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THE RELATIONSHIP BETWEEN FOOD SECURITY, DIETARY INTAKE, PHYSICAL ACTIVITY LEVELS AND GLYCAEMIC STATUS OF ADULTS IN A PERI-URBAN COMMUNITY IN GHANA

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ABSTRACT

Purpose: *Diabetes is a serious global public health issue with increasing prevalence over the years especially in developing countries. This study assessed the relationship between food security, dietary intake, physical activity levels and blood glucose levels of adults in a peri-urban community in Ghana.*

Methodology: *In this cross-sectional study, 94 participants were recruited and quantitative data were collected using a structured questionnaire. Socio-demographics, anthropometry, fasting blood glucose (FBG), dietary intake, physical activity and food security data were collected.*

Findings: *Of the 94 eligible respondents aged 18 years and above, 37.2% were men while 62.8% were women. The mean age, BMI and FBG levels were 33.3 years, 26.8 kg/m^2 and 6.4 mmol/L respectively. About 27.7% of the participants were food insecure. Average calorie intake was 3244.20 kcal and this had a significant association with blood glucose status ($p < 0.001$). Prevalence of impaired fasting glucose was 71.3% (range: FBG = 5.7 - 6.9 mmol/L) and 19.1% (range: FBG ≥ 7mmol/L) in the prediabetes and diabetes range respectively. About 52.1% of the population were physically active with males being more physically active (54.3%) than females (50.8%). Total energy intake ($p < 0.001$) and BMI levels ($p = 0.009$) were significantly associated with the FBG levels. There was however no significant relationship between physical activity, food security and FBG.*

Conclusion: *Stakeholders should design plans to encourage a balanced diet, enough physical exercise, and a healthy weight in the municipality in order to curb the prevalence of prediabetes and type 2 diabetes in the study population.*

Keywords: Prediabetes, diabetes, body mass index, diet, physical activity

INTRODUCTION

A thorough understanding of the complex and multifaceted factors influencing diabetes development is necessary given the global rise in the disease and its related consequences. The International Diabetes Federation (IDF) estimates that 463 million persons worldwide had diabetes in 2019, and by 2045, that number is predicted to increase to 700 million (IDF, 2019). Diabetes is recognized as a public health concern that affects many people from many socioeconomic and racial origins in both industrialized and developing countries (Obirikorang *et al.*, 2016). Although the prevalence of diabetes has historically been lower across Africa, notably West Africa (Peer *et al.*, 2014), it is now rising as a result of urbanization, altered dietary practices, and rising obesity rates. Studies indicate that the prevalence of diabetes is rising in Ghana, occurring in 6.7% among persons aged 25 to 74 years in 2013 (Agyemang *et al.*, 2013). Projections from the International Diabetes Federation (IDF) have shown that the prevalence of diabetes will keep rising (IDF Atlas, 2021). It is anticipated that more than two-thirds of the increase in the prevalence of diabetes will occur in low- and middle-income countries, especially those in sub-Saharan Africa (George *et al.*, 2022; Wild *et al.*, 2004). Diabetes is linked to a number of risk factors, such as obesity, physical inactivity, high blood pressure, low HDL cholesterol, high triglyceride levels, and a history of gestational diabetes. In order to avoid or postpone the onset of type 2 diabetes and lower the risk of complications, early detection and management are essential (Tuei *et al.*, 2010).

Over the past few decades, developing countries like Ghana are experiencing rapid spate of urbanization (Ellahi *et al.*, 2022). For the first time in recent history, urban regions are home to 54% of the world's population (Ruel *et al.*, 2017). In 2018, the United Nation Human Settlement Program, dubbed UN-HABITAT, estimated the urban population of Ghana to be 54.8% with a steady growth rate of 4.2% per annum (UN-Habitat, 2018). According to the 2017 report by the Non-Communicable Disease Risk Factor Collaboration Africa (NCD-RisC-Africa), the rapid urbanization and economic growth in certain African countries have led to a significant rise in the middle class (Wang *et al.*, 2019). The rise in the middle class has resulted in increased disposable income, increased access to motorized transport and a shift away from low sugar, low fat and high fibre diets, known to protect against diabetes (Pretorius *et al.*, 2021). This has been associated with the rising rates of prediabetes and diabetes in developing settings like Ghana (Obirikorang *et al.*, 2016). Furthermore, the present-day environment, driven by economic expansion and technological advancements, promotes certain behaviors, like sedentariness and energy-dense diet, that contribute to obesity, which further exacerbates the burden of diabetes (Hills *et al.*, 2018; Van Rhoon *et al.*, 2020). Sedentary practices at the workplace, such as long sitting time, frequent automobile and elevator use, have been linked to diabetes (Charansonney & Després, 2010). Engaging in minimal physical activity throughout the workday contributes to a more sedentary lifestyle, which could in turn negatively impact glucose metabolism (Voss *et al.*, 2014). The preference for fast foods over homemade meals is commonly observed among individuals in the workforce due to work-related fatigue and time constraints. However, this trend presents a challenge as these readily available food options often contain excessive amounts of added sugars and fats/oils, leading to obesity and ultimately elevated blood glucose levels with negative implications for overall health and well-being (Banerjee *et al.*, 2020; Brennan, 2005). Research suggests that a significant portion of urban dwellers in developing nations experience food insecurity (Obayelu, 2018; Smith *et al.*, 2006). There is limited data on the impact of food insecurity on the rising rates of diabetes among urban residents in Ghana, a developing country. In light of this, a study was carried out in a Ghanaian municipal area to evaluate the impact of nutritional intake, physical activity, and food security on the glycaemic status of peri-urban people.

MATERIALS AND METHODS

Study Site

This study was conducted within the Ejisu and Juaben Municipalities, in the Ashanti region, Ghana. Ejisu and Juaben municipalities are rapidly urbanizing areas primarily due to their close proximity to Kumasi, the regional capital and the second largest city in Ghana. Middle class workers in Kumasi have been increasingly opting to reside in Ejisu and Juaben due to their proximity and relatively affordable housing (Quagraine & Opoku, 2021). In view of this, the Ejisu and Juaben municipalities were selected for this study which sought to assess the influence of food security, diet, and physical activity on glycaemic status in an urbanizing community.

Sample Size and Subjects

Adults (n=94) between the ages of 18-45 years who are residents of the Ejisu and Juaben municipalities were recruited for this study. The participants of this study were from Ejisu, Juaben, Fumesua, Bonwire and Kwamo. Using Ghana's 6.46% diabetes prevalence, as reported by Asamoah-Boaheng *et al.* (2019) the sample size was established using the Cochran formula.

Data collection and measurements

A structured questionnaire (S1)was utilized to get the socio-demographic data, whereas a standardized questionnaire was employed to gather information on food security, dietary intake, and physical activity levels.

Anthropometric Measurements

Body weight was measured using an Omron Body Composition Analyzer scale (HBF-514C, China) to the nearest 0.1 kg without footwear. Height was measured using the Seca 213 Stadiometer (CE0123 Germany). The Body Mass Index (BMI) was computed as BMI = weight (kg)/height^2 (m^2). BMI of less than 18.5 kg/m^2 was classified as underweight, 18.5 kg/m^2 to 24.9 kg/m^2 as normal, 25.0 kg/m^2 to 29.9 kg/m^2 as overweight and 30 kg/m^2 or higher was used to describe general obesity (World Health Organization, 2010). A non-stretchable measuring tape called the Scottish Jig Pro was used to measure the circumference of the waist and hips. When participants were standing, the measuring tape was used to draw a horizontal line slightly above the topmost lateral border of the right ilium to determine their waist circumference. A waist circumference (WC) of more than 102 cm for men and more than 88 cm for women was considered unhealthy (Han *et al.*, 2019). These measures are consistent with the cut-off points for characterizing metabolic syndrome. Waist-to-hip ratio was used to assess the risk of cardio-metabolic risk and was utilized in the study as; low risk (0.80), moderate risk (0.81-0.85) and high risk (0.86) for women and 0.95, 0.96-1.0 and 1.1 or more for men (Han *et al.*, 2019).

Dietary Assessment

A three-day, 24-hour dietary recall were used to measure dietary intake. Individuals were requested to recollect and report all the meals they had consumed, including both food and beverages, along with the specific times at which these meals were consumed. Standard Ghanaian household measurements were employed to correctly quantify the amounts of meals and beverages consumed by the subjects. Then, using the Nutrient Analysis Template from the Department of Nutrition and Food Science of the University of Ghana, the nutritional makeup of the food was examined (Vuvor *et al.*, 2017).

Food Security Assessment

Food security status was assessed using a USDA questionnaire (Blumberg *et al.*, 1999) which was also previously employed in a previous study by Abbasi *et al.* (2016). The total score for each respondent was categorized as: food secure, if the score was between 9-11; slightly insecure if the score was between 11-14; and food insecure if the score was greater than 14.

Biochemical Analysis

Fasting blood glucose levels (FBG) were measured between 8am to 10am. Before the test, participants were instructed to fast for eight to twelve hours. This was done to avoid any fluctuations in FBG and to ensure accuracy of measurement. The left middle finger was pricked using sterile lancets to obtain a capillary blood sample for measuring FBG using a "NO CODING one plus" (PGA1E3263, Germany) blood glucose monitoring system. Fasting blood glucose in the diabetes range was defined as FBG ≥ 7.0 mmol/L; prediabetes range was defined as FBG range of 5.6-6.9 mmol/L; and normoglycemia was defined as FBG = 3.9 – 5.6 mmol/L (WHO, 2021).

Physical Activity Measurement

The Global Physical Activity Questionnaire (GPAQ) version, a physical activity surveillance tool developed by the WHO, was used to measure levels of physical activity. Records were kept on participants' participation in the workplace, in transit, in leisure activities, and in sedentary behavior. The weekly total of physical activity was measured in metabolic Equivalents (MET-minutes). Individuals were classified as high, moderate, or low physical activity practitioners if their total physical activity was at least 3000 MET minutes/week, ≥ 600 MET minutes/week, or 600 MET minutes/week, respectively (Singh & Purohit, 2012).

Ethical Approval

The Declaration of Helsinki's criteria were followed in the conduct of this study. The study was approved by the Committee on Human Research Publications and Ethics, School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (CHRPE/AP/405/22). The participants also signed an informed consent indicating their willingness to participate in the research. They were told that their information would stay anonymous and that their participation was completely optional and confidential.

Data Analysis

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. The study population's characteristics were illustrated using descriptive statistics according to FBG level, physical activity levels, and sociodemographic variables. To ascertain a link between the quantitative variables, an independent t-test was employed. To find correlations, Fisher's exact test, Pearson's correlation, and Chi-square tests were utilized. $P < 0.05$ was designated as the statistical significance threshold.

RESULTS

Sociodemographic characteristics

Of the 94 eligible respondents from Ejisu and Juaben Municipalities aged 18 years and above, 37.2% were men whiles 62.8% were women. Table 1 provides the respondents' sociodemographic details. A high literacy rate was reported amongst the respondents. Only 23.4% had a family history of diabetes.

Table 1: Sociodemographic characteristics

Variable	Male	Female	Total
	n (%)	n (%)	n (%)
Sex	35 (37.2)	59 (62.8)	94 (100)
Age			
18-25	5 (14.3)	5 (8.5)	10 (10.6)
26-35	16 (45.7)	29 (49.1)	45 (47.9)
36-45	14 (40)	25 (42.4)	39 (41.5)
Education Level			
No formal education	1 (2.9)	5 (8.4)	6 (6.4)
Primary	2 (5.7)	4 (6.8)	6 (6.4)
Junior high school	5 (14.3)	8 (13.6)	13 (13.8)
Secondary school	2 (5.7)	8 (13.6)	10 (10.6)
Tertiary	25 (71.4)	34 (57.6)	59 (62.8)
Marital Status			
Single	14 (40)	18 (30.5)	32 (34)
Married	21 (60)	37 (62.7)	58 (61.7)
Divorced	0	1 (1.7)	1 (1.1)
Separated	0	1 (1.7)	1 (1.1)
Widowed	0	2 (3.4)	2 (2.1)
Occupation			
Trader	7 (20)	19 (32.2)	26 (27.7)
Civil Servant	19 (54.3)	30 (50.8)	49 (52.1)
Unemployed	5 (14.3)	5 (8.5)	10 (10.6)
Others	4 (11.4)	5 (8.5)	9 (9.6)
Monthly Income (GHS)			
0-999	20 (57.1)	35 (59.3)	55 (58.5)
1000-1999	10 (28.6)	20 (33.9)	30 (31.9)
2000-3000	5 (14.3)	4 (6.8)	9 (9.6)
Family History of Diabetes			
Yes	1 (2.9)	21 (35.6)	22 (23.4)
No	34 (97.1)	38 (64.4)	72 (76.6)

Anthropometric and biochemical parameters

Table 2 shows the descriptive statistics of anthropometric and biochemical parameters of respondents. Females (33.6±7.0 years) were generally older than males (32.7±6.4 years). Female participants had higher waist circumference (67.4±27.6 cm) than males (62.2±27.2 cm) ($p<0.05$). Females were also observed to have a higher fasting blood glucose level (6.5 ±1.4 mmol/L) than males (6.3 ±0.8 mmol/L). BMI was also observed to be significantly higher in females (28.1±6.1 kg/m^2) than in males (24.8±4.7 kg/m^2), p=0.004.

Table 2: Participant's information: anthropometric and biochemical parameters

Variable	Male Mean (+SD)	Female	Total	P-value
Age (years)	32.7+6.4	33.6+7.0	33.3+6.8	0.558
BMI (kg/m^2)	24.8±4.7	28.1±6.1	26.8±5.8	0.004*
WC (cm)	62.2±27.2	67.4±27.6	65.5±27.4	0.371
HC (cm)	74.5±33.6	80.6±32.6	78.4±32.9	0.392
WHR	0.85±0.12	0.84±0.09	0.85±0.10	0.809
FBG (mmol/L)	6.3±0.8	6.5±1.4	6.4±1.2	0.238
Monthly income (GHS)	1031.4±833.3	854.9±608.6	920.6±701.6	0.004*
Total physical activity (Met-minutes)	6174.0±6114.1	5426.8±6171.9	5705.0±6128.2	0.570

BMI = Body mass index, **WC** = Waist circumference, **HC** = Hip circumference, **WHR** = Waist to Hip Ratio and **FBG** = Fasting Blood Glucose

Food security status of Participants

Food security status of participants are reported in Table 3. About 27.7% of the population were slightly insecure/highly food insecure. Females had a similar food security level as males (3.14±3.53 vs 3.14±3.23). The participants were marginally food secure as they had a mean score of 3.14±3.04. Males (6174.00±6114.11) were more physically active than females (5426.8±6171.9).

Table 3: Food security status of respondents

Category †	Male n (%)	Female n (%	Total n (%)	p-value
Food Security				0.786
Food secure	20 (57.1)	34 (57.6)	54 (57.4)	
Marginally secure	6 (17.1)	8 (13.6)	14 (14.9)	
Slightly insecure	6 (17.1)	8 (13.6)	14 (14.9)	
Highly insecure	3 (8.6)	9 (15.3)	12 (12.8)	
Mean score (+SD)	3.14+3.23	3.14+3.53	3.14+3.40	0.992

† = According to the food security questionnaire from the USDA; score of
0-2= food secure, 3-5= marginally secure,
6-8= slightly insecure
9-10 = highly food secure

Fasting blood glucose levels of participants

The study suggests that 71.3% of the participants had their fasting blood glucose within the prediabetes (impaired fasting glucose) range while only 9.6% had their fasting blood sugar in the normal range. The prevalence in the diabetes range (≥ 7 mmol/L) was found to be 19.1%.

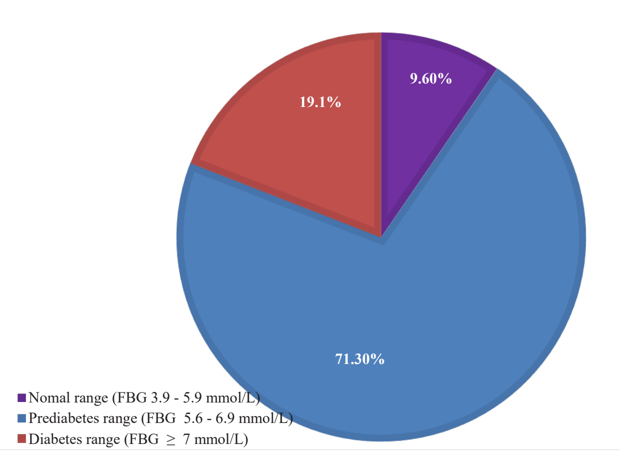

Fig 1: Fasting blood glucose levels of participants.

Physical activity

Shown in Table 4 is the physical activity level of respondents. Only 11.7% of the participants had low physical activity. The majority (88.3%) had moderate to high physical activity status in line with the World Health Organization's standards for physical activity.

Table 4: Physical activity levels of respondents

Category †	Male n (%)	Female n (%)	Total n (%)	p-value
Low	4 (11.4)	7 (11.9)	11 (11.7)	
Moderate	12 (34.3)	22 (37.3)	34 (36.2)	0.120
High	19 (54.3)	30 (50.8)	49 (52.1)	

† = According to World Health Organization's recommendation for physical activity. PA=Physical Activity

Dietary Intake of respondents

Mean total calorie intake (3244.20 kcal) exceeded the recommended daily allowance with males consuming more (3361.08 kcal) than females (3175.47 kcal). In contrast, intake of carbohydrates (54.98%), fats (24.65%) and proteins (20.74%) were all within the acceptable macronutrient distribution ranges. Results are shown in Table 5.

Table 5: Dietary Intake of respondents

Nutrient	Mean Intake Male (n=35)	Female (n=59)	Total(N=94)	AMDRs†
Energy (kcal)	3361.08±2051.96	3175.47±1771.64	3244.20±1869.80	2000-2600
Protein (%)	21.08±16.45*	19.95±15.37*	20.37± 15.7*	10-25%.
Fat (%)	24.91±11.48*	24.49±8.29*	24.65±9.5*	20-35%
Carbohydrate (%)	54±24.37*	55.55±21.34*	54.98±22.4*	45-65%

†AMDR = accepted macronutrient distribution ranges. Cut offs: Energy: 2600 for males, 2000 for females.: (Source of RDA/ AI: Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Institute of Medicine. Press of The National Academies, Washington, DC, 2002)

Relationship between dietary intake, sociodemographic characteristics, anthropometric indices, physical activities, lifestyle practices, food security and elevated blood glucose levels

A statistically significant positive correlation was observed between BMI and FBG (p<0.009, r=0.266). Weak positive associations were established between waist circumference, hip circumference and waist-to-hip ratio, however these associations were not significant.

Also, a significant association was found between total energy intake and FBG levels (p<0.001, r=0.418). Proteins, fats and carbohydrates all had positive correlation on FBG, however these associations were not significant.

Table 6: Bivariate correlation and chi square tests between dietary intake, sociodemographic and anthropometric features, physical activities, lifestyle practices and elevated blood glucose levels

Variable	BMI r (p-value)	WHR r (p-value)	FBG r (p-value)
Total Energy	0.008 (0.939)	-0.018 (0.886)	0.418 (<0.001)*
% Proteins	0.139 (0.183)	0.19 (0.066)	0.017 (0.871)
% Fats	.226(0.029)*	0.025 (0.814)	0.035 (0.735)
% Carbohydrates	-0.193 (0.062)	-0.144 (0.167)	0.027 (0.060)
Physical Activity	0.194 (0.061)	0.171 (0.099)	-0.046 (0.658)
Age	.356* (<0.001)	.381 (<0.001)*	0.188 (0.069)
Food Security	-.223* (0.031)	-0.005 (0.964)	-0.098 (0.348)
BMI	-	-0.005 (0.964)	0.266 (0.009)*
Diabetes History	0.280 (0.006*)	0.110 (0.290)	-0.253 (0.014)*

* = Pearson correlation coefficient (r) is significant at the 0.05 level (2-tailed), BMI = Body mass index, WC = Waist circumference, HC= Hip circumference, WHR = Waist to Hip Ratio, FBG = Fasting blood glucose df = degree of freedom

Shown in Table 7 is the regression model, which includes age, BMI, physical activity, %proteins, %fats and total energy is statistically significant in explaining the variation in FBG, $F(6, 87) = 8.054$, $p < 0.001$. The adjusted R square value of 0.313 indicates that 31.3% of variation in FBG is explained by our predictors.

Table 7: Overall model fit

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.	Adjusted R square
1	Regression	47.093	6	7.849	8.054	<0.001[b]	0.313
	Residual	84.783	87	.975			
	Total	131.877	93				

Table 8 indicates that, among the predictor variables, BMI (β=0.044, p=0.029), %protein (β=0.30, p=0.002) and total energy intake (β=0, p<0.001) were significant.

Table 8: Predictors of FBG levels

Correlation

Model		Unstandardized Coefficients			
		B	Std. Error	T	Sig.
1	(Constant)	3.330	.653	5.099	<0.001
	Physical Activity	-3.266E-5	.000	-1.891	.062
	Total Energy	.000	.000	5.962	.000*
	% Proteins	.030	.009	3.221	.002*
	% Fats	-.003	.013	-.208	.836
	BMI	.044	.020	2.225	.029*
	Age	.016	.016	.980	.330

DISCUSSION

The current study set out to look into the connections between people's blood glucose status, nutritional intake, physical activity levels, and food security in a peri-urban Ghanaian community.

About 27.7% of the population were food insecure. The increasing urbanization coupled with limited employment opportunities could contribute to the high food insecurity rate. The participants' average monthly income stood at GHS 920±701.6 ($80.93), indicating a significantly low-income level (Ghana Statistical Service, 2023), consequently affecting their purchasing power. Having sufficient purchasing power is crucial for individuals to afford a wide variety of nutritious foods and ensure food security. Conversely, when income is low and purchasing power is limited, it could be a barrier to accessing adequate, safe, and nutritious foods resulting in food insecurity (Ayaviri-Nina *et al.*, 2022).

Additionally, this investigation revealed that about 58.3% of food insecure individuals had blood glucose levels in the prediabetes range and this is because food insecurity often leads to limited access to nutritious foods (Castillo *et al.*, 2012). People who experience food insecurity frequently turn to inexpensive, high-energy foods that are high in processed carbohydrates, sugars, and harmful fats. These types of foods contribute to weight gain and increase the risk of developing diabetes and other cardiovascular diseases (DiNicolantonio *et al.*, 2016). Food security however showed no significant relationship with blood glucose level among the participants. This finding is in contrast to findings from Janzadeh *et al.* (2020). The disparity in the respective findings may be explained by the fact that, although food security may impact fasting blood glucose levels, other factors as well play crucial roles in regulating blood glucose levels (Gucciardi *et al.*, 2014).

More than half of the respondents were overweight or obese (54%). Also, there was a significant positive relationship between BMI and glucose level. Findings from this research is similar to findings from Lee and Wan Muda (2019) who studied the relationship between dietary intake and obesity in Malaysian adults. The authors found the prevalence of overweight and obesity to be 52.5% (Lee & Wan Muda, 2019). This high prevalence could be as a result of the significant shift towards diets that are high in calories, unhealthy fats, added sugars and processed foods. These dietary patterns, coupled with larger portion sizes and easy access to unhealthy food options, contribute to weight gain and obesity (Chen *et al.*, 2019).

Most of the study participants were physically active. Although proportionally, more females were less active than males, the mean physical activity score for males was higher than that of females. The propensity for men to devote more time than women to work-related activities that involve physical exertion can be plausible explanation to the higher average physical activity score seen in males (Tigbe *et al.*, 2017). These results are in congruence with findings from Matshipi *et al.* (2017) who studied the relationship between physical activity and blood glucose levels in South Africa (Matshipi *et al.*, 2017). However, contrary to their research, there was no significant relationship between physical activity and blood glucose levels among participants in this study (Matshipi *et al.*, 2017).

The significantly high prevalence of prediabetes (impaired fasting glucose) (FBG=5.6 - 6.9 mmol/L) in the municipality (71.3%) is alarming while prevalence of impaired fasting glucose diabetes (FBG≥7 mmol/L) was also found to be high (19.1%). Results from this study are higher than findings from Bawah *et al.* (2021) who estimated the prevalence of prediabetes at 17.3% in Ho Municipality in Ghana. The high carbohydrate intake and excess calorie intake by the study population could be a reason for this increase. Participants in this study were found to be consuming high calories (mean energy intake was 3244.20 kcal). Additionally, total calories had a significant relationship with blood glucose status. This is due to the fact that a number of food components may affect how carbohydrate foods affect blood glucose levels. These include the type of carbohydrate, the food's preparation (boiled, fried, or raw), the kind and quantity of dietary fiber, and the existence of specific food ingredients that may interfere with the digestive or absorptive systems (Singh *et al.*, 2017).

The regression model as a whole exhibits statistical significance indicating that it can satisfactorily account for a sizable proportion of the variability in participants' blood glucose status. The adjusted R-square value of 0.313 implies that the predictors account for 31.3% of the variation in blood glucose. The relationship between BMI and FBG among the various predictor factors was positive and statistically significant, suggesting that greater BMI values are linked to higher FBG levels. Additionally, amount of proteins showed a favorable and significant association with blood glucose indicating that consuming more protein is associated with higher FBG levels. Notably, total energy intake was statistically significant but had a beta coefficient of zero, indicating a complex relationship with FBG that warrants further investigation. These findings underscore the importance of monitoring BMI and protein intake in managing FBG levels, although causation cannot be inferred from our study design. It is crucial to recognize the potential implications of these associations and consider them in public health and clinical nutrition interventions.

CONCLUSION

The present study found that total calorie consumption, carbohydrate intake, and physical activity are all strongly related to blood glucose levels among the participants. Based on this study's findings, there was a significant proportion of the study participants with blood glucose status in the prediabetes range. This puts them as at risk of developing pre-diabetes and eventually diabetes. To the best of our knowledge this is one of the first few studies that has addressed food security and blood glucose levels in a young population. As such, it has laid the groundwork for further studies in this area

However, this study has limitations; because this is a cross-sectional study with a small sample size, this research may not be able to prove causality. The study may not account for all potential confounding variables that can influence the association between socioeconomic conditions, food security, dietary intake, physical activity levels, and elevated blood glucose levels. In view of that, it may not be able to establish whether changes in socioeconomic conditions, food security, dietary intake, and physical activity levels are the cause of elevated blood glucose levels among the participants. Factors such as genetics, medication use, and comorbidities may also play critical roles in the development of elevated blood glucose levels. Further research may be needed to explore the reasons behind the high prevalence of elevated blood glucose in the study population, and to identify potential interventions that can reduce the prevalence and incidence of this condition.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data can be obtained by contacting the corresponding author.

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