Diabetes, Metabolic Syndrome and Obesity

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ORIGINAL RESEARCH

Prevalence of Prediabetes and Related Modifiable Cardiovascular Risk Factors Among Employees of Ayder Comprehensive Specialized Hospital, Tigray, Northern Ethiopia

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Background: Prediabetes is considered an important risk factor for type 2 diabetes and related cardiovascular problems. However, evidence shows that both prediabetes and its associated cardiovascular risk factors could be mitigated through lifestyle modification. This study aims at determining the magnitude of prediabetes and related modifiable cardiovascular risk factors as an initial step towards undertaking such mitigation measures.

Methods: A cross-sectional study was conducted on employees of a tertiary care hospital from March to June/2019. Socio-demographic data were collected using a self-administered questionnaire. Anthropometric and blood pressure measurements were performed following WHO guidelines. Biochemical parameters were assayed following standard operating procedures. Categorical variables are summarized using frequencies and percentages. Normality test was performed ahead of describing the numeric data and log transformations were carried out when appropriate. International Diabetes Federation (IDF) and American Diabetes Association (ADA) criteria were used to classify glycemic status. Likewise, IDF and revised National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) were employed for the diagnosis of metabolic syndrome.

Results: In this study, we engaged a total of 265 employees. About 35.1% were males and 64.9% were females. The median age was 29 (9) years. About 5.7% and 18.1% had prediabetes based on IDF and ADA criteria, respectively. Equally, 3.4% had FBS levels that meet the criteria for overt diabetes on IDF and ADA. Besides, 55.1% had a metabolic risk as implied by the elevated waist-to-height ratio (WhtR), 24.2% had hypertriglyceridemia, 27.9% had above optimal LDL and 57% had low HDL. Overall, 17.9% and 21.9% of the participants had metabolic syndrome according to IDF and revised NCEP ATP III criteria, respectively.

Conclusion: The prevalence of prediabetes and metabolic syndrome observed in hospital employees is comparable with the general population.

Keywords: prediabetes, metabolic syndrome, hospital employees

Introduction

Prediabetes is a medical condition in which the blood glucose level is higher than the normal value but not high enough to meet the criteria for the diagnosis of diabetes mellitus.[1] It is characterized by a fasting plasma glucose level of 100 – 125 mg/dL and/or 140–199 mg/dL 2 hours after a 75 g oral glucose load. These conditions are known as impaired fasting glucose (IFG) and impaired glucose tolerance (IGT), respectively.[2] It is also defined by hemoglobin A1C levels of 5.7–6.4% as additionally introduced by the American Diabetes Association (ADA).[3]

Prediabetes produces no symptoms but it is a substantial risk factor for developing type 2 diabetes mellitus (T2DM) and its consequences.[4,5] It has been estimated that a prediabetic person is 5 to 15 times more likely to develop T2DM compared to a normoglycemic one.[6,7] Likewise, in comparison with adults who have normal

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glucose; people with IFG have a 2–3-fold increased risk of cardiovascular events, which are most marked in younger subjects.[8] Additionally, shreds of evidence show that some long-term damage to the body, especially the heart and circulatory system, may already be occurring during prediabetes.[9]

Nevertheless, studies report that for prediabetic patients, lifestyle modification can help prevent or reduce its progression to diabetes by 40–70%. This emphasizes the need for early diagnosis, initiating an evidence-based intervention, and close monitoring of cases.[10,11] Unfortunately, the majority of people have no idea that they have prediabetes as the condition develops gradually and without warning. The symptoms of T2DM are not necessarily obvious when someone becomes prediabetic. As a result, most individuals with the disease present late, when lifestyle measures can no longer avert the disease.[9]

Currently, the global population with prediabetes has reached approximately 318 million, accounting for 6.7% of the total adults. About 69.2% of these prediabetic population live in low- or middle-income countries (LMIC).[12] Being one of the LMIC, our continent Africa is facing this increasing burden. Contemporary estimates show the prevalence of prediabetes in Africa is about 7.9%.[13] If it is not intervened, this estimated prevalence is expected to double by 2040.[14]

In Ethiopia, the national prevalence was reported to be 5.4%.[15] Moreover, various institutional and community-based studies indicated an increasing prevalence of prediabetes. However, the magnitude varies with the weight of the implicated risk factors in a given target.[16,17] The situation among hospital employees is debatable. Some argue hospital staffs are particularly vulnerable to the condition because of the work circumstances that make them have interrupted sleep and spent large hours in a sedentary position. Others claim that they are supposed to be better aware of how to prevent it and hence could have less risk. Thus, the aim is to assess the prevalence of prediabetes and related modifiable CVD risk factors among employees of a tertiary care hospital in North Ethiopia.

Materials and Methods

Study Design, Setting, and Participants

A cross-sectional study was conducted at Ayder Comprehensive Specialized Hospital (ACSH), Mekelle, Ethiopia from March - June/2019. The study participants were apparently healthy employees of ACSH.

Sample Size

The sample size was calculated based on the prevalence of prediabetes indicated in a study conducted in North West Ethiopia, 19.5%.[16] The calculation was done using a single population proportion formula considering 5% tolerable error, 95% confidence level, and 10% non-response. Accordingly, the sample size was 265.

Data Collection Tools and Data Collectors

A self-administered structured questionnaire was utilized to collect socio-demographic and other relevant study variables. Two BSc nurses collected socio-demographic, anthropometric, and clinical data. Likewise, collection, processing, and analysis of biochemical data were carried out by two laboratory technologists. Both data collectors were well experienced and context-specific training was given to them for 1 day.

Anthropometric and Blood Pressure Measurement

Height was measured to the nearest 0.1 cm using SECA 877. Weight was also measured to the nearest 0.1 kg with light clothing using the same equipment. Waist circumference was measured using a constant tension tape across the umbilicus level. Similarly, hip circumference was measured at the highest extension of the buttock. Both measurements were carried twice and the average value was recorded. Obesity indices were computed from the physical measurements. Blood pressure was measured using a validated blood pressure machine (OMRON M2 device). Two readings were each taken for systolic blood pressure (SBP) and diastolic blood pressure (DBP) and the average was recorded.

Biochemical Measurement

Five mL whole-blood sample was collected to determine participants' fasting blood glucose levels and lipid profiles. The whole blood was allowed to clot for 30 min and get centrifuged at 2000 rpm for 5 min. Blood sugar was determined immediately using the enzymatic peroxidase method. Lipid profile parameters were measured from an aliquot of serum stored at −20°C.

Data Quality Management

To assert the quality of data, the questionnaire was pretested and the entire data collection process was strictly supervised. Moreover, the laboratory analysis was carried out in a properly calibrated analyzer (ABX Pentra C-400) with controls running alongside the subject sample for validating the process.

Data Analysis

SPSS version 20 was used for data entry and analysis. Categorical variables were summarized using frequencies and percentages. Normality was checked for numeric data. Normally distributed variables were described using the arithmetic mean (±SD). Non-Gaussian continuous variables were log-transformed and described using geometric mean and 95% confidence interval. Median and interquartile ranges were reported for continuous variables that remained non-Gaussian. International Diabetes Federation (IDF) and American Diabetes Association (ADA) criteria were used to classify glycemic status. Likewise, IDF and National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) were employed for the diagnosis of metabolic syndrome. The level of statistical significance was set at 5% ($p < 0.05$).

Ethical Considerations

This study was approved by the Institutional Review Board of College of Health Sciences, Mekelle University. Permission was acquired from Ayder Comprehensive Specialized Hospital (ACSH). Each participant provided informed consent and voluntarily gave a blood sample. There was no significant harm in connection with the volume of blood collected and the collection process. Participants with panic results were immediately linked to their physician. The study was conducted in accordance with the declaration of Helsinki.

Results

Socio-Demographic Characteristics of the Participants

The present study was conducted on a total of 265 participants. Their median age was 29 years. More than half were females 172 (64.9%). Both clinical and supportive staffs were represented with equitable proportions, Table 1.

Prevalence of Prediabetes and Related Modifiable CVD Risk Factors

In this study, 5.7% and 18.1% of the participants had prediabetes based on IDF and ADA criteria, respectively. Besides, 3.4% had their FBS values in the diabetic range (>126 mg/dl). The occurrence of IFG was found to increase with the age of participants, peaking at 40–49 years (Figure 1). Similar derangements were noted on lipid parameters. About 27.9% and 24.2% of the participants had LDL and triglyceride values above optimal. Conversely, 82.3% of males and 60.8% of females had low HDL. More than half, 55.1%, of the participants had an increased risk for central obesity, Table 2.

Overall, 17.4% and 21.9% of the participants had metabolic syndrome according to IDF and NCEP ATP III criteria, respectively. High-density lipoprotein (HDL) was the most deranged parameter, followed by WC (Figure 2). There was no huge difference among sexes with the prevalence of metabolic syndrome. However, individuals in the higher age category were found to have an increased proportion of metabolic syndrome on both criteria, Table 3.

Table 1 Socio-Demographic Characteristics of the Study Participants (n = 265)

Variables		Male, N (%)	Female, N (%)	Total, N (%)
Marital status	Married	41 (15.5)	100 (37.7)	141 (53.2)
	Single	51 (19.2)	56 (21.1)	107 (40.4)
	Divorced	0 (0)	13 (4.9)	13 (4.9)
	Widowed	1 (0.4)	3 (1.1)	4 (1.5)
Age	20–29	41(15.5)	95(35.8)	136(51.3)
	30–39	40(15.1)	55(20.8)	95(35.8)
	40–49	9(3.4)	16(6.0)	25(9.4)
	50–59	3(1.1)	6(2.3)	9(3.4)
Occupation	Nurse	29(10.9)	88 (33.2)	117 (44.2)
	Laboratory	8 (3.0)	9 (3.4)	17 (6.4)
	Pharmacy	6 (2.3)	11 (4.2)	17 (6.4)
	Physician	19 (7.2)	10 (3.8)	29 (11.0)
	Supportive	26 (9.8)	47 (17.7)	73 (27.5)
	Others	5 (1.9)	7 (2.6)	12 (4.5)
Educational status	Primary school (1–8)	0 (0.0)	6 (2.3)	6 (2.3)
	Secondary school (9–12)	2 (0.8)	14 (5.3)	16 (6.0)
	High-grade completed (college, University)	91 (34.3)	152 (57.4)	243 (91.7)
Monthly income, ETB	601–1650.00	6(2.3)	6(2.3)	12(4.5)
	1651.00–3200.00	17(6.4)	35(13.2)	52(19.6)
	3201.00–5250.00	26(9.8)	60(22.6)	86(32.5)
	5251–7800	30(11.3)	36(13.6)	66(24.9)
	7801–10,900	8(3.0)	23(8.7)	31(11.7)
	>10,900	6(2.3)	12(4.5)	18(6.8)

Abbreviation: ETB, Ethiopian Birr.

Discussion

The current study has assessed the occurrence of pre-diabetes and related cardiovascular risk factors among employees of a tertiary care hospital. Accordingly, pre-diabetes was found on 5.7% and 18.1% of the employees based on IDF and ADA criteria, respectively. Similarly, metabolic syndrome was observed on 17.9% and 21.9% of the participants according to IDF and revised NCEP ATP III criteria, respectively.

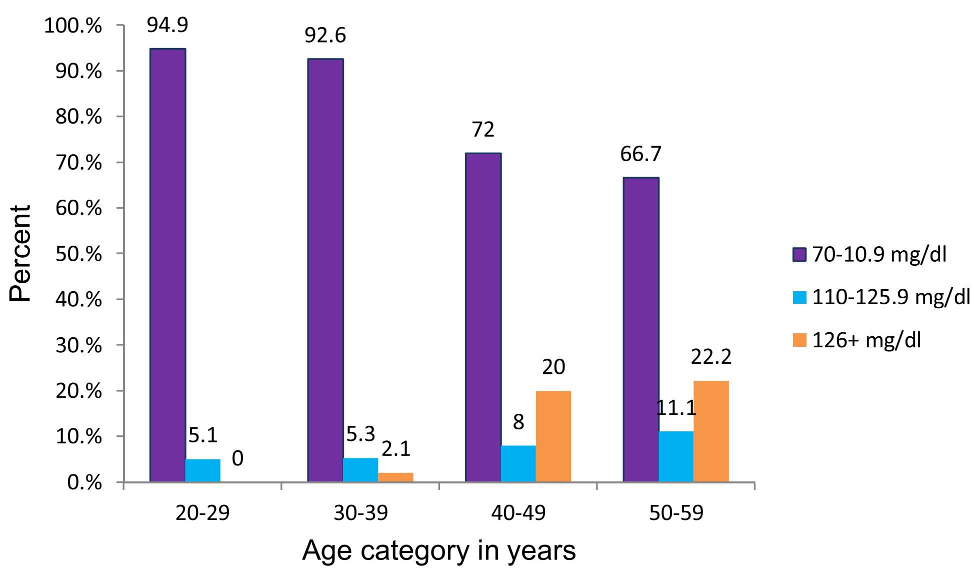

Figure 1 Fasting blood sugar levels across age categories (based on IDF).

Table 2 Anthropometric and Biochemical Characteristics of Participants by Glycemic Level (N= 265)

Feature		**FBS <110 mg/dl**	**FBS ≥110 mg/dl**	**Total**	**P. value**
BMI	21.36 (17.76, 25.69)*				
	<18.5 kg/m2	59 (24.5)	0 (00)	59 (22.3)	0.000
	18.5–24.9 kg/m2	148 (61.4)	15 (62.5)	163 (61.5)	
	≥ 25 kg/m2	34 (14.1)	9 (37.5)	43 (16.2)	
WC (male)	84.45 (74.05, 96.30)*				
	< 94 cm	197(94.7)	50 (87.7)	247 (93.2)	0.065
	≥ 94 cm	11 (5.3)	7 (12.3)	18 (6.8)	
WC (female)	80.61 (69.31, 93.76)*				
	< 80 cm	134 (64.4)	34 (59.6)	168 (63.4)	0.30
	≥ 80 cm	74 (35.6)	23 (40.4)	97 (36.6)	
WHR (male)	0.19 (0.13, 0.26)*				
	< 0.9 cm	176 (84.6)	44 (77.2)	220 (83)	0.13
	≥ 0.9 cm	32 (15.4)	13 (22.8)	45 (17)	
WHR (female)	0.18 (0.12, 0.28)*				
	< 0.85 cm	160 (76.9)	37 (64.9)	197 (74.3)	0.05
	≥ 0.85 cm	48 (23.1)	20 (35.1)	68 (25.7)	
WHtR	0.25 (0.20, 0.30)*				
	< 0.5	116 (48.1)	3 (12.5)	119 (44.9)	0.000
	≥ 0.5	125 (51.9)	21(87.5)	146 (55.1)	
SBP	112.3 (13.53)#				
	< 130 mmHg	222 (48.1)	20 (83.3)	242 (91.3)	0.141
	≥ 130 mmHg	19 (7.9)	4 (16.7)	23 (8.7)	
DBP	71.31(9.8)#				
	< 85 mmHg	224 (92.9)	23 (95.8)	247 (93.2)	0.499
	≥ 85 mmHg	17 (7.1)	1 (0.4)	18 (6.8)	
Total CHOL	156.31 (125.2, 195.1)*				
	< 200 mg/dl	216 (89.6)	20 (83.3)	236 (89.1)	0.259
	≥ 200 mg/dl	25 (10.4)	4 (16.7)	29 (10.9)	
LDL	84.55 (60.75, 117.67)*				
	< 100 mg/dl	176 (73)	15 (62.5)	191 (72.1)	0.193
	≥ 100 mg/dl	65 (27)	9 (37.5)	74 (27.9)	
HDL (male)	40.64 (32.65, 50.60)*				
	< 40 mg/dl	201 (83.4)	17 (70.8)	218 (82.3)	0.108
	≥ 40 mg/dl	40 (16.6)	7 (29.2)	47 (17.7)	
HDL (female)	47.63 (39.29, 57.74)*				
	< 50 mg/dl	149 (61.8)	12 (50)	161 (60.8)	0.18
	≥ 50 mg/dl	92 (38.2)	12 (50)	104 (39.2)	
TAG	100 (74.69, 133.88)*				
	< 150 mg/dl	149 (80.5)	7 (29.2)	201 (75.8)	0.00
	≥ 150 mg/dl	47 (19.5)	17 (70.8)	64 (24.2)	

Notes: * Geometric mean (95% confidence interval), #Arithmetic mean (Standard deviation), frequency (%).

Abbreviations: BMI, body mass index; WC, waist circumference; WHR, Waist to hip ratio; WHtR, Waist to height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; CHOL, cholesterol; LDL, lowdensity lipoprotein; HDL, High density lipoprotein; TAG, Triacylglycerol.

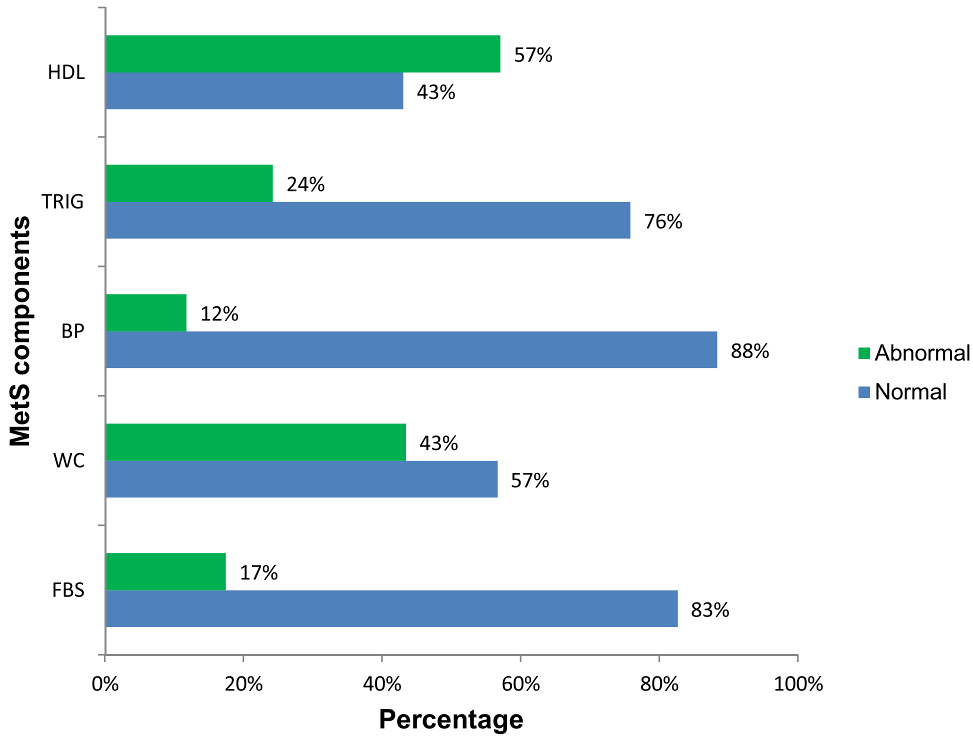

Figure 2 Prevalence of derangement among components of metabolic syndrome (IDF).

The marked variation in the frequency of pre-diabetes between the WHO/IDF and ADA cut-offs is due to the differences in setting up the upper limit. WHO/IDF chose to keep the upper limit for normal FBS at 110 mg/dl while ADA is set at 100 mg/dl. Both organizations have their rationales. The ADA cut-off allows early identification of cases and swift management of pre-diabetes. The higher cut-off on WHO/IDF minimizes cases diagnosed with pre-diabetes so that cost of intervention fits with the capacity of resource-constrained countries.[18,19] However, an FPG level of 100 mg/dl and higher is correlated with a higher occurrence of diabetes-related complications in

Table 3 Prevalence of Metabolic Syndrome by Classification Criteria, Sex, Age Category, and Glycemic Level (n=265)

Features		**IDF Criteria**		**Revised NCEP ATP III Criteria**	
		No MetS	**MetS**	**No MetS**	**MetS**
Overall		219 (82.6)^	46 (17.4)	207 (78.1)	58 (21.9)
Sex	Male Female	81 (87.1) 138 (80.2)	12 (12.9) 34 (19.8)	71 (76.3) 136 (79.1)	22 (23.7) 36 (20.9)
Age category	20–39 40–59	201 (87) 18 (52.9)	30 (13) 16 (47.1)	191 (82.7) 16 (47.1)	40 (17.3) 18 (52.9)
FBS ADA	< 100 mg/dl	188 (90.4)	20 (9.6)	186 (89.4)	22 (10.6)
FBS IDF	≥100 mg/dl < 110 mg/dl ≥110 mg/dl	31 (54.4) 209 (95.4) 10 (4.6)	26 (45.6) 32 (69.6)	21 (36.8) 201 (97.1) 6 (2.9)	36 (63.2) 40 (69) 18 (31)

Note: ^- frequency (%).
Abbreviations: FBS, Fasting blood sugar; ADA, American Diabetes Association; IDF, International Diabetes Federation.

several studies.[19] Moreover, offering education on lifestyle modification poses less economic harm compared to the potential benefits of reversing it before becoming frank diabetes and putting individuals on chronic care. Hence, the discussion hereafter is based on the ADA result.

The 18.1% prevalence of pre-diabetes observed in this study is in line with the 15.7% revealed among healthcare professionals in Poland and 22.3% among administrative staff in Southern Nigeria.[20,21] However, it is much lower than the 51% among Armed Forces Hospital employees in Kuwait.[22] The exceedingly higher prevalence in the latter study is because it was carried out among professionals who had a high risk for diabetes. However, the current result is similar to findings found from population studies in Ethiopia,[23,24] China,[25] Uganda,[26] and Bangladesh.[27] However, the findings are higher than those from other studies in Ethiopia,[28] Tanzania and Uganda,[29] Canada,[30] and lower than those from Oman,[31] Iraq,[32] Saudi males,[33] China,[34] and Ecuador.[35] This could be explained by genetic, socio-demographic, duration of T2DM, and lifestyle differences.

It is understood that people with pre-diabetes have an increased risk of progression to T2DM.[1,36] Evidence shows that people with IFG or IGT develop frank T2DM at a rate of approximately 5% per year. The risk appears similar to either IFG or IGT and is highest when people have both simultaneously.[1] In this study, 3.4% of the employees had diabetes. This result is concordant with the 3.7% observed among hospital administrative staff in South Nigeria.[21] Nevertheless, it is lower than the prevalence revealed among health-care workers in Poland.[20] The observed difference could be due to variation in health checking behavior among African and Western societies. Westerners routinely check their status and take deterrent measures early.

Blood glucose in the pre-diabetic range is modestly correlated with many risk factors, including central obesity, blood pressure, triglyceride, and lipoprotein levels.[37] As a consequence, the strength of the glycaemia effect itself depends on the extent to which related vascular risk factors exist.[10] In this study, an overall 17.9% and 21.9% of the participants had metabolic syndrome according to IDF and revised NCEP ATP III criteria, respectively. This is concurrent with the 15.4% and 15.5% IDF-based prevalence in Nigeria[38] and multi-center study in Latin America[39] and 22.4% and 24.2% metabolic syndrome on NCEP ATP III-based criteria in Iran and Nigeria, respectively.[40,41]

However, it is lower than the 12% prevalence of metabolic syndrome in Taiwanese hospital employees as stated based on American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) criteria.[42] The lower prevalence in this particular study could be due to the consideration of a relatively higher waist circumference cut-off (≥102 for male and ≥88 for female) as compared to the ≥94 cm and ≥80 cm in the IDF criterion.[43] Similarly, the present finding is lower than the overall MetS prevalence of 12.8%, 16.2% in males, and 11.6% in females, among workers in a university hospital in Brazil. This could be because the participants in this particular study were predominantly females, 72.4%, as the rate in males was comparable enough to the current report.[44] In general, despite the young age and presumed better awareness, a significant proportion of the employees had metabolic syndrome. This could be due to excessive workloads, extended working hours, and shift work the health-care workers experience as demonstrated in other studies (46–48).

Limitations

Purposive selection of the study site was one shortcoming. Another limitation is that the glycemic status was determined based on a single fasting blood glucose measurement. Hence, misclassification due to transient fluctuations might have occurred.

Conclusion

A notable proportion of the employees had pre-diabetes and metabolic syndrome, which are comparable to the prevalence observed in the general population. Hence, health institutions should establish a healthy workplace and encourage employees to be role models in adopting healthy behavior and having regular health checkups.

Abbreviations

ADA, American Diabetes Association; American Heart Association/National Heart; Lung; and Blood Institute (AHA/NHLBI); BMI, body mass index; DBP, diastolic blood pressure; ETB, Ethiopian birr; FBS, fasting blood sugar; FPG, fasting plasma glucose; HgA1, hemoglobin A1c; HDL, High, density lipoprotein; IDF, International Diabetes Federation; IGT, Impaired glucose tolerance; IFG, Impaired fasting glucose; LDL, low, density lipoprotein; LMIC, low, or middle, income countries; NCEP ATP III, National Cholesterol Education Program Adult treatment panel III; OGTT, oral glucose tolerance test; SBP, systolic blood pressure; TAG, triacylglycerol; T2DM, type 2 diabetes mellitus; WC, waist circumference; WHtR, waist-to-height ratio; WHR, waist-to-hip ratio; WHO, World Health Organization.

Data Sharing Statement

The data set concerning the main finding is contained in this article. However, it can also be obtained from the corresponding author upon reasonable request.

Consent to Publish

Study participants have provided written informed consent regarding the publication of this article.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval for the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that they have no conflicts of interest for this work.

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