle nutritional disorders in all its forms and track progress made to achieve sustainable development Goals by 2030. Cut off points should be established for sub-Saharan countries so as to properly asses the metabolic risk factors. Longitudinal prospective studies with a larger sample size should be conducted so as to get the clear snapshot of challenges facing this sub-population.

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Conflicts of Interest

The authors declare no conflicts of interest.

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