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Original Article

School-based Study of the Prevalence and Associated Factors of Prediabetes Among Adolescents in Kano, Nigeria

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Abstract

Background: Prediabetes and diabetes are important metabolic public health problems, especially among adolescents. However, they are being given little or no attention, especially in Sub-Saharan Africa (SSA). Prediabetes increases the risk of developing type 2 diabetes mellitus (T2DM) and cardiovascular diseases.

Objective: To determine the prevalence of prediabetes and its associated factors among adolescents in Kano, northwest, Nigeria.

Methods: This was a cross-sectional study of 650 secondary school students aged 10-19 years in Tarauni LGA of Kano state. A self-administered questionnaire was used to obtain the socio-demographic data and family history of diabetes of the participants. Each participant had his/her FBS and OGTT measured. Prediabetes was defined using the ISPAD criteria (FBS of 5.6-6.9mmol/L and 2HPP glucose level of 7.8-11.0mm). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were determined for the FBG test against the OGTT test. Bivariate and multivariate logistic regressions were done to ascertain the associated factors of prediabetes.

Results: There were 372 females and 278 males. The age range was 10-19 years with a mean 14.9±1.8 years. The prevalence of prediabetes using FBG was 5.5% while using OGTT was 8.9%, while 0.6% of students had combined IFG/IGT. FBG had a sensitivity of 7%, specificity of 95%, PPV of 11% and a NPV of 91%. Male gender (AOR=2.56, C.I= 1.25 – 5.23) and socioeconomic class (AOR= 3.36, C.I = 1.32 – 8.54) were found to be associated with IFG while positive family history of diabetes (AOR= 0.39, C.I = 0.18 – 0.84) was associated with IGT.

Conclusion: Prediabetes is common among the study population and the sex-specific prevalence rate was higher among males. Higher socioeconomic class and a positive family history of diabetes were significant associations.

Keywords: Prediabetes; Fasting Blood Glucose; Prevalence; Risk Factors; Adolescents.

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Introduction

Diabetes is a worldwide health problem,[1] with increasing prevalence not only in adults but also among adolescents.[2] Weir proposed a three-stage model for the development of diabetes mellitus.[3] Stage 1 is characterized by fasting hyperinsulinaemia with normal or slightly raised blood glucose, especially mild fasting hyperglycaemia. Stage 2 is characterized by prediabetic glucose intolerance with insulin resistance, and Stage 3 is the development of classical symptomatic or non-symptomatic diabetes with more persistent hyperglycaemia present.[3] Many of the macrovascular changes associated with diabetes and related to cardiovascular disease (CVD) begin in Stages 1 and 2, well before overt diagnosis.[4]

Prediabetes occurs in stage 2 and is characterized by insulin resistance accompanied by a compensatory increase in insulin secretion.[5] Insulin resistance is a state in which a given concentration of insulin produces a less-than-expected biological effect (that is to achieve a desired glycemic control). Prediabetes is usually asymptomatic with only high blood sugar as the only sign.[6] Individuals with prediabetes are at an increased risk of developing type 2 diabetes mellitus (T2DM) and cardiovascular diseases compared to normoglycaemic individuals if management is not initiated early.[7] Unlike adults, children and adolescents with prediabetes can convert back to normoglycaemia.[3,8,9]

Adolescents, according to the world health organization (WHO) are individuals within the age bracket of 10-19 years.[10] Adolescence is a period of transition from childhood to adulthood.[2] Hormonal, physiological, psychological, and lifestyle changes in adolescence have been associated with disruptions in glucose homeostasis, such as decreased insulin sensitivity, insulin resistance, or a combination of both.[2]

Most of the studies done on prediabetes in Africa were among adults. [11,12] Little is known about the prevalence of prediabetes and diabetes in children and adolescents. The prevalence of prediabetes in adults ranges from 2.2% to 16.2% with a prevalence of 7.3% in sub-Saharan Africa.[13] Previous studies on childhood prediabetes in Nigeria was done on secondary school adolescents using impaired fasting blood glucose. [4,11,13,18,19]

To the best of our knowledge, there is no published study on prediabetes among adolescents in Kano or northwest Nigeria. This study aimed to provide data from a population that has different socio-cultural backgrounds, climatic conditions, and lifestyles from the previous studies from the south-south and south-west Nigeria respectively. In addition, this study used two methods of diagnosing prediabetes, that is, fasting blood glucose test and oral glucose tolerance test (OGTT) concurrently.

Subjects and Methods

The cross-sectional study was conducted in Tarauni, Kano State in Northwestern Nigeria between October 2019 and December 2019. Kano is the second largest city in Nigeria after Lagos with 44 local government areas (8 urban and 36 semi-urban). Tarauni Local Government Area (LGA) is an urban LGA with 80 government-approved secondary schools: 57 privately owned and 23 public secondary schools, giving a public: private ratio of 1:2.5. Tarauni has a total of 19,994 secondary school students; 12,477 in public schools while 7,517 are in private schools.

Ethical approval for this study was obtained from the Research Ethics Committee of the Aminu Kano Teaching Hospital Kano (AKTH). Approval was also obtained from the Kano State Senior Secondary School Management Board, Tarauni Local Government Education Board, and the Kano State Private and Voluntary Institution Board. Informed consent was obtained from the parents/guardian while the study participants gave their assent before data collection commenced.

The minimum sample size was determined using the prevalence of prediabetes in secondary school students reported from a study by Jaja and colleagues in Port Harcourt.[13] It was calculated using a standard formula for a cross-sectional prevalence study.[14]

A multistage sampling technique was used to recruit 650 in-school adolescents between the ages of 10 and 19 years. A total of fifteen schools, 10 private and 5 public, were randomly selected from a list of all the schools in the LGA. Exclusion criteria for intending participants included students who are known diabetics, students who were unable to follow the instruction for fasting before fasting plasma glucose estimation, and unwillingness to participate in the study by either students or parents.

Data Collection

Before the commencement of the study, four assistants who were medical officers had a two-day training about the study. Thereafter, multiple visits were made to the selected schools during which the researcher and assistants familiarized themselves and created awareness and sought the cooperation of the staff and students. During the visits, health talks were given during the school assembly periods to staff and students on diabetes, with emphasis on prediabetes and how the study was to be carried out. After permission to proceed with the study was obtained from the school management and knowing the specific numbers of students to be selected from each class, the subject selection was done using the class registers with the aid of the class teachers.

Blood glucose determination

The blood tests were carried out twice on each participant (FBG and OGTT). The FBG test was donebetween7:00 am and 8:00 am on each test day on participants who had been fasting from the previous evening (8-9 hours) [15] thereafter the second test (OGTT) was done after 2 hours of ingestion of a glucose drink (Allenburys ® Anhydrous Glucose D). Accu-Chek active® glucometer was used for blood glucose estimation. The exact quantity of glucose to be dissolved in 300mls of water was determined by multiplying the weight of each participant by 1.75 (1.75g/kg), to a maximum of 75g. Prediabetes (IFG/IGT) was defined according to the ADA/ISPAD criteria.[7] To check for quality control, for each 50th student that had the lancet prick, blood sample of about 3ml was collected and taken to the chemical pathology laboratory of AKTH for estimation of blood glucose using the hexokinase method.

Anthropometric and other vital measurements

Weight (in kilograms) was taken using a calibrated Harsun^{R} bathroom scale which was kept on a flat and firm surface and the weight was recorded to the nearest 0.1kg.[16] The height (in meters) was measured using a stadiometer (manufactured by Health-O-Meter, Inc. Bridgeview, Illinois, USA) with a maximum height of 78 inches (198cm) fixed to the wall. Each student was barefooted or with socks, standing erect with heels together and looking straight ahead. Three measurements were taken at the eye level of the examiner. The average of the results was taken and recorded to the nearest 0.1cm. [16] The body mass index (BMI) was calculated using the formula weight (kg)/height (m^2) and the percentile was determined from the WHO chart for boys and girls aged 2-20 years. The BMI was then categorized into 4 groups: underweight defined as BMI-for-age <5th percentile, normal weight as the 5th-85th percentile, overweight>85th - <95th percentile, and obesity>95th percentile.[16]

The blood pressure in millimeters of mercury (mmHg) was measured to the nearest 2 mmHg, on the right arm with participants seated quietly after five minutes of rest using an aneroid sphygmomanometer. The recorded blood pressures were categorised into normal blood pressure, prehypertension, and hypertension. Normal BP was defined as SBP and DBP that are <90th percentile for gender, age, and height. Prehypertension was designated as average SBP or DBP levels that are ≥90th percentile but <95th percentile. In adolescents, BP >120/80 mmHg is prehypertension, even if this figure is at the 90th percentile. Hypertension was categorized into stage 1 and stage 2. Stage 1 hypertension is defined as blood pressure from the 95th percentile to the 99th percentile plus 5 mm Hg. Stage 2 hypertension is blood pressure that is >99th percentile plus 5 mm Hg.[17]

Statistical analysis

Statistical analysis was performed using the 21st version of Statistical Package for Social Sciences (SPSS), IBM cooperation 2011, Armonk, New York, USA. Categorical variables like age groups, gender and school type were described as frequencies and percentages and presented in tables. Continuous variables like weight, height and blood glucose levels were assessed for normality using the Kolmogorov-Smirnov test then expressed as mean ± standard deviation. All data in this study were normally distributed.

Means and standard deviations were compared between subject groups of normal and impaired blood glucose levels using Student's t-test. Chi-square or Fisher's exact tests (where necessary) were used to determine the associations of IFG or IGT. Significant associations were subjected to further analysis using multivariate logistic regression analysis to determine associated factors of prediabetes. A p-value< 0.05 was considered statistically significant.

Results

Socio-demographic characteristics and Anthropometric indices of the study population.

There were 278 males (42.8%) and 372 females (57.2%), with a male-to-female ratio of 0.7:1. The mean (SD) age was 14.9 (1.8) years with the majority (62.6%) of the participants being in the age group 15-19 years. Fifty-three percent of the population were students from private schools compared to 46.5% from public schools. More than a third (38.9%) of the participants were from the middle socioeconomic class. Females were found to be heavier and slightly taller than males. Apart from the height, the differences in means of all other measured and calculated anthropometric indices between males and females were statistically significant ($p < 0.05$ in all cases). Almost two-thirds of the participants were underweight while only 1.7% were obese.

Prevalence of prediabetes

Fourteen participants (14%) were found to have a diabetic range of blood glucose and were excluded from the final analysis. Overall, 36 (5.5%) of students were found to have IFG, and 6.6% were found in the age group 10-14 years. More males (7.9%) compared to females (3.8%) had IFG. Most of the participants (8.3%) with IFG had no family history of diabetes. Fifty-eight (8.9%) participants were found to have IGT with more students from public schools (10.6% vs 7.5%) having IGT. There was no statistically significant association between IGT and BMI as the proportions of underweight and obese students with IGT were similar (9.3% vs 9.1%) (Table 1).

Table 1: Prevalence and relationship between participants' socio-demographic characteristics by IFG and IGT

Variable	Total number (%)	IFG	Chi-square	p-value	IGT	Chi-square	p-value
Age category (years)							
10-14	243 (37.4)	16 (6.6)	0.81	0.380	23 (9.5)	0.14	0.776
15-19	407 (62.6)	20 (4.9)			35 (8.6)		
Gender							
Males	278 (42.8)	22 (7.9)	5.24	0.025*	30 (10.8)	2.09	0.165
Females	372 (57.2)	14 (3.8)			28 (7.5)		
School							
Public	302 (46.5)	16 (5.3)	0.62	0.865	32 (10.6)	1.94	0.170
Private	348 (53.5)	20 (5.7)			26 (7.5)		

FHx diabetes							
Yes	215 (33)	8 (3.7)	6.43	0.045*	16 (7.4)	7.24	0.026*
No	266 (41)	22 (8.3)			33 (12.4)		
Don't know	169 (26)	6 (3.6)			9 (5.3)		
BMI							
Underweight	407 (62.6)	19 (4.7)	2.74	0.434	38 (9.3)	0.39	0.966
					17 (8.5)		
Normal	200 (30.8)	15 (7.5)					
Overweight	32 (4.9)	2 (6.3)			2 (6.3)		
Obese	11 (1.7)	0 (0)			1 (9.1)		
SBP							
Normal	620 (95.4)	35 (5.6)	0.61	0.872	56 (9)	0.40	0.892
Prehypertension	20 (3.1)	1 (5)			1 (5)		
Hypertension	10 (1.5)	0 (0)			1 (10)		
DBP							
Normal	517 (79.5)	26 (5.0)	2.26	0.280	43 (8.3)	3.50	0.157
Prehypertension	104 (16)	9 (8.7)			14 (13.5)		
Hypertension	29 (4.5)	1 (3.4)			1 (3.4)		
Socioeconomic class							
1	191 (29.4)	17 (8.9)	6.24	0.039#	15 (7.9)	0.43	0.817
2	253 (38.9)	12 (4.7)			23 (9.1)		
3	206 (31.7)	7(3.4)			20 (9.7)		

*Pearson chi-square, # Fischer exact test, BMI: body mass index, SBP: systolic blood pressure, DBP: diastolic blood pressure: FHx, family history.

The sensitivity and specificity of fasting glucose versus 2HPP.

Using the 2HPP glucose as the gold standard for diagnosing prediabetes, the sensitivity, and specificity of the fasting blood glucose test (FBG) were compared to the 2HPP. The majority (560) were found to have normal glucose tolerance, 32 had isolated IFG, 54 isolated IGT and 4 students were found to have combined (IFG/IGT) prediabetes.

The FBG test was found to have low sensitivity (7%) but high specificity (95%) in diagnosing prediabetes. The positive predictive value (PPV) for FBG was 11% while the negative predictive value (NPV) was 91% (Table 2).

Table 2: Sensitivity and specificity of fasting glucose test.

	Glucose tolerance test (gold standard)		
	Positive	Negative	Total
Fasting glucose test			
Positive	4 (Tp)	32 (F_P)	36
Negative	54 (F_N)	560 (T_N)	614
Total	58	592	650

Sensitivity =7%, specificity =95%, PPV = 11%, NPV =91%.

The associated factors of prediabetes.

In a bivariate analysis, gender (p=0.025), family history of diabetes (p=0.045), and socioeconomic class (p=0.039) were found to be associated with IFG (Table 1) but following multivariate logistic regression model (R^2= 0.093, chi-square 21.35, d=7, p=0.003), male gender (AOR-= 2.56, C.I= 1.26-5.23, p-value= 0.010) and socioeconomic class (AOR= 0.30, C.I= 0.12- 0.76, p-value= 0.011) remained strongly associated factors of IFG (Table 3). It shows that males compared to females were 2.6 times more likely to have IFG. Students from the middle socioeconomic class were 70% less likely to have IFT compared to those from higher socioeconomic classes in the studied population. Likewise, lower socioeconomic classes are less likely to have IFG compared to high socioeconomic classes though the association was not significant.

Table 3: Logistic regression for significant predictors of impaired fasting glucose among the participants.

Variable	OR (95% C.I)	AOR (95% C.I)	p-Value
Gender			
Female	1		
Male	2.20 (1.10- 4.38)	2.56 (1.26-5.23)	0.010*
FHx of diabetes			
Yes	1		
No	0.43 (0.19 to 0.98)	0.96 (0.32 to 2.86)	0.940
Don’t know	1.05 (0.36 to 3.09)	0.40 (0.16 to 1.03)	0.058
DBP			
Normal	1		
Pre-hypertension	0.56 (0.25 to 1.23)	0.68 (0.09 to 5.32)	0.716
Hypertension	1.48 (0.19 to 11.33)	0.39 (0.05 to 3.30)	0.388
Social class			
1	1		
2	1.96 (0.91 to 4.21)	0.30 (0.12 to 0.76)	0.011*
3	2.78 (1.13 to 6.86)	0.55 (0.21 to 1.46)	0.230

*Statistically significant, FHx, family history, DBP, diastolic blood pressure.
OR, odd ratio, AOR, adjusted odd ratio.

IGT was found to be associated with a family history of diabetes in bivariate analysis (p=0.026) (Table I), the association remained positive (AOR= 0.39, C.I= 0.18 – 0.84, p = 0.017) even after adjusting for other variables among the adolescents in the multivariate model (R^2=0.051, chi-square=15.16, d= 6, p=0.019) (Table 4). Students that do not know their family history of diabetes were 61% less likely to have IGT compared to those that reported a positive family history.

Table 4: Logistic regression for significant predictors of impaired glucose tolerance among the participants.

Variable	OR (95% C.I)	AOR (95% C.I)	p-Value
Gender			
Female	1		
Male	1.49 (0.87-2.55)	1.50 (0.86-2.60)	0.156
School			
Public	1		
Private	0.68 (0.40 to 1.71)	0.72 (0.41 to 1.28)	0.262
FHx of diabetes			
Yes	1		
No	0.70 (0.30 to 1.63)	0.63 (0.27 to 1.48)	0.288
Don't know	0.40 (0.19 to 0.85)	0.39 (0.18 to 0.84)	0.017*
DBP			
Normal	1		
Pre- hypertension	0.40 (0.05 to 2.97)	0.41 (0.50 to 3.08)	0.383
Hypertension	0.23 (0.03 to 1.82)	0.21 (0.03 to 1.70)	0.144

*Statistically significant. FHx, family history, DBP, diastolic blood pressure.

Discussion

The overall prevalence of prediabetes (IFG and IGT) in the studied population was 13.8%. Adopting the ISPAD[7] criteria for defining prediabetes, the prevalence of IFG in the studied adolescents was 5.5%. This finding is lower than that reported in previous studies in Nigerian school children by Jaja and colleagues (17%) in Port Harcourt [13] and Oluwayemi and colleagues (28.7%) in Ado Ekiti[4] respectively. The differences in the rates could be partly explained by the characteristics of the study areas. Port Harcourt is the oil-rich city of Nigeria located in the south and is profoundly different in terms of environmental factors, dietary habits, and lifestyle from Kano in the north where this study was carried out. However, the finding in this study is just slightly higher than the 4% reported by Arigbede and colleagues in Ibadan.[18] The difference may be accounted for by the criteria used for defining prediabetes, while this study used the ISPAD criteria for IFG, the stricter WHO criteria were used in their study.

Studies from West African countries showed a higher prevalence of IFG than our study. Agbre-yace et al in Abidjan, Cote d Ivoire[19] reported 14.5% while Sunwiale in the Kassena-Nankana district of Ghana[20] reported IFG of 11.5%. The higher rates could be attributed to the wider age group of 2-20 years of the studied participants in both studies while our study involved those in the age group 10-19 years. Differences in ethnicity of the populations in these studies might have also accounted for the values seen. Findings from Asia and the Middle East were comparable to the findings in this study: Narayanappa et al [21] in India reported a slightly lower prevalence of 3.7%, while Chahkandi in Iran [22] reported a slightly higher value of 7.5%. Both studies, like this study, were from developing countries and used the same ISPAD criteria for diagnosis.

Following the OGTT, the prevalence of IGT was found to be 8.9%. This is lower than that documented by Jaja and colleagues in Port Harcourt [13](15%), Sinha et al in the USA [23] (21%), and Ghergherechi in Iran [24] (14.5%) but higher than that reported by Ranjaniet alin India[25] (3.4%). Jaja and Ranjani et al studied both obese and non-obese adolescents in our study. While Jaja and colleagues found IGT to be more among overweight adolescents, our study found IGT more among the non-obese participants, who are also the majority in our study. This might have accounted for their higher prevalence rates.

The sensitivity of FBG test compared with 2HPP for diagnosing prediabetes in this study was low (7%), owing to a very high false negative result. However, the specificity was high (95%) while the ability of FBG to correctly diagnose those with prediabetes was poor (11%) and the negative predictive value was high 91%. The findings from this study were comparable to that reported by Schianca and colleagues in Novara Italy,[26] where they studied 398 individuals aged 17-66 years. FBG from their study had a sensitivity of 19% which is higher than the value from this study. Their specificity was 89% like that found in this study, the positive predictive value was 39% which is higher than that found in this study while the negative predictive value was 83% which is comparable to 91%. The high sensitivity and positive predictive value from their study may be a result of differences in ethnicity (Italian Vs Nigerians), the older age group (adults), and being a hospital-based study. The finding from this study is also in agreement with the study by Cheng and colleagues in Philadelphia USA.[27]

Findings from our study have shown that gender, particularly the male gender, is an important risk factor for acquiring IFG. Similarly, Arigbede and colleagues in Ibadan, [18] reported that males have an increased risk for IFG. This is also in agreement with Mamtani et al in Doha, Qatar, [28] who showed that males were 3 times more likely to develop prediabetes. However, our finding is contrary to some studies where females were found to be more at risk. Oluwayemi and colleagues in Ado Ekiti [4]and Guerrero and colleagues in Mexico[29] both showed females to be more at risk for prediabetes. The reason for this difference is unknown though some studies like that by Guerrero and colleagues [29] assumed that estrogen in girls may play a role in the pathogenesis of prediabetes. This study did not find any association between gender and IGT.

Family history (FHx) of diabetes especially T2DM is a recognized risk factor for prediabetes.[30] In this study, students who either have no FHx of diabetes or were unaware of their family status of diabetes were found to be less likely to have IGT compared to those with positive FHx of diabetes. This agrees with the findings by Rodriguez- Moran et al in Mexico.[31] They reported 88% of their studied population with FHx of diabetes to have IGT compared to only 1.9% of those without FHx of diabetes. Jaja and colleagues [13] reported that 1 out of every 10 participants in their study had a family history of diabetes irrespective of whether they were obese or not, though the association was not statistically significant with either IFG or IGT. Contrary to our finding, however, Shalitin and colleagues in Israel [32] reported no significant association between positive family history of diabetes and IGT. There was no statistically significant association between IFG and FHx of diabetes in this study. The reason for the variation in findings may be that other genetic and metabolic mechanisms may play a role in the pathogenesis of prediabetes in the different populations studied rather than just having a family member with diabetes. It is a known fact that populations differ genetically in their risk for impaired glucose tolerance or diabetes based on the presence of some genes specific to them. Some individuals have certain HLA types (HLA-DR3/4, HLA-DQB1*0201) that increase their risk for diabetes and glucose intolerance.[33]

Overweight and obesity in adolescents have been shown to be on the rise with associated increased risk of T2DM. [9,34] Obesity is associated with fatty acid destruction of the beta cells and also insulin resistance and insulin insensitivity. [9,34] In this study, 43 out of 650 students were found to be either overweight or obese while the majority were underweight. This finding may be reflective of the high rate of undernutrition prevalent in Kano and other northern states as reported in the national nutrition and health survey (NNHS) of Nigeria.[35] Impaired fasting glucose was found in only 2 of the overweight students while none of the obese students had IFG. Similarly, only 3 students out of 58 with IGT were either overweight or obese respectively. There was no significant association between prediabetes and overweight or obesity in the studied population. Jaja and colleagues [13] also reported similar findings with no significant association between BMI and prediabetes, although quite a number of their overweight and obese students had IFG. This finding is not surprising as prediabetes can be seen both in obese and non-obese individuals.[13]

The mechanism of this, is postulated to be due to direct beta cell damage in non-obese individuals while fatty acid destruction of beta cells occurs in the obese. Arigbede and colleagues in Ibadan,[18] reported a different finding; that being overweight or obese, doubles the risk of prediabetes. This agrees with the study by Sunwiale in Ghana,[20] where he also reported obesity to be significantly associated with prediabetes. The high rate of underweight adolescents in our studied population may account for the difference in the rates from the southern part of Nigeria and Ghana.

Much of the study population belongs to the middle socioeconomic class. These students and those in lower socioeconomic classes were less likely to have IFG compared to those in higher socioeconomic classes. Arigbede and colleagues in Ibadan,[18] reported an indirect association between prediabetes and socioeconomic class. They found that those students who attended private schools had a higher risk of having prediabetes and that these students were all from a higher socio-economic class. This is because they were likely to live a more sedentary lifestyle and also have increased intake of junk food. The risk of having prediabetes in this study was independent of whether the students attended private or public school.

Although prediabetes was found to be more common in older adolescents in this study, there was no significant association between the age categories of the studied population and prediabetes irrespective of the criteria or definition used (IFG/IGT). This is like the previous reports in the literature. Jaja and colleagues,[13] Arigbede and colleagues,[18] Agbre-yace,[19]Sunwiale,[20]Chahkandi and colleagues,[22] Sinha et al,[23] and Ghergherechi et al,[24] all reported increased prevalence of prediabetes in older adolescents though the associations were not statistically significant. This could be explained by the fact that insulin resistance reaches its peak by the end of puberty after which it starts to decline.[5] In contrast to the finding in our study, a higher prevalence of prediabetes (IFG) was found in a larger proportion of younger adolescents in the study by Oluwayemi and colleagues in Ado Ekiti.[4] This was however not statistically significant.
High blood pressure is a known risk factor for diabetes and related conditions.[36] In this study, most of the participants had normal systolic and diastolic blood pressures. There was no significant association between blood pressure and prediabetes. This finding is in agreement with the finding by Jaja et al in Port Harcourt[15] and Sinha et al in the USA,[23] but in contrast to the report by Arigbede et al[18] in Ibadan and also Maffeis et al[37] in Italy where they found that elevated blood pressure increases the odds of having prediabetes.

Our study had some limitations: the possibility of the participants taking something in the morning before FBG test cannot be strictly ruled out. Even though several risk factors were explored, they were not exhaustive; for example, the history of gestational diabetes in their mothers and their birth weight were not investigated. Lastly, due to the cross-sectional nature of the study, the students with prediabetes could not be followed up to monitor their progression.

However, our study has important recommendations for the prevention and control of prediabetes and diabetes among adolescents within the formal school setting. The need for health education on prediabetes and diabetes at school levels to increase awareness among school-based adolescents. Also, public health interventions like creating awareness on prediabetes and diabetes among families and improved health seeking behaviour in general among the population is recommended. Government and stakeholders in education should include screening for prediabetes for all children at school entry and periodically due to the significance of the condition. Finally, school feeding programmes by government and other education stakeholders needs to be intensified to avoid eating of junk foods in schools by students.

In conclusion, prediabetes is common among the study population and a combination of FBG and OGTT should be recommended for screening and diagnosis of prediabetes. The sex-specific prevalence rate was higher among males compared to females; therefore, routine screening of male adolescents especially those from higher socioeconomic class and a positive family history of diabetes should be emphasized.

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