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Epidemiology of General, Central Obesity and Associated Cardio-Metabolic Risks Among University Employees, Ethiopia: A Cross-Sectional Study

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Background: Evidence suggests that middle and low-income countries such as Ethiopia are facing the growing epidemic of both communicable and non-communicable diseases creating a burden on their economy and healthcare system. The increasing prevalence of non-communicable diseases is attributed to sedentarism, lifestyle changes, nutritional transition, and the presence of other cardiometabolic risk factors. Therefore this study was designed to assess the prevalence and association of overweight, obesity, and cardio-metabolic risks and to explore if there was any agreement among the anthropometric measurements among the academic employees of the University of Gondar, Ethiopia.
Methods: An institutional-based cross-sectional study was conducted using the WHO stepwise approach and recommendations on 381 academic staff of the university. In addition, physical measurements such as weight, height, waist and hip circumferences, and biochemical measures such as blood pressure and fasting blood glucose level (peripheral blood samples by finger puncture) were measured using standardized tools.
Results: The mean age of the participants was 33.5 (95% CI: 32.7, 34.2) years. The prevalence of obesity among the study participants calculated by body mass index, waist circumference (WC), waist-height ratio (WHtR), and waist-hip ratio (WHR) was 13.1%, 33.6%, 51.9%, and 58.5% respectively. The prevalence of diabetes was 4.7% among which 1.3% was not diagnosed prior to this study. About 53 (13.9%) of the study sample were found to be hypertensive (HTN) (6.3% known versus 29 7.6% newly diagnosed). Among the participants, 39.4% and 23.4% were found to be pre-hypertensive and pre-diabetic respectively. WC was significantly associated with hypertension (AOR = 5.14; 2.503, 9.72), pre-DM (AOR = 4.03; 2.974, 5.96), DM (AOR = 3.29; 1.099, 6.01). In addition, WHtR was significantly associated with Pre-HTN (AOR = 2.69; 1.49, 4.58), HTN (AOR = 2.066; 1.008, 6.31), and DM (AOR = 1.855; 0.76, 4.32). On the contrary, both WHR and general obesity measured by BMI were not significantly associated with pre-HTN, HTN, pre-DM and DM groups.
Conclusion: This study results revealed the variable prevalence between general obesity and the anthropometric indices (IDF cutoff) defining central obesity; WC, WHtR, and WHR among the participants. The result of this study suggests that the constructs of central obesity, not BMI has to be used to screen risks of cardio-metabolic risks among Ethiopians.
Keywords: central obesity, diabetes mellitus, hypertension, prehypertension, prediabetes, Ethiopia

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Background

The increase in the global prevalence of non-communicable diseases in the past four decades in high-income countries is well documented.[1–3] There is evidence to suggest that low-income countries face the triple burden of undernourishment, communicable and non-communicable diseases attributed to low socio-economic status, lifestyle and nutrition changes.[4–6] In sub-Saharan Africa (SSA), about 69% of mortality is caused by infectious diseases, while non-communicable diseases (NCDs) contribute around one-fourth of the deaths.[7,8] However, due to the ongoing epidemiological transition in these countries, there is a projection that death due to non-communicable diseases is estimated to surpass death from infectious diseases in the year 2030.[9,10]

Ethiopia is among the countries in the sub-Saharan region that is facing an increasing burden related to non-communicable diseases. For instance, in previous Ethiopian studies, the prevalence of metabolic syndrome (Mets) and diabetes among the working population was reported as 14% and 6.5% respectively, while the prevalence of high blood pressure among these populations ranges from 19.6%-30.3%.[11–13] The International Diabetic Federation (IDF) 2014 reports estimated the number of people living with diabetes to be 4.9 million and about 2.9 million people living with impaired blood glucose in Ethiopia. In addition, the report also estimated that the prevalence of undiagnosed diabetes to be about 1.4 million being higher in urban than rural population.[14,15] Moreover, among urban dwellers in Ethiopia, about 64.8% of hypertensive subjects and 53.4% of diabetic subjects were estimated to be undiagnosed.[16,17]

Previous regional studies used IDF criteria to estimate cardio-metabolic risks and the association of anthropometric indices among bank workers, school teachers, policemen, and other general population.[18–20] The IDF recommended Asians and Sub-Saharan Africans (SSA) to use the Europid driven cut off point to define central (abdominal) obesity which is a known indicator and predictor for cardio-metabolic risks.[20] WHO recommends using the Europid standards until national data becomes available. As a result, many studies in Ethiopia used the recommended cut off point to define obesity. Lifestyle behaviors of University staffs and associated cardio-metabolic risks in this population are reported elsewhere.[21–23] University academic staff in Ethiopia might be at risk of developing overweight, obesity, and cardio-metabolic risk due to the following reasons; Ethiopian middle-aged working population, urban-dwelling, lesser workplace physical demand, better income, and economic status. Though it is recommended to use more reliable population-specific anthropometric cut off measures and it is well known that slender body framed Ethiopian and some Asian countries still use international or European anthropometric cut off values to identify cardio-metabolic risks.[24,25] Hence, it is a high time for Ethiopia to initiate small and/or large scale high risk approaches for screening NCDs in susceptible populations using simple and sensitive screening tools. Anthropometric indices are simple and effective indicators of general and central adiposity in identifying cardio-metabolic risks in the community and institutional populations in low-income countries.[21,22]

Evidence substantiates the presence of correlation between sedentarism and the increased chances of cardio-metabolic risks among the different populations.[23,26,27] Since University academic employees are more likely at risk of sedentarism, occupational status, higher income, and other lifestyle changes, it is crucial to study cardio-metabolic risks and its associated factors among this population. In Ethiopia, population-based data on the prevalence of diabetes; IFG and hypertension are scant unlike elsewhere, where these data across various occupational groups are recent interest.[27–30] Current knowledge of cardio-metabolic risks in Ethiopia is mostly based on sporadic, convenience based, and hospital data from patients who present with NCDs. Considering the devastating effects of cardio-metabolic health problems on individuals living with chronic illnesses and the country at large, there is an urgent need and impartial attention to exploring cardio-metabolic health problems and its underlying risk factors in Ethiopia. Therefore, the aim of this study was to assess the prevalence of general obesity and central obesity and the association of these anthropometric indices with cardio-metabolic risks such as hypertension, pre-hypertension, impaired fasting glucose, and diabetes among academic employees in Northwest Ethiopia.

Methods

Study Design and Subjects

This institutional-based cross-sectional study was conducted on 381 academic staff working at the University of Gondar, Gondar, Ethiopia. The University of Gondar is one of the oldest and highest educational institutions in Ethiopia located at 750 km north to capital city Addis Ababa. A total of 1387 Ethiopian academic staff (1221 male, 166 female) who were working as permanent staff were considered as the study population. The study was conducted from November 2017 to January 2018.

The sample size was determined using Epi info version 7.0 (Centers for Disease Control and Prevention, USA). A two population proportion formula was used to calculate the desired sample size based on the previous study (25) with obesity in hypertensive and obesity in normotensive subjects as 45% and 30% respectively with an odds ratio of 1.91. A power of 80% to detect real association of exposure variable and 95% level of confidence was used. The derived sample size was n = 390, accounting for estimated refusal or non-response rate of 10% the required sample size was n = 429. Obesity with DM and hypertension was taken from various regional studies. Finally, hypertension with the highest sample size was chosen.

Among the 1387 permanent academic staff list secured from UOG, the human resource department a computer-generated random list was prepared and 429 questionnaires were distributed to randomly selected staff in this survey. Socio-demographic, anthropometric indices and cardio-metabolic risk factor data of recruited staffs were used in this study. About 62 Expatriate staffs, 5 subjects with abdominal surgeries within the previous 3 months, 9 pregnant women and recent partitions were excluded.

Data Collection

Data were collected by 8 nurses and 2 lab technicians. The data collectors were randomly selected from the registered list and questioned by BJ for their English proficiency. Two days of intensive training was given to the data collectors by BJ on the data collection procedures. The English version of WHO STEPS wise approach for surveillance of chronic Non-communicable Diseases Risk factor, version 4)[31] was used for data collection in this survey. The stepwise questionnaire risk factor assessment; Step 1 (interview questions), step 2 (physical measurements) and step 3 (biochemical measurement) were used. Procedure in this survey included completing the questionnaire, anthropometric measurement, measurement of blood pressure, and fasting blood glucose measurement. The digital weighing scale (Electrolux, Korea) was used to measure weight to the nearest 0.1 kg in light indoor clothing and bare feet or with socks. Height was measured using a portable stadiometer (Charder Scales, HM200P ProtStad) to the nearest 0.1 cm with the participants standing erect posture, without shoes. Waist circumference was measured by placing a non-elastic plastic tape to the nearest 0.1 cm, horizontally midway between the 12th rib and iliac crest on the mid-axillary line, using a stretch-resistant tape. Hip circumference was measured at the level of the greater trochanters with the tape parallel to the floor. Blood pressure (digital Omron, HEM-7111) was measured, according to WHO guidelines participant in sitting position rested for 10 mins and 3 consecutive measurements at the interval of 3 min each. A portable glucometer (one-touch, USA) and finger prick in the middle finger was used to measure fasting blood glucose. Self-reported current use of antihypertensive drugs and/or antidiabetic drugs was recorded. The randomly selected participants were contacted in the late evening prior to the day of data collection and were instructed about the zero-calorie intake 8 to 9 hrs to estimate fasting plasma glucose.

Definition of Obesity and Cardio-Metabolic Risks

The definition criteria were based on the International Diabetic Federation (IDF), WHO/International Society of Hypertension guidelines and American Diabetic Association (ADA).[32] General obesity was defined as BMI ≥ 25 kg/m^2, central obesity was defined using Europid values; waist circumference (WC) of ≥ 94cm (men), ≥80cm (women), waist-height ratio (WHtR) of ≥ 0.50 and waist-hip ratio (WHR) of ≥ 0.90 (men), ≥ 0.85 (women). The cardio-metabolic risk was defined as; Pre-diabetes (Pre-DM) was diagnosed if the FBG value was ≥100 mg/dL to ≤120 mg/dL. Diabetes was diagnosed if the FBG value was ≥126 mg/dl, self-reported Type II diabetes mellitus, or there is a history of diabetic medication. Undiagnosed diabetes mellitus (UDM) is defined as unknowingly having an elevated fasting glucose level that meets the definition of DM.[33] Pre-hypertension (Pre-HTN) was diagnosed if systolic blood pressure (SBP) >120 to <140 mmHg and/or diastolic blood pressure >80 to <90 mmHg. Hypertension (HTN) was defined as SBP ≥ 140 mmHg and/ or DBP ≥ 90 mm Hg.

Ethical considerations

This study was approved by the School of Medicine Research and Ethical Review Board, University of Gondar (Ref/RPC312014). A detailed orientation of the survey objectives, procedures, possible outcomes and safety precaution in needle prick were explained prior to the signing of the informed consent form. Referral forms were used in case of abnormal biochemical findings for medical consultation and counseling in UOGH. This study was conducted in accordance with the Declaration of Helsinki.

Statistical Analysis

Data were coded and entered in Epi info software version 7.0 and exported to IBM Statistical Package for Social Sciences (SPSS) version 24 for Windows for statistical analysis. Mean and percentage with 95% CI adjusted for age was used to describe the distributions of socio-demographic characteristics, anthropometric measures and cardio-metabolic of the study population by cross-tabulation and independent *t*-test across gender. Pearson's chi-square was used to evaluate the difference between a categorical variable and age-adjusted one-way ANOVA was used to compare continuous variables. Pearson's correlation test was done to measure the association between anthropometric measures (BMI, WC, WHtR & WHR), age, and cardio-metabolic risk variables (FBG, SBP, DBP). Age controlled bivariate analyses were conducted with the dependent variables (FBG, SBP, DBP) and independent variables that were found statistically significant were included in multivariate analysis. When clear subgroups seemed present in the data, significance testing (Pearson χ^2) and, if appropriately sized subgroups per category remained, logistic regression was performed. The prevalence estimates for obesity defined by BMI, WC, WHtR, and WHR were determined separately. In all cases p-value < 0.05 at 95% confidence interval was considered statistically significant.

Results

A total of 429 academic employees were approached for consent, out of which 381 employees (330 male, 51 females) consented and completed questionnaires, physical measurements, and biochemical measurements. The response rate was 89% and this is 97.6% of the power calculated sample size (n = 390). The mean age (in years), height (cm), and weight (kg) of the total participants were 34.33, 164.15 and 64.8 respectively with a significant difference between gender. The majority of the participants (64.8%) were below the age of 35 years and 339 (88.97%) participants of the total sample were less than 45 years old. About73% had postgraduate education levels and no significant difference in educational level between genders. Among the participants, 6.3% and 7.6% were known HTN and newly diagnosed HTN, while 2.9% and 1.6% were known DM and newly diagnosed DM respectively. About 15 (3.9%) participants had concurrent HTN and DM (Table 1). A gender-wise statistically significant difference was observed between age, height, weight, and all anthropometric measures. The majority of the participants (n = 239, 62.7%) were diagnosed either or both prehypertension and pre-diabetes.

The age-adjusted mean of overall BMI was 23.4 kg/m^2 and 24.8 kg/m^2 for men and women respectively. Age-standardized prevalence of pre-obesity in men (23.6%), and women (23.5%) and the prevalence of obesity are; men (3.3%) and women (9.8%). Mean BMI and the prevalence of pre-obesity or overweight and obesity by age group are shown in Table 2.

Mean of WC, WHtR, WHR and the prevalence of central obesity are shown in Table 3. The age-adjusted mean of overall WC, WHtR, and WHR for men was 88.2cm, 0.52, and 0.93 respectively. The age-adjusted mean of overall WC, WHtR, and WHR for women was 81.9 cm, 0.51, and 0.90 respectively. Age-standardized prevalence of central obesity based on WC, WHtR, and WHR among men was 31.2%, 53.3%, and 58% respectively. Age-standardized prevalence of central obesity based on WC, WHtR, and WHR among women was 49%, 43.1%, and 56.9% respectively. Among 275 participants with normal BMI, more than half (n = 154 (56%)) were identified as centrally obese by WC, WHtR, and WHR. Moreover, among participants with normal BMI, 96 (34.9%), 26 (9.5%), 48 (17.5%), and 13 (4.7%) were diagnosed and/or self-reported to have pre-HTN, HTN, pre-DM, and DM respectively. Only diabetes mellitus had no statistically significant difference among BMI categories. The frequency distribution and association between anthropometric indices (stratified by general and central obesity) and cardio-metabolic risks are presented in supplementary Tables 1–5.

Gender wise occurrence and mean of cardio-metabolic risks in both general obesity by BMI and central obesity by WC, WHtR, and WHR are shown in Table 4. Higher rate of pre-HTN and HTN in women was observed in central obesity groups whereas in men both general and central obesity groups showed close to similar occurrence. A higher rate of pre-DM was observed in the central obesity group defined by WC in both men and women 58.3% and 64% respectively.

Among men, a significant positive correlation was seen between BMI, WC, WHtR, and WHR with SBP, DBP, and FBG. Among women, BMI showed a poor correlation with all cardio-metabolic risks. Pearson's correlation for the association between cardio-metabolic factors and anthropometric measure and age for both genders are shown in Table 5. In addition, all central obesity measures showed a significant positive correlation with cardio-

Table 1 Socio-Demographic, Anthropometric, Clinical Characteristic, and Physical Measurement of the Study Population Stratified by Gender, North West Ethiopia (n = 381)

	Sex		**Total**	**p-value[c]**
	Mean (95% CI)/N (%)		**Mean (95% CI)/N (%)**	
	Male (N = 330)	**Female (N = 51)**		
Age (years)[a]	33.15 (32.4, 33.9)	35.51 (33.0, 38.1)	33.46 (32.7, 34.2)	0.03
Age category[b]				
25–35	219 (66.4)	28 (54.9)	247 (64.8)	0.002
36–45	82 (24.8)	10 (19.6)	92 (24.2)	
46–55	29 (8.8)	13 (25.5)	42 (11)	
Education level[b]				
Under graduate	80 (24.2)	14 (27.5)	94(24.7)	0.874
Post graduate	242 (73.3)	36 (70.6)	278 (73)	
PhD	8 (2.4)	1 (2)	9 (2.4)	
Marital status[b]				
Married	140 (42.4)	19 (37.2)	159 (41.7)	0.100
Single	178 (53.9)	31 (60.8)	209 (54.9)	
Divorced/widowed	12 (3.7)	1 (2.0)	13 (3.4)	
Height cm[a]	168.2 (167.7, 168.7)	160.1 (158.5, 161.8)	167.1 (166.5, 167.8)	0.00
Weight kg[a]	66.2 (65.3, 66.5)	63.4 (61.1, 65.5)	65.8 (65.0, 66.5)	0.02
BMI kg/m^{2,a}	23.4 (23.1, 23.7)	24.8 (23.8, 25.7)	23.7 (23.3, 23.9)	0.003
WC cm[a]	88.2 (87.4, 88.9)	81.9 (80.3, 83.5)	87.4 (86.6, 88.1)	0.000
WHtR[a]	0.52 (0.51, 0.52)	0.51 (0.50,0.52)	0.51 (0.50, 0.52)	0.074
WHR[a]	0.92 (0.91, 0.93)	0.89 (0.87, 0.91)	0.92 (0.91,0.92)	0.002
Pre-diabetes	73 (22.12)	16 (31.4)	89 (23.4)	0.146
Diabetes[b]				
Known	10 (3.0)	01 (1.9)	13 (3.4)	
Newly known	05 (1.5)	01 (1.9)	05 (1.3)	0.841
Pre-hypertension	126 (38.2)	24 (47.1)	150 (39.4)	0.227
Hypertension[b]				
Known	21 (6.4)	03 (5.9)	24 (6.3)	
Newly known	24 (7.3)	05 (9.8)	29 (7.6)	0.694

Notes: [a]Data are expressed as mean with 95% confidence interval. [b]Data are expressed as n (%). [c]Chi-square test for categorical variables, Analysis of variance for continuous variables.

Abbreviations: BMI, body mass index; WC, waist circumference; WHR, waist-hip ratio; WHtR, waist height ratio.

metabolic risks except for WHtR and WHR with DBP which were non-significant.

The overall age-adjusted odds ratio of pre-HTN, HTN, pre-DM and DM for general obesity by BMI and central obesity defined by WC, WHtR, and WHR are shown in Table 6. WC was significantly associated and was the most sensitive for HTN (OR 5.14 $p < 0.001$), pre-DM (OR 4.03 $p < 0.001$) and diabetes (OR 3.29 $p < 0.02$). WHtR was significantly associated with pre-HTN (OR 2.690), HTN (OR 2.066) and diabetes (OR 1.855). However, BMI and WHR were found not to be significantly associated with the cardio-metabolic risks included in the multivariate and bivariate regression model respectively.

Discussion

This study is unique in investigating the association between anthropometric measures which includes central and general obesity and cardio-metabolic risk factors such

Table 2 Mean General Obesity/Body Mass Index (BMI) and the Prevalence of Pre-Obesity (25–29.9 Kg/M^2) and Obesity (≥ 30 Kg/M^2) by Gender and Age, Gondar, Ethiopia

Age Group	Men (N=330)				Women (N=51)			
	N	Mean (95% CI)*	N (%)		N	Mean (95% CI)	N (%)	
			Preobese	Obese			Preobese	Obese
25–35	219	23.1 (22.7,23.4)	41 (18.7)	5 (2.3)	28	24.0 (23.1,24.9)	6 (21.4)	1 (3.6)
36–45	82	24.1 (23.4,24.7)	26 (31.7)	3 (3.7)	10	27.0 (22.9,31.0)	3 (30)	3 (30)
46–55	29	24.4 (23.4,25.3)	11 (37.9)	3 (10.3)	13	24.7 (23.0,26.4)	3 (23.1)	1 (7.7)
Age adjusted	330	23.4 (23.1,23.7)	78 (23.6)	11 (3.3)	51	24.8 (23.8,25.8)	12 (23.5)	5 (9.8)

Notes: Values are presented as mean (95% confidence interval) and n (% among each gender) adjusted for age. *Significant difference in mean BMI between age groups in men.

Table 3 Mean of Measures of Central Obesity (CO) and the Prevalence of Central Obesity (WC, WHtR, WHR) by Age and Gender, N = 381(M = 330, F = 51) Gondar, Ethiopia

Age Group & Gender (N)	WC		WHtR		WHR	
	Mean (95% CI)	CO by WC, n (%)	Mean (95% CI)	CO by WHtR, n (%)	Mean (95% CI)	CO by WHR, n (%)
Men						
25–35 (219)	86.8 (85.9,87.7)	51 (23.3)	0.52 (0.51,0.52)	101 (46.1)	0.92 (0.91,0.93)	116 (53)
36–45 (82)	89.6 (88.1,91.1)	35 (42.7)	0.53 (0.52,0.54)	52 (63.4)	0.94 (0.92,0.95)	57 (69.5)
46–55 (29)	94.2 (90.9,97.6)	17 (58.9)	0.56 (0.53, 0.57)	23 (79.3)	0.96 (0.92,0.99)	21 (72.4)
Age adjusted	88.2(87.4,88.9)*	103 (31.2)*	0.52 (0.51, 0.53)*	1 (53.3)*	0.93 (0.92,0.94)*	194 (58.8)*
Women						
25–35 (28)	80.8 (78.5,83.0)	10 (35.7)	0.50 (0.49,0.52)	9 (32.1)	0.87 (0.85, 0.90)	13 (46.4)
36–45 (10)	82.6 (78.2,86.9)	6 (60)	0.51 (0.48,0.54)	5 (50)	0.92 (0.87, 0.97)	7 (70)
46–55 (13)	84.0 (81.1,86.9)	9 (69.2)	0.53 (0.51,0.55)	8 (61.5)	0.93 (0.88, 0.97)	9 (69.2)
Age adjusted	81.9 (80.3,83.5)	25 (49)	0.51 (0.50,0.52)	22 (43.1)	0.90 (0.88, 0.92)	29 (56.9)

Notes: *$p < 0.05$, central obesity by WC (M ≥94 cm, F ≥80 cm), central obesity by WHtR (M & F ≥ 0.50) and central obesity by WHR (M ≥ 0.90, F ≥ 0.85). Values are presented as mean (95% confidence interval) and n (%) adjusted for age.
Abbreviations: M, male; F, female; CI, confidence interval; CO, central obesity; WC, waist circumference; WHtR, waist-to-height ratio; WHR, waist-to-hip ratio.

as Diabetes Mellitus and hypertension among the university academic employees in Ethiopia. This study results revealed a variable prevalence between general obesity (27.8%) and the anthropometric indices (IDF cutoff) defining central obesity; WC, WHtR and WHR were 33.6%, 52%, and 58.5% respectively among the participants. In the current study more than half of all adults with excess body fat defined by WC, WHtR, and WHR were defined as non-obese according to BMI, which shows the possible bias associated with the use of BMI and underestimates of obesity and higher sensitivity of measures of central obesity in the study population.

A higher prevalence of central obesity among the study participants and its association with pre-diabetes, diabetes, pre-hypertension, and hypertension explains that these comorbid conditions are reaching epidemic proportions in Ethiopia. Moreover, it is surprising to observe newly diagnosed diabetes (1.3%) and hypertension (7.6%) among the study samples given these populations attained higher literacy levels. This study also found that measures of central obesity defined by WC, and WHtR but not general obesity were strongly associated with cardio-metabolic risks in men and women. Though, the prevalence of WC was lower among measures of central obesity it showed the strongest association with HTN, pre-DM and DM while WHtR showed association with pre-HTN, HTN, and DM in our study participants. This is very unlike the findings reported elsewhere, while the difference could be explained by the uniqueness of the stature of Ethiopians.[31]

Our study revealed that there is a high prevalence of pre-obesity among males (29.4%) and females (24.8%) using BMI measurement. On the contrary, the prevalence of obesity among men and women was 5.4% and 11.5% respectively. This is rather an intriguing finding and

Table 4 Cardio-Metabolic Risk Factors Difference Based on General Obesity, Central Obesity by WC, Central Obesity by WHtR and Central Obesity by WHR in Academic Employees University of Gondar, Ethiopia

Cardio-Metabolic Factors	General Obesity BMI		CO by WC		CO by WHtR		CO by WHR	
	Non-Obese	Obese	Non-Obese	Obese	Non-Obese	Obese	Non-Obese	Obese
Men								
SBP	122.1±7.5	127.5±8.7*	120.3±5.3	129.3±8.1*	119.1±3.9	126.7±8.6*	119.6±4.8	125.6±8.5*
DBP	78.7±3.6	80.8±4.5*	78.3±3.4	81.4±4.3*	77.6±2.7	80.7±4.2*	77.8±2.8	80.3±4.2*
Pre HTN	81 (33.6)	45 (50.6)*	74 (32.6)	52 (50.5)*	36 (23.4)	90 (51.1)*	36 (26.5)	90 (46.4)*
HTN	21 (8.7)	24 (27)*	10 (4.4)	35 (34)*	4 (2.6)	41 (23.3)*	5 (3.7)	40 (20.6)*
FBG	89.9±9.1	94.4±11.5*	86.1±8.1	99.1±11.1*	85.8±8.4	95.0±15.1*	86.1±8.7	94.0±15.0*
Pre DM	39 (16.2)	34 (38.2)	13 (5.7)	60 (58.3)*	6 (3.9)	67 (38.1)*	6 (4.4)	34.5 (28.9)*
DM	12 (5.0)	3 (3.4)	3 (1.3)	12 (11.7)*	3 (1.9)	12 (6.8)*	3 (2.2)	12 (6.2)*
Women								
SBP	123.9±9.7	123.4±7.2	119.7±4.7	127.9±9.6*	121.1±6.8	127.1±9.5*	120.2±5.7	126.3±9.5*
DBP	80.6±4.3	79.7±2.7	78.7±2.2	81.8±4.2*	79.9±3.7	80.6±3.6	79.6±3.6	80.6±3.7
Pre HTN	14 (50)	10 (43.5)	8 (33.3)	16 (64)*	10(34.5)	14(63.6)*	7 (31.8)	17 (58.6)*
HTN	6 (21.4)	2 (8.7)	1 (3.8)	7 (28)*	3 (10.3)	5(22.7)	2 (9.1)	6 (20.7)
FBG	90.2±11.4	93.1±13.5	84.1±2.	99.2±13.8*	86.6±6.5	98.0±9.1*	85.2±5.6	96.3±9.9*
Pre DM	7 (25)	9 (39.1)	0 (0.0)	16 (64)*	4 (13.8)	12 (54.5)*	2 (9.1)	14 (48.3)*
DM	1 (3.6)	1 (4.3)	0 (0)	2(8)	0 (0)	2 (9.1)	0 (0)	2 (6.9)

Notes: Values are presented as mean ± SD or N (%) adjusted for age as indicated. P < 0.05, (Chi-square for categorical and analysis of variance for continuous variable). *P < 0.05 between non-obese and obese in the same group.
Abbreviations: BMI, body mass index; WC, waist circumference; WHtR, waist-height ratio; WHR, waist-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; HTN, hypertension; FBG, fasting blood glucose.

Table 5 Correlation (r) Between Cardio-Metabolic Risk Factors with BMI, WC, WHtR, WHR and Age

Variables Sex Wise	BMI (r)	WC (r)	WHtR (r)	WHR (r)	Age (r)
Men					
SBP	0.388**	0.608**	0.582**	0.357**	0.499**
DBP	0.315**	0.477**	0.452**	0.366**	0.399**
FBG	0.282**	0.582**	0.511**	0.314**	0.443**
Age	0.275**	0.340	0.305**	185**	1
Women					
SBP	0.010	0.361*	0.366*	0.345*	0.430**
DBP	0.116	0.340*	0.264	0.152	0.323*
FBG	0.110	0.656*	0.633*	0.547**	0.264
Age	0.179	285*	0.278*	. 385**	1

Notes: **Significant at the level 0.001 (2-tailed), *significant at the level 0.05 (2-tailed).

reasons might be that the majority of the study participants were younger than 35 years old and may eventually become obese if not intervened.

The overall prevalence of overweight in the current study was 27.1%, which is much higher than a pooled prevalence of overweight of 15.9% reported in Demographic and Health Survey (DHS) of 32 Sub-Saharan African countries, ranging from 5.6% in Madagascar and 27.7% in Swaziland.[34] However, the prevalence of obesity defined by BMI in this study is within the range reported by the DHS study. According to the WHO 2016 report, the estimated prevalence of overweight or pre-obesity was 39% among men and 40% among women, while the estimated prevalence of obesity was 11% among men and 15% among women, which is much lower than the figures reported in this study.[35] Regardless, the trending of the prevalence of obesity in Ethiopia as reported by a previous study,[7] including this study requires attention. More interestingly, the obesity defined based on WC, WHtR and WHR were highly prevalent than defined by BMI. And it is worth to note that slender body framed Ethiopians have higher body fat at relatively low body mass index compared to study samples from other countries.[31] Systematic reviews of a large amount of high-quality and consistent evidence showing that the use of BMI to define obesity (the degree of excess body fat) might be highly specific, but has low to moderate sensitivity when compared with obesity defined by WC, WHtR, and WHR.[36,37]

The overall prevalence of hypertension and diabetes among the participants was 13.9% and 4.5% respectively. Among which a larger proportion of them was undiagnosed and thus untreated. In addition, this study also found that 39.4% of the participants were pre-hypertensive and based on IDF criteria 23.4% were pre-diabetic which

Table 6 Multivariate Analysis Adjusted Odds Ratio of Pre-DM, DM, Pre-Hypertension and Hypertension for General Obesity (BMI) and Central Obesity Measures (WC, WHtR, WHR) Among Men and Women Academic Employees of UOG, Ethiopia

	General Obesity BMI	Central Obesity by WC	Central Obesity by WHtR	Central Obesity by WHR
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Pre HTN	1.14 (0.633, 1.77)	1.33 (0.737, 2.03)	2.690 (1.49, 4.58)**	1.369 (0.781, 2.40)
HTN	1.24 (0.626, 2.328)	5.14 (2.503, 9.72)**	2.066 (1.008, 6.31)*	1.119 (0.778, 3.38)
Pre DM	1.17 (0.570, 2.398)	4.03 (2.974, 5.96)**	1.716 (0.864, 4.62)	1.620 (0.956, 4.68)
DM	1.45 (0.447, 4.727)	3.29 (1.099, 6.01)*	1.855 (0.76, 4.32)*	——

Notes: *p < 0.05, **p < 0.001, multi–variate logistic regression analysis adjusted for age. Anthropometric measures with significant OR value are in bold.
Abbreviation: CI, confidence interval.

implies that these people are at risk of developing HTN and diabetes in the future if not intervened early. The prevalence of hypertension reported in this study involving a healthy population is significantly higher than that of earlier reports in Ethiopia which were 7.1% and 1.8%[38,39] of two and three decades ago respectively which is suggestive of the ongoing salient rise in this country. The reasons for higher undiagnosed cardio-metabolic risks might be due to low health-seeking behavior among Ethiopians and if this is the case among the educated study population, it might be a major concern among the larger illiterate Ethiopian population.

However, the prevalence of hypertension reported in this study is lower than other community-based studies in Ethiopia which is 28.3%[40] and 30%.[41] The prevalence of diabetes in the current study is consistent with the growing body of regional evidence, particularly urban dwellers.[42,43] Unlike many other regional studies,[16,40,43,44] the odds of likely cardio-metabolic risks in this current study population is only explained by measures of central obesity and not by body mass index. Moreover, surprisingly WHtR which is proposed[45] as a good indicator of abdominal obesity (AO) and a better predictor of cardio-metabolic risk had lesser odds of likely cardio-metabolic risks than WC in our study participants. This might be due to over estimation because WC does not take height (risk of tall) into consideration while defining AO and unique morphology of Ethiopians. About 91% of the current study samples were aged between 25 and 45 years and hence, higher prevalence of prehypertension and impaired fasting glucose risks among them based on central obesity (WC and WHtR) as indicated in this study should stand as an alert for Ethiopia.

Although there is a variability of the prevalence of prediabetes reported in different literature,[46–48] our finding suggests that 23.4% of our study samples are prediabetic. This figure is slightly higher than a cross-sectional study conducted in Kenya 18% and 8.6% reported by a population study conducted in Uganda.[18,49] Likewise, our finding indicated a significantly higher prevalence of pre-hypertension among our samples when compared to a report from Iran 33.7%,[50] while it is lower than what is reported in a Nigerian study 45.5%.[46] This variability in the prevalence of pre-hypertension and pre-diabetes among different literature could be attributed to the population characteristics in the studies. Regardless, the finding from our study suggests that the necessity of designing health promotional activities that promote early health screening of cardio-metabolic risks such as diabetes and hypertension. In addition, since the majority of patients with diabetes and hypertension would undergo a long time of pre-diabetes and pre-hypertensive duration, it is essential to design target interventions to either reverse or slow down the progression of these conditions before it becomes full-blown diabetes or hypertension.

This study has reported a well-powered insight into the prevalence of self-reported and measured hypertension and diabetes (impaired fasting glucose) and its relationship with anthropometric indices among urban-dwelling university teachers. In addition, this study also reported on the prevalence of measurement based pre-hypertension and pre-diabetes unlike the previous studies done in Ethiopia. For the benefits of future research few limitations are to be addressed. Since females are less represented in this study as a result of a low proportion of female academic employees at the University of Gondar, the results of this study should be interpreted with caution especially when policy decisions are made. The definition of measured DM and pre-DM is based on only impaired fasting glucose level and post-prandial glucose level was not measured. The results of this study must be interpreted with caution; the study samples were academic employees of the University of Gondar and thus the findings cannot be generalized to all Ethiopians. Due to the cross-sectional nature of the study, temporal relations could not be established between measure obesity and the cardio-metabolic risks. Its cross-sectional design was also limited in evaluating cause-and-effect associations. More importantly, in the absence of unequivocal hyperglycemia or subsequent day testing according to ADA guidelines, the diagnosis of DM based solely on FPG should be considered a provisional one. Despite these limitations, the findings from this study may strengthen the existing body of knowledge and also fill the gaps in the already limited data on cardio-metabolic risks in Sub-Saharan Africa and in the study area.

Conclusion and Recommendation

Despite the fact that this study adapted Europid cutoff to define central obesity, the findings of this study can alarm the epidemics of non-communicable diseases and obviate the need for Ethiopian cutoff to define central obesity. The expected rapid escalation of cardio-metabolic risks cannot be ruled out, particularly in Ethiopia, as it can destabilize the economy and health care cost which is still reeling from infectious diseases. However, it should be understood that anthropometric Europid cut-offs for detecting central obesity may not be appropriate for Ethiopians.

Previous studies outlined that cardio-metabolic risk factors disproportionately affect the less educated and poorer segment of the society which has been attributed to health-seeking behaviors.[11,39,42] In contrast, a systematic review of studies from Sub-Saharan African countries[47] indicated that increased wealth and better education were associated with an increased risk of diabetes in both male and female participants. Given this contrasting suggestion from literature and the high number of pre-hypertension and pre-diabetes among university staff in our study, we recommend future researchers to conduct comparative studies on the prevalence and risk factors of cardio-metabolic risk factors between the less educated, economically disadvantaged rural and the highly educated urban populations in Ethiopia. We also suggest that appropriate screen methods are put in place to mitigate the public health crisis that may arise from undiagnosed hypertension and diabetes.

Abbreviations

AO, abdominal obesity; AOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; DHS, Demographic Health Survey; DBP, diastolic blood pressure; EDHS, Ethiopian Demographic Health Survey; FBG, fasting blood glucose; FPG, fasting plasma glucose; IFG, impaired fasting glucose; IDF, International Diabetes Federation; METs, metabolic syndrome; NCDs, non-communicable diseases; SBP, systolic blood pressure; UDM, undiagnosed diabetes mellitus; WC, waist circumference; WHO, World Health Organization; WHtR, waist height ratio; WHR, waist hip ratio.

Ethical Approval and Consent to Participate

Ethical clearance was secured from the ethical review committee of the College of Medicine and Health Sciences, University of Gondar, Ethiopia. [Reference number of ethical approval: Ref/RPC312014]. Written consent was obtained from all participants prior to participation in the study.

Data Sharing Statement

Since this is funded work the raw data is the property of the University of Gondar and the data that are confidential cannot be made publicly available in order to protect participant's privacy. Data may be available to interested researchers upon formal request from the corresponding author.

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Author Contributions

BJ brought the original idea, was involved in the proposal writing, defending the proposal, securing grant, designed the study, and participated in all the implementation stages of the project. All the authors contributed to data analysis, drafting, and revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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