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Diabetes and pre-diabetes in adult Nigerians: Prevalence, and correlations of blood glucose concentrations with measures of obesity

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The quantification of the number of people with diabetes is an important factor that allows for effective planning and distribution of scarce resources for the management of diabetes. This study therefore investigated the prevalence of diabetes and impaired fasting glucose in a convenient population of adults in Umudike, a semi-urban town in South-East Nigeria. The relationship between measures of obesity and blood glucose concentration was also evaluated. Standard protocols were followed for all measurements, determinations and definitions. The results show that the prevalence of diabetes in the studied population is 3.0% (3.6% for females and 2.3% for males). Impaired fasting glucose was found in 1.1% of the population (females 1.6%; males 0.6%), such that 4.1% of the population had dysglycemia. Diabetic females had significantly ($P < 0.02$) higher body mass index (BMI), fat mass, waist-to-height ratio (WHtR) and waist-to-hip ratio (WHpR) compared to non-diabetic female subjects. For the males, mean BMI and fat mass were statistically similar between the groups whereas WHtR and WHpR were significantly ($P < 0.01$) higher in diabetics. The assessed measures of obesity (except for BMI in males) were weakly but significantly ($r < 0.5$, $P < 0.05$) correlated with blood glucose concentration in all subjects. The results are discussed and their public health significance highlighted.

Key words: Diabetes, dysglycemia, impaired fasting glucose, obesity, pre-diabetes.

INTRODUCTION

Diabetes mellitus (DM) is an aetiologically multifactorial metabolic disorder, characterised by chronic hyperglycaemia. It results in aberrations in carbohydrate, fat and protein metabolism, which arise due to defects in insulin secretion, and/or action. DM is currently a very prevalent disease, especially in Africa (Bos and Agyemang, 2013). Globally, at the end of 2013, as much as 382 million people had the disease; while the number is expected

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to reach 592 million by 2035. Interestingly, the burden of diabetes is highest in low and middle income countries (LMICs) (it is reported that in 2011, for instance, 14 million Africans had diabetes; and 80% of diabetics currently live in LMICs) (IDF, 2013).

LMICs will experience significant increases in the prevalence of the disease over the next 22 years (Guariguata et al., 2014). The increasing burden of DM in LMICs is thought to be related to the changes in physical activity (due to the availability of energy-sparing devices), dietary patterns (which are becoming westernised), and an improvement in life expectancy (Van Dieren et al., 2010). It is however worrisome that cases of undiagnosed diabetes are quite rampant in LMICs, reaching 50% (Chow et al., 2006) to 75% (IDF, 2009) of all cases.

Owing to the fact that one important factor (in diabetes management) that allows for effective planning and distribution of scarce resources is the quantification of the number of people with diabetes (Soriguer et al., 2012), this study investigated the prevalence of diabetes and impaired fasting glucose concentration in a convenient sample of a sub-urban adult population in Nigeria, and assessed the relationship between fasting blood glucose concentrations and measures of obesity. The findings are expected to be useful in guiding future research efforts and public health policy formulation and action.

MATERIALS AND METHODS

Adult subjects in Umudike, a University town in Abia State, South-East Nigeria, aged 18 years and older, were approached and the goals of the study explained to them. Those who gave an informed consent were then recruited. Exclusion criteria included overt or reported ill-health and pregnancy or recent delivery (in women). A total of 365 subjects (52.9% females) participated in this cross-sectional study.

Self-reported age and diabetic status were recorded per subject while weight, height, waist and hip circumferences were measured using standard protocols as described previously (Ejike and Ijeh, 2012). From the above variables, body mass index (BMI), waist-to-hip ratio (WHpR), and waist-to-height ratio (WHtR) were calculated using standard equations. Fat mass (percent) was measured using a bio-electrical impedance analysis (BIA) machine (Omron BF-400, Omron Healthcare Europe BV, Hoofddorp, The Netherlands). Fasting capillary blood glucose concentrations of the subjects who had fasted for at least 12 h (overnight) were determined using a glucometer (Accu-check Advantage, Roche Diagnostics, Mannheim, Germany).

Diabetes was diagnosed as a fasting blood glucose concentration of ≥ 126 mg/dL (≥ 7 mmol/L), or self-reported use of glucose lowering medication. Impaired fasting glucose (IFG) was defined as a fasting blood glucose concentration between 110 and 125 mg/dL (6.1-6.9 mmol/L) (WHO, 2006). Subjects with either diabetes or IFG were regarded as having dysglycemia. Where necessary, subjects were stratified into four dissimilar age ranges thus: 18 to 30 years, 31 to 45 years, 46 to 60 years, and more than 60 years, for convenience purposes.

This study was carried out between the months of August and September 2014. The design for this study, which is in accordance with the Helsinki declaration, was approved by the Board of the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike since the University is yet to constitute a Human Experiments Ethics Review Board.

Statistical analysis

Descriptive statistics and frequency counts were done on the data generated and the results reported as means ± standard deviations and percentages, respectively. Pearson's correlation coefficients were calculated to assess the correlation between blood glucose concentration and measures of obesity. Differences between group means were separated using one-way analysis of variance (ANOVA), with the significant threshold fixed at $P < 0.05$. Data analysis was carried out using the statistical software IBM-SPSS version 20.0 (IBM Corp., Atlanta, GA) while graphs were plotted using Microsoft Excel (Microsoft Corp., Redmond, WA).

RESULTS

The prevalence of diabetes in the studied population was 3.0% (3.6% for females and 2.3% for males). Females had an earlier onset of the disease (7.8% in the 31 to 45 years group) compared to males (0.0% in the same age group). Figure 1 shows the distribution of the prevalence of diabetes stratified by age and sex of respondents. IFG was found in 1.1% of the population (females 1.6% aged 20 to 41 years; males 0.6% aged 26 years). From Figure 2, it is seen that 4.1% of the population (5.2% for females and 2.9% for males) had dysglycemia. The distribution of the state by sex and age group is also shown in the figure.

All the diabetic males had prior knowledge of their status while blood glucose concentrations were lower in females of known diabetic status compared to those who had no prior knowledge of their status. No female diabetic, younger than 46 years knew of her status. IFG was found only in those aged 18 to 45 years (Table 1). Diabetic females had significantly ($P < 0.02$) higher BMI, fat mass, WHtR and WHpR compared to non-diabetic female subjects. For the males, mean BMI and fat mass were similar between the groups; whereas, WHtR and WHpR were significantly ($P < 0.01$) higher in diabetics. Irrespective of sex, all the measures of obesity were significantly ($P < 0.01$) higher in diabetics relative to non-diabetics (Table 2). The assessed measures of obesity (except for BMI in males only) were weakly but significantly ($r < 0.5$, $P < 0.05$) correlated with blood glucose concentration in all subjects. BMI in males was not significantly ($P > 0.05$) correlated with BGC (Table 3). No significant correlation was found between lean mass and BGC.

DISCUSSION

The prevalence of diabetes and dysglycemia reported in this study [3.0% (3.6% for females and 2.3% for males) and 4.1% (5.2% for females and 2.9% for males),

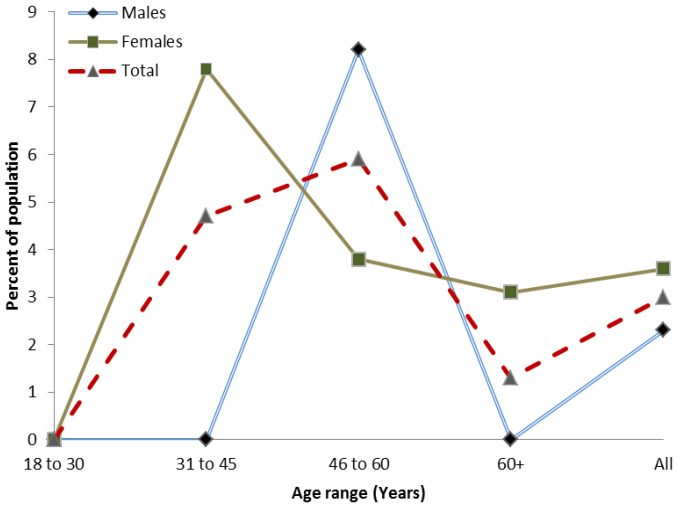

Figure 1. Prevalence of diabetes mellitus stratified by sex and age range.

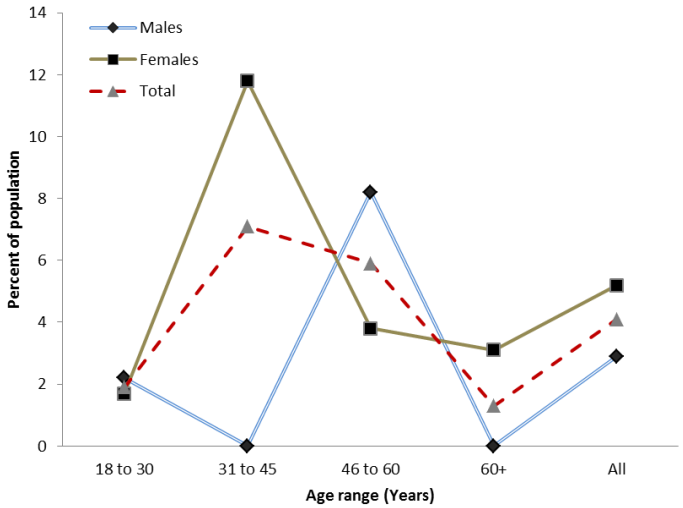

Figure 2. Prevalence of dysglycemia (diabetes mellitus + impaired fasting glucose) stratified by sex and age range.

respectively] are within the reported ranges in Nigeria. Chinenye et al. (2008) noted that the prevalence of diabetes in Nigeria ranged from 0.65% in rural Mangu village to 11.0% in Lagos, an urban centre. Recently, Enang et al. (2014) reported a prevalence of 6.5% for diabetes in Calabar, another urban centre. It is understandable that, given the contributions of lifestyle modifications in the aetiology of chronic diseases, the prevalence of diabetes is higher in urban areas compared to rural areas. This may also explain the figure reported in this study as the setting is a semi-urban area. Arguments about the variations being due to fewer studies in rural areas and lower access to healthcare facilities in those areas are nonetheless plausible.

The higher prevalence of diabetes (3.0%) compared to impaired fasting blood glucose (1.1%) may be indicative of a rapid progression of the disease. A slower progression would have ensured that those with impaired blood glucose homeostasis would be more than those with the full blown disease. The design of the present study however forecloses any emphatic deduction in the direction of disease progression. Moreover, the use of capillary blood for this study may have had an impact on the data. The female preponderance of diabetes found in this study is not an isolated finding. Prior to this report, Ohwovoriole et al. (1998), Chinenye et al. (2008) and Enang et al. (2014) had reported a female preponderance of diabetes in Nigeria. Such preponderance was not however found in some other studies in Nigeria (Okoro et al., 2002; Rotimi et al., 2004). Though male *homo sapiens* are larger than female *homo sapiens*, females often have more obesity-related challenges arising likely from their proportionally larger visceral adipose tissue. This coupled with variations in steroid hormones that may affect metabolism, may be responsible for this female preponderance of diabetes reported here and elsewhere.

Our finding that diabetics were younger than 61 years is consistent with other reports from Nigeria (Chinenye et al., 2008; Enang et al., 2014); whereas in economically more developed countries, diabetics are usually older than 60 years. In the majority of countries in Europe for instance, the prevalence of diabetes is less than 10% in people younger than 60 and 10 to 20% in people aged 60 to 80 years (DECODE-Study-Group, 2003). Guariguata et al. (2014) summarised this scenario nicely when they reported that for the year 2013, “people with diabetes in high-income countries are predominantly over the age of 50 (74%) while those in low- and middle-income countries are mostly under the age of 50 (59%)”. This disparity may be explained by the poor state of healthcare in low- and middle-income countries, resulting in higher mortality rates and probably an earlier onset of the disease in such countries were the nutrition transition is already taking place. Whatever the explanation is, it does not bode well for these countries especially as economic development comes with improved life expectancy and an increased burden of non-communicable diseases. If the healthcare infrastructures in these countries are not strengthened now, the challenges of the future may be too much for them to cope with.

Many of the diabetics found in this study were not aware of the condition and were naive to treatment. Such high prevalence of undiagnosed diabetes (and other chronic diseases) is considerably common in low- and middle-income countries (Elbagir et al., 1996; Chow et al., 2006; Bo and Agyemang, 2013) where the cost of

Table 1. Concentrations of blood glucose in the subjects.

Subject		Blood glucose concentrations (mg/dL)				
		18 - 30 years	31 - 45 years	46 - 60 years	> 60 years	All
KD	Male	-	-	324 ± 53	-	324 ± 53
	Female	-	-	127 ± 21	-	127 ± 21
	Total	-	-	179 ± 83		179 ± 83
UKD	Male	-	-	-	-	-
	Female	-	151 ± 33	205 ± 49	-	183 ± 48
	Total	-	151 ± 33	205 ± 49	-	183 ± 48
IFG	Male	121 ± 0	-	-	-	121 ± 0
	Female	119 ± 0	113 ± 1	-	-	115 ± 4
	Total	120 ± 1	113 ± 1	-	-	117 ± 4
ND	Male	83 ± 11	88 ± 10	88 ± 10	86 ± 10	86 ± 10
	Female	84 ± 10	87 ± 10	89 ± 10	84 ± 11	86 ± 10
	Total	83 ± 11	87 ± 10	88 ± 10	85 ± 10	86 ± 10

KD, UKD, IFG and ND represent known diabetes, unknown diabetes, impaired fasting glucose and no diabetes, respectively. The distribution of the population by age range is: 18-30 years, 104 (58 females, 46 males); 31-45 years, 85 (51 females, 34 males); 46-60 years, 101 (52 females, 49 males); > 60 years, 75 (32 females, 43 males).

Table 2. Variations in measures of obesity between diabetic and non-diabetic subjects.

Subject	Diabetic				Non-diabetic			
	BMI (kg/m^2)	FM (Kg)	WHtR	WHpR	BMI (kg/m^2)	FM (Kg)	WHtR	WHpR
Female	30.1 ± 3.8	30.7 ± 6.6	0.61 ± 0.07	0.94 ± 0.07	25.2 ± 4.7	20.6 ± 8.6	0.52 ± 0.08	0.86 ± 0.08
P (F vs. M)					(0.019)	(0.001)	(0.001)	(0.001)
Male	26.6 ± 1.1	19.0 ± 4.9	0.59 ± 0.00	0.96 ± 0.02	23.5 ± 6.1	12.2 ± 5.9	0.46 ± 0.00	0.84 ± 0.06
P (F vs. M)					(0.270)	(0.118)	(<0.001)	(<0.001)
Total	28.8 ± 3.5	27.2 ± 9.8	0.60 ± 0.06	0.95 ± 0.06	24.4 ± 5.5	16.8 ± 8.4	0.49 ± 0.08	0.85 ± 0.07
P (F vs. M)					(0.009)	(<0.001)	(<0.001)	(<0.001)

F, M, BMI, FM, WC, HC, WHtR and WHpR represent female, male, body mass index, fat mass, waist circumference, hip circumference, waist-to-height ratio and waist-to-hip ratio, respectively.

Table 3. Correlations between blood glucose concentrations and anthropometric indices/measures of obesity.

Subject		Correlations [r (p)]							
		Height	Weight	BMI	FM	WC	HC	WHtR	WHpR
BGC	Females	-0.043 (0.553)	+0.258 (<0.001)	+0.282 (<0.001)	+0.264 (<0.001)	+0.333 (<0.001)	+0.235 (0.001)	+0.317 (<0.001)	+0.281 (<0.001)
	Males	-0.040 (0.600)	+0.018 (0.812)	+0.037 (0.634)	+0.116 (0.140)	+0.381 (<0.001)	+0.234 (0.002)	+0.376 (<0.001)	+0.327 (<0.001)
	All	-0.016 (0.759)	+0.090 (0.085)	+0.105 (0.044)	+0.124 (0.020)	+0.299 (<0.001)	+0.192 (<0.001)	+0.265 (<0.001)	+0.271 (<0.001)

BMI, FM, WC, HC, WHtR and WHpR represent body mass index, fat mass, waist circumference, hip circumference, waist-to-height ratio and waist-to-hip ratio, respectively.

regular medical check-ups may be out of reach of ordinary people and poor illness concepts are widespread (Ejike, 2014). The ratio of known to newly diagnosed diabetes is a good indicator of the level of diabetes awareness in a population. For this population, there is a need for aggressive public health education especially with respect to diabetes and related chronic diseases.

We found that measures of obesity were significantly higher in diabetics compared to non-diabetics (except for BMI and fat mass in males). The assessed measures of obesity (except for BMI in males) were weakly but signify-cantly ($r < 0.5$, $P < 0.05$) correlated with blood glucose concentration in all subjects. It has been reported that the increase in the prevalence of diabetes is interwoven with the upsurge in obesity in affected regions. About 90% of type 2 diabetes is known to be attributable to excess adiposity (Hossain et al., 2007). The absence of correla-tion between BMI and blood glucose concentration in males may be as a result of higher muscle mass in the males. BMI as an instrument is known to be unable to differentiate sufficiently between bone, muscle and fat mass, such that an individual may be obese by BMI standards yet post normal metabolic profile as seen in the metabolically-healthy-obese phenotype reported in Nigeria (Ejike et al., 2009; Ijeh et al., 2010). Interestingly, no significant correlation was found between lean mass and fasting BGC in either males or females.

Furthermore, patients with a low WHpR rarely have diabetes, irrespective of BMI, indicating the role of visceral fat in diabetes. Obesity comes with increased visceral tissue mass. Increased visceral obesity results in increased free fatty acids which in turn induces oxidative stress, inflammation and insulin resistance. Since insulin resistance results in hyperinsulinemia, adipocyte hormone sensitive lipase under such conditions ensures sustained lipolysis and an increased free fatty acid concentration which in turn perpetuates the cycle. Due to the chronic nature of obesity, it causes a tonic low grade activation of inflammation; and the attendant sustained insulin resistance, through the afore-discussed and other pathways, ultimately results in diabetes mellitus (Bloomgarden, 2000; Dandona et al., 2005; Lumeng and Saltiel, 2011; Watson, 2014). This relationship explains the complicity of obesity in diabetes and the correlations reported in this study.

This study is limited by the small sample size which was necessitated by the limited funds at our disposal, cultural belief systems that make people scared of procedures that require their blood, and lack of honoraria paid to participant. The sample size is nonetheless sufficient to highlight the challenges of diabetes in resource-poor settings typified by the semi-urban location we studied. The sampling method used may have also introduced some bias, as it is possible that those who suspected they had problems with glucose homeostasis may have more readily volunteered to be part of the study.

The use of capillary blood glucose for this study is yet another limitation. Capillary blood glucose is known to have a wider coefficient of variation compared to venous plasma (Anjana et al., 2011). However, logistical constraints such as the limited funds and cultural encum-brances mentioned earlier, lack of phlebotomists, and the challenges of proper transportation and storage of samples, foreclosed the used of venous blood for this study. This limitation is however attenuated by the report of Priya et al. (2011) which shows that capillary blood glucose compares well with venous blood glucose in studies like ours. Again, diabetes and IFG would have been better diagnosed if the oral glucose tolerance test was administered to the subjects with elevated fasting blood glucose concentrations. This calls for caution in the interpretation of diabetes prevalence data and data for those with IFG (a fraction of who may be reclassified as having diabetes if the OGTT was performed).

In conclusion, this study assessed the prevalence of diabetes and pre-diabetes in a convenient sample of adult Nigerians and examined the correlation between blood glucose concentration and measures of obesity. The prevalence of diabetes was found to be 3.0% (3.6% for females and 2.3% for males). Except for BMI in males, the assessed measures of obesity were all weakly but significantly ($r < 0.5$, $P < 0.05$) correlated with blood glucose concentration in all subjects. Public health action is needed to educate the masses about diabetes, especially the need for early diagnosis and the development of healthy lifestyles that may prevent or delay the onset of the disease.

Conflicts of interests

The authors declared that there is no conflict of interest.

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