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Double Jeopardy: Preponderance of Impaired Glucose Homeostasis and Overweight/Obesity Among Adult Females in Ikwo, Ebonyi State

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Abstract

The nutrition transition being faced by most economically developing countries has resulted in changes in chronic diseases patterns in such countries, yet such diseases are rarely studied in rural areas, where the majority of the population live. The prevalence of diabetes/impaired fasting glucose (IFG) and overweight/obesity was therefore studied in a population of adults in Ikwo LGA, Ebonyi State, Nigeria. Standard internationally accepted methods were used for this cross-sectional population study. A total of 720 subjects (53.1% females) were recruited and studied. Diabetes was found in 4.0% of the subjects (3.0% for males and 5.0% for females) while 7.1% of the population (6.5% for males and 7.6% for females) had IFG. About 20% of the entire population (and a quarter of the females) were overweight/obese yet, 11.7% of them (10.7% males, 12.6% females) were underweight. The modal age range for those who were diabetic or overweight/obese was 26-40 years irrespective of sex. Blood glucose concentration was found to be significantly correlated only with BMI ($r = +0.116$; $P < 0.01$). The preponderance of both diabetes/IFG and overweight/obesity in women as seen in this study is indeed a double jeopardy, requiring urgent interventions.

Keywords

Diabetes, Glycaemia, Impaired fasting glucose, Obesity, Overweight

Introduction

Globally, obesity and diabetes are two major non-communicable diseases (NCDs) constituting very significant healthcare challenges, irrespective of region. Indeed, obesity is a bigger health crisis compared to hunger and it is the global leader among causes of death and disabilities. Its burdens are projected to increase in the future [1]. Similarly, the prevalence of diabetes mellitus (DM) is rising steeply around the world, often in parallel with the prevalence of obesity [2]. Both obesity and type 2 DM are related as they are multifactorial, complex diseases, which are (in many cases) preventable, or at least amenable to lifestyle modifications. They are known to significantly raise the risk for cardiovascular disease (CVD) and stroke. In addition, underweight is known to be associated with increased risk of morbidity and mortality and with adverse pregnancy outcomes in women [3]. Painfully, in sub-Saharan Africa, NCDs are projected to account for nearly half of all deaths by 2030, as deaths arising from infectious diseases and under-5 mortality drop and life expectancy increases [2].

Globally, there has been an increase in the age-standardized prevalence of obesity from 3.2% in 1975 to 10.8% in 2014 in men, and from 6.4% to 14.9% in women [4]. The WHO Obesity and Overweight Fact Sheet indicate that more than 1.9 billion adults were overweight in 2016 and more than 650 million of them were obese. This gives a prevalence of 39% for overweight, and 13% for obesity for the year 2016. In Nigeria the prevalence of obesity has been reported to be 0.8% to 15% in males and 2.9% to 42% in females; while the prevalence of overweight is reported to be 12.2% to 42% in males and 18.0% to 32% in females [5-7]. Though underweight is rarely reported, especially in Nigeria, a recent report indicated that 4.7% of adult Nigerians (3.8% males, 6.0% females) were underweight [8]. Reports from rural areas in Nigeria are either nonexistent or sparse.

Cho et al., report that the "prevalence of diabetes among women (18-99 years) in 2017 was estimated to be 8.4%, which is lower than in men (8.9%)". In Africa the figure was 4.2% (CI 2.7 - 7.7%) [9]. The said authors estimated that there were 451 million adults with diabetes globally in 2017. They projected that the figures will increase to 693 million by 2045. Earlier the NCD Risk Factor Collaboration estimated that the "number of adults with diabetes in the world increased from 108 million in 1980 to 422 million in 2014 (28.5% due to the rise in prevalence, 39.7% due to population growth and ageing, and 31.8% due to interaction of these two factors)" [10]. A recent study in Nigeria reported that the prevalence of diabetes among adults was 3.0% (3.6% for females and 2.9% for males) [7]. Unfortunately, the prevalence of diabetes is rarely reported in rural Nigeria.

It is thought that urbanization and the dramatic lifestyle changes that come with it are responsible for the rapid transitions that accompany increases in risk factors for NCDs [11, 12]. Many developing countries are classified as low and middle income countries (LMICs) where poverty rates are high. Yet, it is known that obese individuals pay about 42% more in healthcare costs than their normal-weight counterparts, and diabetics pay slightly more than twice as much as their counterparts without DM [1]. Consequently, it is imperative that countries that are rapidly urbanizing, such as Nigeria, must undertake studies of the local and national estimates of the burdens of (especially) obesity and diabetes as such numbers are central to appropriate resource allocation, health-policy development and action, and disease prevention or management. Interestingly, both urban and rural areas of Nigeria are currently experiencing urbanization, albeit to varying degrees. Unfortunately, however, the rural areas (where majority of the population live) are rarely studied. The current study was therefore designed to provide data on the prevalence of obesity and diabetes in adults in Ikwo LGA of Ebonyi State - an understudied rural area of Nigeria.

Subjects and Methods

Subjects

This cross-sectional study was carried out in Ndufu-Alike and Ndufu-Echara communities of Ikwo LGA of Ebonyi State. The heads of both communities were approached and their support and approval obtained. Thereafter, adults in both communities were randomly approached and the rationale for the study was explained to them. Subsequently, those who gave an informed verbal consent were recruited for the study. The exclusion criteria adopted included the presence of severe physical deformity (as could make anthropometric measurements difficult), and overt or reported ill-health and pregnancy (in women). The same protocol and equipment were used for data collection which was performed in three batches between 2016 and 2018. The same researcher trained the field data collectors and supervised data collection and collation. A total of 720 subjects (46.9% males) were recruited and studied.

Methods

Self-reported age at last birthday was recorded per subject. Their weights, heights, and waist circumferences were measured using standard protocols used regularly by our group and previously described in details [7]. From the above variables, body mass index (BMI), and waist-to-height ratio (WHtR) were calculated using standard equations. All the subjects recruited were required to fast for at least 12 hours (overnight) after which their fasting capillary blood glucose concentrations were determined using a glucometer (Accu-chek Advantage, Roche Diagnostics, Mannheim, Germany) according to the manufacturer's instructions.

Definitions

Overweight and obesity were defined by three definitions thus: (1) body mass index (BMI) ≥ 25 but < 30 and BMI ≥ 30 respectively; [2] waist circumference (WC) ≥ 80 for women and ≥ 94 for men; and [3] waist-to-height ratio (WHtR) ≥ 0.5 as described previously [5]. Diabetes was defined as a fasting blood glucose concentration of ≥ 126 mg/dL (≥ 7 mmol/L), or self-reported use of glucose lowering medication(s). Impaired fasting glucose (IFG) was defined as a fasting blood glucose concentration between 110 and 125 mg/dL (6.1-6.9 mmol/L). Diabetic and individuals and those with IFG were referred to as hyperglycaemic. Hypoglycemia was defined as a fasting blood glucose concentration of ≤ 70 mg/dL (3.9 mmol/L) [13]. Where necessary, subjects were stratified into 4 convenient age ranges *viz*: 18 to 25 years, 26 to 40 years, 41 to 60 years, and more than 60 years.

The study was designed in line with the Helsinki declaration, and was approved by the Board of the Department of Biochemistry, Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria.

Statistics

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 other relevant (measured or derived) variables. Differences between group means were separated using One-Way 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 mean age and height of the subjects were statistically similar ($P > 0.05$) between the glycaemic phenotypes, irrespective of sex. Hypoglycemic females weighed significantly ($P < 0.05$) less than their normoglycaemic counterparts. They also had significantly lower ($P < 0.05$) BMI, WC and WHtR compared to their normoglycaemic counterparts. Males with IFG had significantly ($P < 0.05$) higher WC and WHtR values relative to their normoglycaemic counterparts. In all other respects, the values obtained were not significantly different between any of the glycaemic phenotypes compared to the normoglycaemic group, for both sexes (Table 1). Diabetes was found in 4.0% of the subjects (3.0% for males and 5.0% for females) while 7.1% of the population (6.5% for males and 7.6% for females) had IFG. Only 25% of those with diabetes were medically diagnosed of the condition, and therefore knew about it. As much as 12.8% of the population (10.1% for males and 15.2% for females) were hypoglycemic (Figure 1). The modal age range for those who were hyperglycaemic was 26-40 years irrespective of sex (Figure 2).

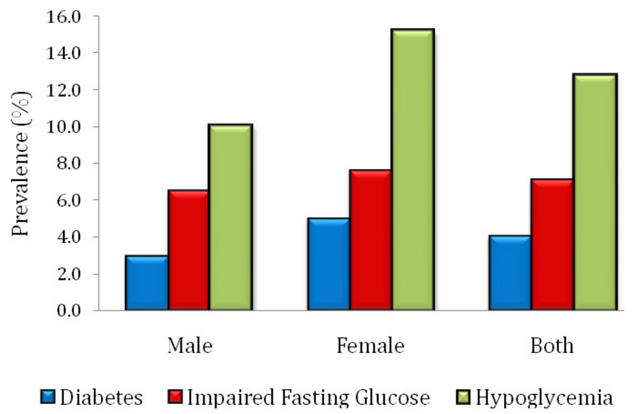

Figure 1: Prevalence of different glycaemic statuses in the population.

(27.2% for males and 49.7% for females) were overweight/obese (Figure 3B). As much as 71.4% and 85.7% of males, and 95.2% and 100% of females, who were diagnosed with the BMI standard were also overweight/obese using the WC and WHtR, respectively. The modal age range for those who were overweight/obese was 26-40 years irrespective of sex (Figure 2). None of the males had both diabetes and overweight/obesity while 2.1% of the females had diabetes and overweight/obesity co-existing.

Table 1: Relevant characteristics of the subjects stratified according to their sex and blood glucose phenotypes.

	Group (N)	Age (Years)	Weight (kg)	Height (m)	BMI (kg/m²)	WC (cm)	WHtR	BGC (mg/dl)
Females	Normo-glycaemic (276)	33.2 ± 13.6	59.9 ± 12.4	1.6 ± 0.1	22.9 ± 4.7	82.6 ± 10.8	0.51 ± 0.07	88.7 ± 10.2
	Diabetic (19)	36.1 ± 14.8	60.9 ±12.5	1.6 ± 0.1	24.0 ± 4.1	83.3 ± 11.0	0.52 ± 0.07	166.7 ± 84.8*
	IFG (29)	31.8 ± 13.1	60.7 ± 9.8	1.6 ± 0.1	23.2 ± 3.8	84.7 ± 10.3	0.52 ± 0.07	116.5 ± 5.0*
	Hypoglycaemic (58)	37.3 ± 13.8	55.4 ± 9.8*	1.6 ± 0.1	21.1 ± 3.0*	79.2 ± 9.1*	0.49 ± 0.05*	60.3 ± 6.6*
	Total (382)	33.9 ± 13.7	59.3 ± 11.9	1.6 ± 0.1	22.7 ± 4.4	82.2 ± 10.6	0.51 ± 0.07	90.4 ± 30.1
Males	Normo-glycaemic (272)	40.0 ± 13.3	64.4 ± 12.0	1.7 ± 0.1	22.4 ± 3.5	82.8 ± 43.2	0.49 ± 0.25	87.7 ± 10.0
	Diabetic (10)	39.5 ± 17.9	64.3 ± 5.2	1.7 ± 0.1	22.3 ± 1.5	82.3 ± 6.0	0.49 ± 0.04	219.0 ± 95.0*
	IFG (22)	41.1 ± 15.0	68.5 ± 11.2	1.7 ± 0.1	23.8 ± 3.6	87.7 ± 10.5*	0.52 ± 0.07*	117.4 ± 4.5*
	Hypoglycaemic (34)	43.2 ± 14.6	61.0 ± 11.1	1.7 ± 0.1	21.0 ± 3.5	78.2 ± 9.7	0.46 ± 0.06	59.4 ± 6.9*
	Total (338)	40.4 ± 13.7	64.3 ± 11.8	1.7 ± 0.1	22.4 ± 3.5	80.6 ± 9.4	0.48 ± 0.05	90.7 ± 31.1
All subjects	Normo-glycaemic (548)	36.6 ± 13.9	62.1 ± 12.4	1.7 ± 0.1	22.7 ± 4.1	82.7 ± 31.4	0.50 ± 0.18	88.2 ± 10.1
	Diabetic (29)	37.2 ±15.7	62.1 ± 10.5	1.6 ± 0.1	23.4 ± 3.5	82.9 ± 9.5	0.51 ± 0.06	184.8 ± 90.3*
	IFG (51)	35.8 ± 14.6	64.0 ± 11.0	1.7 ± 0.1	23.4 ± 3.7	86.0 ± 10.4*	0.52 ± 0.07*	116.9 ± 4.8*
	Hypoglycaemic (92)	39.5 ± 14.3	57.5 ± 10.6*	1.6 ± 0.1	21.1 ± 3.2*	78.8 ± 9.3*	0.48 ± 0.06*	60.0 ± 6.7*
	Total (720)	36.9 ± 14.1	61.6 ± 12.1	1.7 ± 0.1	22.5 ± 4.0	82.4 ± 27.8	0.50 ± 0.16	90.5 ± 30.6

* indicates significant difference when compared to the normo-glycaemic group for the respective sexes or the entire population.

Though only 3.9% of the population (2.1% males; 5.5% females) were obese by BMI standards, as much as 16.9% (14.8% males; 18.9% females) were overweight (Figure 3A). About one fifth of the entire population, and a quarter of the females were either obese or overweight. Despite the above, 11.7% of the population (10.7% males; 12.6% females) were underweight. Using WC as a diagnostic criterion, 14.9% of the population (2.7% for males and 25.7% for females) were overweight/obese. As much as 39.3% of the population

Blood glucose concentration was found to be significantly correlated with BMI. The correlation was positive but weak ($r = +0.116$; $P < 0.01$). No significant correlation was found between blood glucose concentration and age or the other anthropometric indices measured.

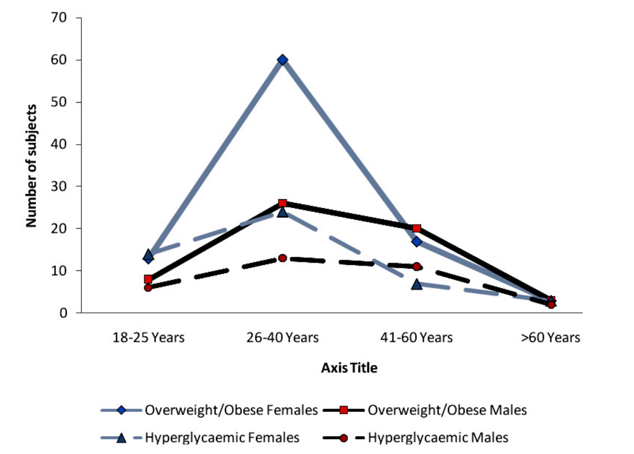

Figure 2: Distribution of overweight/obese (unbroken lines) and hyperglycaemic (broken lines) subjects in the population based on age ranges.

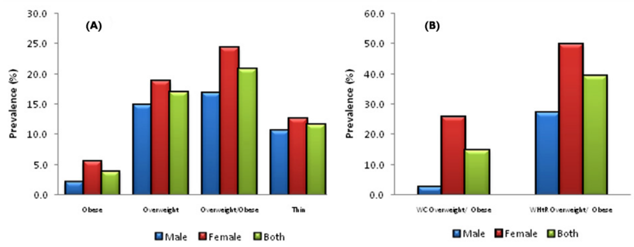

Figure 3: Nutritional status of adults in Ndufu-Echara, determined using **(A)** body mass index (BMI) and **(B)** waist circumference (WC) and waist-to-height ratio (WHtR).

Discussions

Diabetes and obesity, often referred to as diseases of affluence, were hitherto thought to be an insignificant problem in LMICs. However, recent evidence suggests that most people suffering from the diseases in fact live in LMICs. Furthermore, it is projected that such economically developing countries will experience the greatest increase in cases of diabetes in the future [14]. This therefore warrants a change in the perception of these diseases and a deliberate effort to identify individuals who are burdened by (or are at risk of) the disease, characterize the peculiar etiopathological mechanisms, and device appropriate prevention and treatment methods that are relevant to such localities. The study presented here, is therefore an important contribution in this direction as it is the first study (to the authors' knowledge) of diabetes and obesity in Ikwo LGA in particular, and Ebonyi State of Nigeria, in general.

Diabetes was found in 4.0% of the subjects (3.0% for males and 5.0% for females); while 7.1% of the population (6.5% for males and 7.6% for females) had IFG. The prevalence of diabetes is clearly lower than the global prevalence rate of 8.4% in females and 8.9% in males but is similar to the 4.2% prevalence reported for Africa [9]. The figures are also marginally higher than recent figures (4.2%) from the same ethnic group in Nigeria [7]. Here it is important to point out that the prevalence of diabetes in the men was similar between this study and the said earlier study in Nigeria (3.0% vs 2.9%) while the figures were slightly higher (though not significantly so) for females in this study, compared to the previous one (5.0% vs 3.6%). Interestingly, other than the fact that both studies were conducted in the same ethnic group - Igbo - both studies were also conducted in non-urban areas and the same methods and type of equipment were used. An earlier study in Nigeria, had noted that diabetes was more prevalent in urban areas relative to rural areas [15]. Indeed, prevalence values as high as 11.0% and 6.5% have been reported in Lagos and Calabar, respectively [15, 16], two commercial port cities in Nigeria. This appears to buttress the contributions of lifestyle modifications which accompany an urban environment to the pathogenesis of diabetes and indeed all chronic diseases. It is therefore important to recognise these differences in dealing with the scourge of diabetes in different localities.

The higher prevalence of IFG in the population is indicative of a slow progression of the disease and points out the imminent crisis that could ensue if nothing is done to reverse the course of development into full blown disease. This finding is in discordance with the report from Umudike, Nigeria where there was an indication of a rapid progression of the disease [7]. The female preponderance of diabetes found in this study is in agreement with patterns reported in Nigeria [7, 15, 16]. This female preponderance may be connected with gestational diabetes in women which may lead to the development of Type 2 DM if not properly managed. Additionally, females naturally store more body fats than men and these fat stores are known to be sites for the activities of chemical agents (chemokines) that are triggers for chronic diseases, including diabetes [11]. It also thought that certain hormone-related priming may play a part in the predisposing women to metabolic diseases [17]. We do not have any data from this report to support any of the above. Again, we realize that the observed female preponderance of diabetes may be due to nurture, not nature. Clearly more work is needed to illumine these observations. Nevertheless, women should be deliberate targets for interventions on diabetes, using (possibly) antenatal sessions and other outreach programs.

The modal age range for those who were hyperglycaemic was 26-40 years irrespective of sex. Again, this is similar to the findings reported earlier in Nigeria [7]. Earlier, it had been shown that 74% of diabetic individuals in high-income countries are older than 50 years while 59% of diabetics in LMICs are younger than 50 years [14]. Implicit in this is the fact that mortality related to diabetes is higher in LMICs such as Nigeria due to the earlier onset of the disease, poor chronic diseases-related illness concepts [18], and the poor state of the healthcare infrastructure. The exact reasons why people in LMICs develop diabetes earlier are still not known and yet its understanding is important for an appreciation of the early pathogenesis and a development of proper interventions targeting young adults in Nigeria and other LMICs. Again, only 25% of those with diabetes knew about their condition the rest were naïve. Having as much as 75% of the population with undiagnosed diabetes is terrible as it means they may not seek medical help until the disease progresses to end-stage renal failure, diabetic foot ulcers or blindness when little can be done to reverse the course of the disease. This is particularly worrisome when compared to the global average of 49.7% of people living with undiagnosed diabetes [9]. Additional research is needed to identify the cause of the early onset of diabetes in the studied population; and population-wide screening programmes should be developed and implemented such that cases are identified early and treatment initiated timely.

On the other end of the glycaemic spectrum, 12.8% of the population (10.1% for males and 15.2% for females) were hypoglycemic. Hypoglycemia here could be an indication of problems with glucose homeostasis or of poor nutritional status. In fact, the hypoglycemic females had significantly lower anthropometric indices (except height) compared to their normo-glycaemic counterparts. It is therefore plausible that the hypoglycemia may be due to chronic nutritional deficits, though this does not rule-out underlying pathologies. Hypoglycemia could result in dizziness, reduced work output and even myocardial infarction [19].

Obesity is now known to be central to the development of many chronic diseases, including diabetes and some cancers. Indeed, about 90% of type 2 DM is linked to excess adiposity [20]. This is particularly true for visceral obesity as the visceral adipose tissue is known to be the site for the synthesis and activity of chemokines which drive the pathogenesis of chronic diseases, especially those linked to inflammation [11]. Furthermore, this study showed that blood glucose concentration was significantly correlated with BMI, indicating their relationship, even though the correlation was weak and obviously does not indicate any causality.

Obesity defined by BMI standards was found in 3.9% of the population (2.1% males; 5.5% females) while 16.9% of the subjects (14.8% males; 18.9% females) were overweight. This indicates that approximately one fifth of the entire population, and a quarter of the females were either overweight/obese. These figures are considerably lower than the latest WHO report of 13% for obesity and 39% for overweight globally. In Nigeria, the prevalence of obesity and overweight, just like diabetes, are known to increase as one moves from the rural areas to the urban areas. Hence whereas data from Abuja, Nigeria's capital give a prevalence of 15% for men and 42% in females (obesity) and 42% in males and 32% in females (overweight) [6]; data from Umudike, a non-urban area report a prevalence of 0.8% for men and 2.9% for women (obesity) and 12.2% in males and 18.0% in females (overweight) [7]. Clearly the urban environment drives obesity and this is firmly established in the scientific literature. The observation that about 20% and 25% of the males and females, respectively, in the studied population are overweight/obese is nonetheless worrisome as the overweight individuals could easily become obese if nothing is done to halt the progression, and the negative effects of excess weight on both the individual and the community are known to be inimical to personal or national development. Urgent steps are therefore needed to address the impending dangers these figures pose. For convenience purposes, we have limited the discussion to obesity diagnosed using the BMI standards. The other methods used have significant implications for diseases related to fat deposition and distribution, and have been discussed exhaustively elsewhere [5, 21].

Again, as was the case with diabetes, the modal age range for those who were overweight/obese was 26-40 years irrespective of sex. This is typically the age when women bear pregnancies and have children. The effects of pregnancy and lactation on weight gain in women have been reported [22]. Additionally, the negative consequences of excess weight in women of child-bearing age are also known [23]. It however appears that cultural practices which encourage married women to gain weight (as a sign that their husbands take proper care of them) immediately after marriage or during the periods after parturition when they nurse their babies have not been sufficiently challenged with medical evidence. It is important to educate women of child-bearing age about the dangers of excess weight so as to encourage them to maintain a healthy weight during gestation and after parturition. The 26-40 year age-bracket is also the period when people transit to adult "metabolic life" where biological and societal factors conspire to ensure that individuals store more "energy" than they otherwise did as younger people. The period coincides with the period when work- and society-related stressors are high, resulting in the secretion of hormones such as prolactin and cortisol which are known to encourage fat deposition in storage sites [11]. It is therefore important to target this age-bracket in health policy-related programmes aimed at addressing both obesity and diabetes.

Despite the prevalence of overweight/obesity, as much as 11.7% of the population (10.7% males; 12.6% females) were underweight. This clearly indicates a double burden of nutritional diseases in the community. A recent large cross-sectional study of underweight in Nigerians, reported that 4.7% (3.8% males; 6.0% females) were underweight [8]. Interesting, just as was the case with obesity, females were affected more by underweight compared to men and this is in agreement with earlier studies. This is however worrisome, given the average age of the women, as underweight women are known to have problems of infertility and adverse pregnancy outcomes [3].

Limitations

This study is limited by the use of capillary blood for glucose concentration determination. It is known that capillary blood glucose measurements have wider coefficients of variation compared to venous plasma glucose measurements. However, in a cross-sectional study such as this, logistical constraints such as limited funds, cultural challenges making it difficult for people to allow a "foreigner" collect their blood, and infrastructural challenges such as the availability of proper transportation and storage facilities for samples, foreclosed the use of venous blood for this study. Given that capillary blood glucose compares well with venous blood glucose [7], we are confident that the data presented here is reliable. Another limitation of this study is the use of a point determination to make a diagnosis of diabetes and IFG, without recourse to confirmatory tests such as the oral glucose tolerance test. This necessarily warrants that the data presented are interpreted cautiously.

Conclusion

The prevalence of diabetes/IFG and overweight/obesity were studied in a population of adults in Ikwo LGA, Ebonyi State, Nigeria. Diabetes was found in 3.0% for males and 5.0% for females while 6.5% for males and 7.6% for females had IFG. About 20% of the entire population (and 25% of the females) were overweight/obese; yet, 11.7% of them (and 12.6% of females) were underweight. The modal age range for those who were diabetic or overweight/obese was 26-40 years irrespective of sex. Blood glucose concentration was found to be significantly correlated with BMI. Women are more burdened than men with both diabetes/IFG and overweight/ obesity and this is a double jeopardy.

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Declaration

The authors have no real or potential conflict of interest to declare.

Author Contributions

CECCE conceived the study, designed it, supervised it, analysed the data, plotted the graphs/charts, and wrote the manuscript. GNO participated in study design and supervision and contributed in writing the manuscript. MO, CMN, FOI, AQU, AVU, AMO, CDA, CAN, ALO did the field work and collated the data. All authors read and approved the final version of the manuscript.

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