

Comorbidity of Hyperglycemia and Dyslipidemia among Factory Workers: A Study on the Interrelationship of Metabolic Disorders in Occupational Settings

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Abstract

Background: Hyperglycemia, characterized by elevated blood glucose levels, often leads to diabetes mellitus and severe complications if unmanaged. Globally, hyperglycemia is a pressing public health issue, exacerbated by increasing diabetes prevalence. In sub-Saharan Africa, including Ghana, the rise in diabetes cases is alarming, necessitating urgent health interventions. Concurrently, dyslipidemia, marked by abnormal lipid levels, contributes significantly to cardiovascular diseases. This study aims to investigate the comorbidity of hyperglycemia and dyslipidemia among factory workers in an urban center in Ghana, providing insights into this high-risk group's health status.

Methods: Conducted between January 2023 and December 2023 at a food processing factory in Tema, Ghana, this cross-sectional study included 230 participants. Blood samples were analyzed for glucose and lipid profiles using automated chemistry analyzers. Statistical analyses were performed using SPSS software to assess glucose and lipid parameters, and their prevalence was compared across age and gender groups.

Results: The study revealed a gender imbalance with 93% males and 7% females. Most participants (62.2%) were over 40 years old. Hyperglycemia prevalence was 10.9%, predominantly affecting those over 40. Dyslipidemia was observed in 65.7% of participants, with low-density lipoprotein cholesterol (LDL-c) being the most prevalent abnormality. Comorbidity of both hyperglycemia and dyslipidemia was notably higher in individuals over 40 years.

Conclusion: This study highlights significant health issues among factory workers, including high rates of dyslipidemia and hyperglycemia, particularly in older adults. The findings underscore the need for targeted health interventions to manage these conditions and mitigate cardiovascular risk, emphasizing the importance of preventive measures and regular health screenings in occupational settings.

Keywords: Dyslipidemia, Hyperglycemia, Comorbidity, Diabetes mellitus, Lipid profile, Glucose, Cholesterol

Introduction

Hyperglycemia is a condition characterized by elevated levels of glucose in the blood. It typically occurs due to inadequate

insulin production by the body or the body's inability to use insulin effectively. Persistent hyperglycemia can lead to the development of diabetes mellitus and, if not properly managed, may result in serious complications [1]. Globally,

hyperglycemia is a significant public health concern, largely driven by the rising prevalence of diabetes mellitus. According to the International Diabetes Federation (IDF), approximately 537 million adults aged 20-79 years were living with diabetes in 2021, a number expected to rise to 783 million by 2045, and a substantial portion of these individuals experience episodes of hyperglycemia.

The growing incidence of diabetes mellitus worldwide, particularly in sub-Saharan Africa, highlights the urgency of addressing this epidemic. For instance, the number of people with diabetes in this region was projected to increase from 7 million in 2000 to 18 million by 2030, representing a 161% regional increase [2]. In Ghana, the age-adjusted prevalence of diabetes mellitus, impaired fasting glucose (IFG), and impaired glucose tolerance (IGT) were 6.4%, 6%, and 10.7%, respectively, among adults aged 25 years and above [2].

Dyslipidemia can result from intrinsic factors, such as genetic predisposition, extrinsic factors, or a combination of both. Primary dyslipidemias are a heterogeneous group of genetic diseases with monogenic or polygenic etiologies, while secondary dyslipidemias arise from the interaction of risk factors with external influences or other pathologies [3]. It has been noted that dyslipidemia is a primary contributor to atherosclerotic plaque formation, with up to 75% of patients with coronary artery disease (CAD) exhibiting dyslipidemia [4]. However, normalizing lipid levels can reduce the incidence of symptomatic CAD and improve overall survival.

Dyslipidemia is strongly associated with the recurrence of symptomatic CAD, and patients with type 2 diabetes mellitus are at an increased risk of cardiovascular morbidity and mortality. The significant increase in fasting blood sugar, HbA1c, and alterations in protective HDL and harmful LDL levels in diabetic patients compared to controls indicate that individuals with type 2 diabetes are at a higher risk for coronary heart disease (CHD) [5]. Hyperglycemia and dyslipidemia are therefore critical risk factors for diabetes-accelerated atherosclerosis, with macrophage proliferation playing a key role in the progression of atherosclerosis [6].

Alterations in critical genes responsible for glucose and lipid metabolism may be present in individuals from developing regions [7]. The anti-aging gene Sirtuin 1 plays a key role in maintaining glucose balance and regulating insulin production in the pancreas [8]. When Sirtuin 1 is suppressed, it disrupts liver lipid metabolism, contributing to the development of non-alcoholic fatty liver disease (NAFLD) [9]. Interventions such as low-calorie diets, exercise, and activators are necessary to reverse NAFLD and lower glucose and lipid levels [10]. Additionally, in the context of calorie restriction, regulating the Sirtuin 1 gene has become an essential strategy for managing glucose and cholesterol, as well as reversing chronic conditions like obesity, diabetes, and neurodegenerative diseases in populations worldwide [11].

Ghana faces a significant burden of diabetes, with regional and urban-rural variations. Effective and efficient interventions are urgently needed to prevent the anticipated increase in the disease burden, utilizing existing evidence and priority-setting tools like the Health Technology Assessment (HTA) [12]. In the factory sector, many energetic adults may unknowingly live with high glucose levels, unaware of the negative impacts on their health. This study aims to determine the comorbidity of dyslipidemia and hyperglycemia among selected factory workers, which is essential for identifying high-risk individuals, improving workplace health, informing public health strategies, and contributing to the body of occupational health research. It is believed that the findings can lead to more effective health interventions, better resource allocation, and ultimately, improved health outcomes for factory workers.

Materials & Methods

Study site

This study was conducted at a food processing factory in the Tema Municipality. Tema is a city on the Bight and the Atlantic Coast of Ghana.

Study design

This was a cross-sectional study and was carried out between January 2023 and December 2023.

Study population

This study involved 202 factory workers between the ages of 19 – 60 years.

Inclusion criteria

Participants aged 18 years and above. Current full-time factory workers with a minimum of one year of employment in the same factory. Individuals without documented or self-reported hyperglycemia (elevated blood glucose levels) or dyslipidemia (abnormal lipid levels) diagnosed by a healthcare professional. Willingness to provide informed consent to participate in the study.

Exclusion criteria

Individuals under 18 years of age. Individuals employed in non-factory settings or part-time factory workers with less than one year of employment. Individuals with pre-existing chronic conditions unrelated to metabolic disorders (e.g., cancer, chronic kidney disease) may confound the study results. Pregnant women, due to the altered metabolic states associated with pregnancy. Individuals currently on medications that significantly alter glucose or lipid metabolism, unless these are specifically for treating hyperglycemia or dyslipidemia. Individuals were unwilling to provide informed consent or participate in all aspects of the study, including follow-up assessments.

Sampling procedure

Five milliliters (5 ml) of blood were collected aseptically from each participant into a serum separator tube and transported to the laboratory immediately for analysis. Each sampling bottle was properly labeled for easy identification. Samples that were not analyzed immediately were spun with the serum separated and refrigerated between 2.8°C and processed within 72 hours after collection.

Procedure for glucose and lipid profilea

A fully Automated Chemistry Analyzer (Mind ray) was used for the assay. After properly calibrating the analyzer by selecting the appropriate wavelength, and checking the reagent’s expiry date, a serum sample was obtained from the serum separator tube after the blood was allowed to clot and centrifuged at 2,500 rpm for 5 minutes. The serum was then transferred to a plain tube, labeled for easy identification, and placed on the analyzer’s sample rack. The appropriate tests (Glucose and Lipid Profile) were selected on the computer, and the start button was clicked to run the samples in the analyzer, with results obtained at the appropriate time.

Principle of tests conducted

Total cholesterol: Cholesterol is measured enzymatically in serum or plasma in a series of coupled reactions that hydrolyze cholesteryl esters and oxidize the 3-OH group of cholesterol. One of the reaction byproducts, H₂O₂ is measured quantitatively in a peroxidase catalyzed reaction that produces a color. Absorbance is measured at 500 nm, and the color intensity is proportional to cholesterol concentration [13].

Triglycerides: Triglycerides are measured enzymatically in serum or plasma using a series of coupled reactions in which triglycerides are hydrolyzed to produce glycerol. Glycerol is then oxidized using glycerol oxidase, and H₂O₂, one of the reaction products, is measured as described above for cholesterol. Absorbance is measured at 500 nm.

Glucose test: Glucose oxidase (GOD) oxidizes glucose to gluconic acid and hydrogen peroxide. In the presence of Peroxidase (POD), released hydrogen peroxide is coupled with phenol and 4aminoantipyrine to form Quinoneimine dye. The absorbance of the pink-colored dye is measured at 505 nm and is directly proportional to the glucose concentration in the sample [14].

Reference ranges: According to the World Health Organization [15]. The normal reference ranges for fasting blood glucose are said to be 3.5 mmol/L to 5.2 mmol/L. Also, the normal reference range for lipid profile is, Total cholesterol (3.5 mmol/L – 5.5 mmol/L), Triglycerides (0.8 mmol/L-1.7 mmol/L), High Density Lipoproteins (0.9 mmol/L-1.5 mmol/L), Low Density Lipoprotein (2.2 mmol/L- 3.3 mmol/L).

Statistical analysis

The data was transferred into Microsoft Access and then analyzed using statistical package for social science (SPSS) software. The data was also presented in tables and diagrams as necessary. All analyses were based on the stated objectives.

Results

Demographic information of respondents

The study examined 230 participants, with a notable gender disparity where 214 were males comprising 93.0% and only 16 were females, representing 7% of the total. This indicates a significant imbalance in gender representation which is due to the fact that factory workers (the study cohort) are predominantly males. The participants were divided into two groups based on age: below 40 years and above 40 years. Those below 40 years were 87 (37.8%) and those above 40 years, comprised 143 (62.2%) as seen in **Table 1**.

Table 1. Age and gender distribution of participants.		
Variable	Frequency	Percent (%)
Gender		
Male	214	93%
Female	16	7%
Total	230	100%
Age		
Mean age ± SD	42.8 ± 6.9 yrs.	
Age group		
Below 40 yrs	87	37.8%
Above 40 yrs	143	62.2%
Total	230	100.0%

Descriptive analysis of glucose and lipid profile parameters among study participants

From the descriptive analysis, it was seen that the mean fasting blood glucose level across all participants was 5.06 mmol/L with the males showing a slightly lower average of 5.05 mmol/L, while females exhibited a slightly higher average of 5.23 mmol/L. In terms of age categorization, the participants above 40 years had a higher average of 5.37 mmol/L compared to those below 40 years, who averaged 4.55 mmol/L.

With the total cholesterol, the mean level among all participants was 5.36 mmol/L with males averaging 5.33 mmol/L and females with a slightly higher average of 5.74 mmol/L. Age did not significantly affect total cholesterol levels, with both below 40 years and above 40 years groups showing averages of 5.32 mmol/L and 5.38 mmol/L, respectively.

Both males and females exhibited similar mean triglyceride levels, with males at 1.03 mmol/L and females slightly higher at 1.16 mmol/L. Likewise, age did not show significant variation, with the below 40 years group averaging 0.98 mmol/L and the above 40 years group averaging 1.08 mmol/L. The mean HDL level was consistent across gender and age groups, with both males and females showing similar averages of 1.44 mmol/L and 1.45 mmol/L, respectively indicating a relatively uniform distribution of HDL levels among participants. With LDL, the males exhibited a slightly lower average level of 3.44 mmol/L compared to females, who averaged 3.81 mmol/L. Similar to HDL, age did not significantly affect LDL levels, with both below 40 years and above 40 years groups showing comparable averages (**Table 2**).

Urine glucose analysis of participants

The results show that, out of the total participants, 12 (5.2%) tested positive for urine glucose whilst the rest 215 (93.5%) tested negative, and 3 (1.3%) showed trace amounts. In the below 40 years age group, 2 (2.3%) participants tested positive for urine glucose, while 85 (97.7%) tested negative, and none showed trace amounts. For participants above 40 years old, 10 (7%) tested positive, 130 (90.9%) tested negative, and 3 (2.1%) showed trace amounts (**Table 3**).

Categorization of fasting glucose and lipid profile parameters

The categorization of glucose and lipid profile parameters among the study participants revealed that the majority

of participants, 87.4%, demonstrated normal fasting blood glucose levels, however, 12.6% exhibited abnormal levels, indicating a potential risk for glucose dysregulation. On the other hand, with the lipid profiles, the results showed that only 44.3% of participants fell within the normal range for total cholesterol, while 55.7% showed abnormal levels. Similarly, 55.2% had normal triglyceride levels, but 44.8% exhibited abnormal levels, suggesting potential lipid metabolism issues. Furthermore, while 52.6% of participants had normal levels of high-density lipoproteins (HDL), 47.4% showed abnormal levels. Additionally, 46.1% had normal levels of low-density lipoproteins (LDL), while 53.9% showed abnormal levels (**Figure 1**).

Prevalence of dyslipidemia of participants

The prevalence of dyslipidemia among the participants was categorized by gender and age group although gender disparity exists among the participants. The results show that out of the total number of participants, 79 (34.30%) had no dyslipidemia, while 151 (65.70%) were seen to have dyslipidemia. Among the male participants, 76 (33.00%) had no dyslipidemia, while 138 (60.00%) were diagnosed with dyslipidemia. Among the female participants, 3 (1.30%) had no dyslipidemia, while 13 (5.70%) were diagnosed with dyslipidemia. In terms of age, the below 40 years age group had 35 (15.20%) of the participants having no dyslipidemia, while 52 (22.60%) were diagnosed with dyslipidemia. In the above 40 years age group, 44 (19.10%) had no dyslipidemia, while 99 (43.00%) were diagnosed with dyslipidemia (**Figure 2**).

Table 2. Descriptive analysis on glucose and lipid profile parameters among study participants.					
Parameters	Overall	Gender		Age group	
		Male	Female	Below 40 yrs	Above 40 yrs
Fasting blood glucose (mmol/L)	5.06 ± 2.54	5.05 ± 2.47	5.23 ± 3.43	4.55 ± 1.73	5.37 ± 2.89
Total cholesterol (mmol/L)	5.36 ± 0.94	5.33 ± 0.92	5.74 ± 1.13	5.32 ± 0.95	5.38 ± 0.94
Triglycerides (mmol/L)	1.04 ± 0.52	1.03 ± 0.48	1.16 ± 0.94	0.98 ± 0.46	1.08 ± 0.56
High density lipoproteins (mmol/L)	1.44 ± 0.22	1.44 ± 0.21	1.45 ± 0.28	1.44 ± 0.23	1.45 ± 0.21
Low density lipoprotein (mmol/L)	3.47 ± 0.78	3.44 ± 0.75	3.81 ± 1.07	3.44 ± 0.83	3.49 ± 0.75

Table 3. Urine glucose analysis, categorized by gender and age group.			
Variable	Positive n (%)	Negative n (%)	Trace
Gender			
Male	11 (5.1)	200 (93.5)	3 (1.4)
Female	1 (6.3)	15 (93.8)	0 (0)
Age group			
Below 40 yrs	2 (2.3)	85 (97.7)	0 (0)
Above 40 yrs	10 (7)	130 (90.9)	3 (2.1)
Total	12 (5.2)	215 (93.5)	3 (1.3)

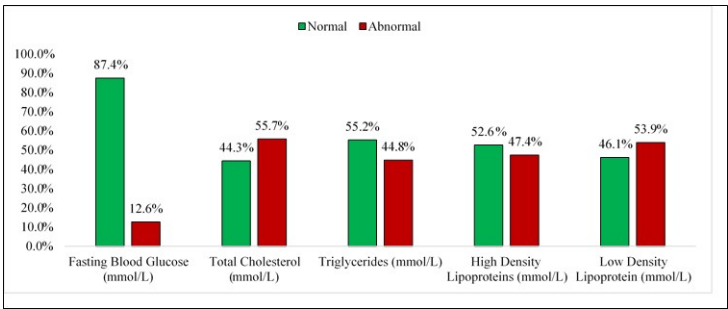


Figure 1. This figure shows the categorization of Glucose and Lipid Profile Parameters amongst the study participant.

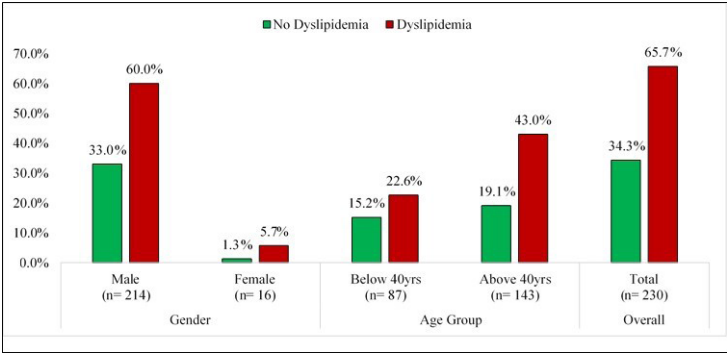


Figure 2. This figure shows the prevalence of dyslipidemia amongst the study participants.

Prevalence of hyperglycemia amongst the participants

The results of the study show that out of the total number of participants, 205 (89.10%) made up of 191 (83.00%) males and 14 (6.10%) females had no hyperglycemia, while 25 (10.90%) consisting of 23 (10.00%) males and 2 (0.90%) females were diagnosed with hyperglycemia. In relation to age, 84 (36.50%) of those below the 40 years age group, had no hyperglycemia, while 3 (1.30%) were diagnosed with hyperglycemia. In the

above 40 years age group, 121 (52.60%) had no hyperglycemia, while 22 (9.60%) were diagnosed with hyperglycemia (**Figure 3**).

Pattern of dyslipidemia among participants

It was seen that low-density lipoprotein cholesterol (LDL-c) was the most prevalent isolated dyslipidemia, affecting 63.00% of the participants, followed by high-density lipoprotein

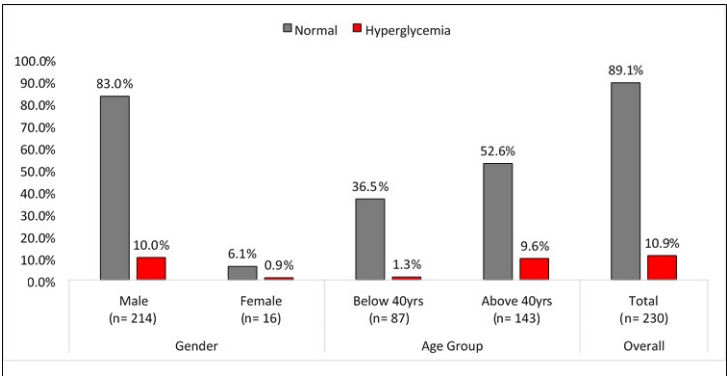


Figure 3. This figure shows the prevalence of hyperglycemia among the participants.

cholesterol (HDL-c) and high triglycerides (TG-c). In terms of combined dyslipidemia, high LDL-c and high TG-c, were more prevalent than the others (Table 4).

Comorbidity of both dyslipidemia and hyperglycemia among the participants

From the results obtained, a greater number of the participants had dyslipidemia without hyperglycemia followed by those with no dyslipidemia and hyperglycemia, dyslipidemia with hyperglycemia, and those with hyperglycemia without dyslipidemia (Table 5).

Discussion

The current study involved 230 participants, with a notable gender imbalance skewed towards males. This disparity is attributed to the fact that the majority of individuals at the facility (factory) where the participants were recruited are male. This aligns with earlier studies that have documented

higher male participation rates in research related to diabetes and dyslipidemia [16,17]. Acquah *et al.* also reported similar gender imbalances in their study on hyperglycemia in rural Ghana [2].

In terms of age distribution, a greater proportion (62.2%) of participants were over 40 years old, while 37.8% were younger than 40. The overrepresentation of older participants in this study contrasts with findings from other research that may have a more balanced age distribution [18].

The overall prevalence of hyperglycemia in the study was 10.9%, which is consistent with similar findings in Ghana reported by Jeannis *et al.* [19]. It was also observed that a higher proportion of participants with hyperglycemia were over 40 years old compared to those under 40. This outcome is similar to a study conducted by Gazzaz *et al.*, which found that 95.4% of participants with T2DM were over 40 years old [20]. This highlights the growing burden of hyperglycemia in this age group, likely due to the decline in glucose metabolism

Table 4. Pattern of dyslipidaemia in male and female.			
Dyslipidemia	Male n (%)	Female n (%)	Total n (%)
Isolated dyslipidemia			
High LDL-c	133 (57.8)	12 (5.2)	145 (63)
Low HDL-c	24 (10.4)	5 (2.2)	29 (12.6)
High TG-c	19 (8.3)	2 (0.9)	21 (9.1)
Combined dyslipidemia			
High LDL-c + High TG-c	18 (7.8)	1 (0.4)	19 (8.3)
High LDL-c + Low HDL-c	22 (9.6)	4 (1.7)	26 (11.3)
High TG-c + Low HDL-c	3 (1.3)	1 (0.4)	4 (1.7)
Mixed dyslipidemia			
High LDL-c + High TG-c + Low HDL-c	3 (1.3)	0 (0)	3 (1.3)
No dyslipidemia	76 (33)	3 (1.3)	79 (34.3)

Table 5. Comorbidity of both dyslipidemia and hyperglycemia amongst the participants.				
Parameters	No dyslipidemia and hyperglycemia	Hyperglycemia without dyslipidemia	Dyslipidemia without hyperglycemia	Dyslipidemia with hyperglycemia
Gender				
Male	73 (31.7)	3 (1.3)	118 (51.3)	20 (8.7)
Female	3 (1.3)	0 (0)	11 (4.7)	2 (0.9)
Total	76 (33.0%)	3 (1.3%)	129 (56.0%)	22 (9.6%)
Age group				
Below 40 yrs	34 (14.7)	1 (0.4)	50 (21.7)	2 (0.9)
Above 40 yrs	42 (18.3)	2 (0.9)	79 (34.3)	20 (8.7)
Total	76 (33.0%)	3 (1.3)	129 (56%)	22 (9.6%)

with age [21]. Additionally, the study showed that 8.3% of participants tested positive for urine glucose compared to the 10.9% who had high blood glucose levels. The difference between hyperglycemia and glycosuria could be due to variations in renal thresholds, timing of tests, and possible underlying renal dysfunction among participants. This finding aligns with previous research indicating that relying solely on urine glucose spot tests for diagnosing or monitoring diabetes is inadequate compared to blood glucose levels [19].

Regarding dyslipidemia, the study found a high prevalence of 65.7%, which is comparable to a retrospective study conducted in Saudi Arabia that reported a prevalence of 82.77% [20]. However, this contrasts with a multicenter hospital-based cross-sectional study in the Ashanti region of Ghana, which reported a lower prevalence of 34.7% [22]. In terms of age, those over 40 years had a higher prevalence of dyslipidemia (43%), compared to those under 40 years (22.6%). This can be attributed to the reduced metabolism of various lipid profile parameters by the liver with age.

The analysis of dyslipidemia patterns revealed that low-density lipoprotein cholesterol (LDL-c) was the most prevalent, affecting about 63% of participants. This was followed by high-density lipoprotein cholesterol (HDL-c) and high triglycerides (TG-c). When combined dyslipidemia was examined, LDL-c and TG-c were more prevalent than other lipid abnormalities (**Table 4**). Regarding lipid profile categorization, only a minority of participants had normal levels of total cholesterol (44.3%), triglycerides (55.2%), HDL (good cholesterol) (52.6%), and LDL (bad cholesterol) (46.1%). This widespread prevalence of dyslipidemia is consistent with a study by Ofori *et al.* that reported high dyslipidemia prevalence in Ghana [4]. Opoku *et al.* also found comparable dyslipidemia rates among rural and urban adults in China, underscoring the global significance of this health issue [23].

In terms of comorbidity, a larger number of participants had dyslipidemia without hyperglycemia, followed by those with hyperglycemia but no dyslipidemia, then those with both conditions and finally those with hyperglycemia without dyslipidemia (**Table 5**). Panjeta *et al.* suggested that dyslipidemia is more prevalent among male and older participants, especially when accompanied by hyperglycemia [3]. This highlights the need for targeted interventions to manage both dyslipidemia and hyperglycemia to reduce the risk of cardiovascular diseases in this population. Specifically, participants over 40 years old had a higher rate (8.7%) of having both dyslipidemia and hyperglycemia compared to those under 40 (0.9%). This finding aligns with a study by Sarfraz *et al.*, which stated that individuals over 40 years have a higher rate of dyslipidemia [6]. A limitation worthy of mention is the imbalanced gender representation, making comparison across genders difficult. Additionally, the study did not explore the causes of dyslipidemia and hyperglycemia, such as diet, physical activity, or family history.

Conclusion

The study of 230 participants revealed a significant gender imbalance, predominantly male, due to the recruitment location. The majority (62.2%) were over 40 years old. The overall prevalence of hyperglycemia was 10.9%, with a higher incidence in those over 40, reflecting age-related declines in glucose metabolism. Dyslipidemia was highly prevalent (65.7%), especially among older participants, with LDL-c being the most common lipid abnormality. The study also found that comorbid dyslipidemia and hyperglycemia were more common in participants over 40, underscoring the need for targeted interventions to manage these conditions and reduce cardiovascular risk.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Authors' Contributions

SAB - Conceptualized the study, prepared the original draft, and supervised the project. BTM - Conceptualized the study, curated the data, developed the methodology, and supervised the project. JO - Conducted the investigation, developed the methodology, curated the data, and performed formal analysis. DNOA - Curated the data, developed the methodology, and performed formal analysis. LA - Reviewed and edited the manuscript.

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