International Scholars Journals

Global Journal of Endocrinology and Diabetes Vol. 4 (5), pp. 001-006, May 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals



*Full Length Research Paper*

# Detecting incident type 2 diabetes mellitus in South Eastern Nigeria: The role of adiposity indices in relation to gender

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Accepted 4 March, 2019

**This work assessed the predicting power of different adiposity indices on incident type 2 diabetes mellitus among adult males and females in Uyo Metropolis, Nigeria. A cross-sectional survey of 3500 adult civil servants (1532 men and 1968 women), aged 18 to 60 years, selected by multi-steps random sampling technique were assessed using 2011 Expert Committee Revised criteria for diagnosing diabetes. Overall cases of incident type 2 diabetes mellitus was 180 (5.4%), 73 men (4.8%) and 116 women (5.9%). Result of comparison between diabetic males and females using independent sample t-test showed that body mass index (BMI) and mid arm circumference (MAC) of the two groups did not differ significantly (*P*= 0.948, 0.648 respectively). Waist circumference (WC) and waist-hip ratio (WHR) of diabetic females were significantly higher than that of the males counterpart (WC: *P* =0.001 and WHR: *P*=0.034). Body mass index (BMI) and mid arm circumference (MAC) had equal predicting powers in both sexes with odd ratio (OR) and 95% confidence interval (CI) as follows: BMI (OR=2.41, C.I=1.728 to 7.01 for male and 2.02, 1.51 to 6.402 for females); MAC (OR =1.624, C.I=1.824 to 7.051 for males and 1.51, 1.62 to 6.59 for females); waist hip ratio (WHR) and waist circumference (WC) were predictive only in women and not in men with OR and C.I as follows: - WHR (OR=2.435, 0.951to 6.413 for women and 0.729, 0.547 to 1.14 for men); WC: (2.834, 1.270 to 5.421 for women and 1.21, 0.695 to 1.845 for men) respectively. All adiposity indices measured were significantly associated with incident type 2 diabetes mellitus in females, with only BMI and MAC showing a consistent significant association in males.**

**Key words:** Adiposity indices, diabetes mellitus, gender, Nigeria.

## INTRODUCTION

Diabetes mellitus is an international public health issue. It can now be found in almost every population in the world. Its scourge to the society is enormous. Its impact on health and economy is substantial. It is now affecting many people in the workforce, causing a major and deleterious impact on both individual and national productivity. It increases risk of some disease state such as heart disease, blindness, nerve disorders, kidney disease and gangrene (WHO, 2011). Epidemiological evidence suggests that without effective prevention and control programmes, the burden of diabetes is likely to continue to increase globally.

Several risk predictive indices have been employed in some preventive programmes; one of such is the use of adiposity indices. They are: body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR) and mid arm circumference (MAC). They are objective and reliable measures of the degree of fatness and risk of associated chronic illnesses such as diabetes mellitus, hypertension, coronary heart disease (CHD) and cancers. Evidence of the relationship between excess adipose tissue and incidence of type 2 diabetes mellitus has been document-ted. Adipose tissue is noted to affect glucose metabolism through its action in modulating tissue concentrations of adipokines, such as adiponectins and resistine (markers of insulin resistance) (Frederico et al., 2011). In clinical practice, physicians cannot measure indices of insulin sensitivity in the context of their practice. Some orga-nizations have therefore proposed to use some clinical

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parameters such as adiposity indices to find individuals at risk (Sosenke et al., 1993). Research findings have shown that, the risk predictive value of individual adiposity index is gender dependent in same environment and race. Gender confers large differences in the subcutaneous as well as visceral adipose tissue distribution, correlation of visceral adipose tissue with metabolic syndrome was shown to be strong in men, but absent in women (Frederick et al., 2011).

Also, studies have shown that women have more fat than men, even within normal weight range in women (25 to 30%) versus (18 to 25%) in men (Lois et al., 1996); women are therefore more obese than men. They gain more weight during pregnancy, and this weight is not entirely shed afterwards. The increased body fat and weight, together with stress, increase their risk of type 2 diabetes mellitus. The relationship of adiposity indices and gender to incidence of type 2 diabetes mellitus have been extensively documented and frequently commented upon enough in developed nations of the world (Allen et al., 1956). Such documentation is scanty in developing countries like Nigeria. Since the detecting value for these indices is population dependent and varies from race to race, it is important to determine what values of simple adiposity measures are associated with the presence of type 2 DM risk in each population to facilitate and enhance screening for disease risk. Thus, the aim of this study was to examine the detecting strength of adiposity indices for onset of type 2 diabetes mellitus with special reference to gender among civil servants in Akwa Ibom State, South Eastern Nigeria.

## MATERIALS AND METHODS

### Study design and population

This was a cross-sectional study conducted in Akwa Ibom state civil service secretariat headquarters located in Uyo metropolis, South Eastern Nigeria, between October 2008 and December 2010. A total of 3500 subjects participated. 1532 (43.8%) were males while 1968 (56.2%) were females. They were selected by stratified random sampling. Exclusion criteria were: individual <18 or >60 years, athletes, pregnant women, and physically deformed. A semi-structure questionnaire was used as the survey instrument. These were distributed to participants to fill out. The questionnaire sought to elicit information on the following areas; socio-demographic data (age, sex, marital status, ethnicity and educational level), family history of diabetes, presence of diabetic symptoms (polyuria, polydipsia, polyphagia and weight loss), and drug history to sort out those on insulin and other hyperglycemic medication.

### Measurement of adiposity indices

Measurement of adiposity indices was the second instrument employed in this study. This was performed by trained paramedical staff in the study team using standard from WHO technical report services-854 on physical status 1995. These include: measurement of weight in kilogram to the nearest 0.1 kg using weighing scale (Seca model, Germany), and ensuring that the individual wears light clothing and without shoes. Height was measured to the nearest 0.1 cm using Stadiometer. Waist circumference was measured to the nearest 0.1 cm using a non-stretchable measuring tape while the subject stood in erect posture. Measurement was taken midway between the umbilicus and pubic symphysis. Mid arm circumference was measured to the nearest 0.1 cm. These measurements were taken two times each, and the average was used for data computation. BMI was computed using the standard formula of weight (kg)/height ($m^2$).

BMI 18.5 to 24.99 as normal, 25 to 29.99 as overweight and ≥30 kg as general obesity were used. For WC, ≥88 cm for females and ≥102 cm for males were regarded as central obesity while WC of ≥88 cm for females and ≥94 cm for males were regarded as central overweight. Hip circumference was measured to the nearest 0.1 cm at the point of the highest protrusion of buttocks. WHR was calculated as WC/HC. WHR of 1 in men and >0.85 in women was regarded as indicative of abdominal or central obesity.

Fasting blood sugar (FBS) test was conducted for those who appeared for the test after overnight fast (at least 8 h of not eating food). Casual plasma glucose test was conducted for those who had eaten breakfast before appearing for the test, while 2 h post-prandial (2 hPP) glucose test was conducted for all participants. FBS measures glucose level in a person who has not eaten anything for at least 8 h. It is preferred because of its convenience in a clinical setting and low cost. Casual blood glucose estimation is defined as estimation at any time of the day without regard to the time since last meal. 2 h PPG is defined as two hours since last meals. Diabetes was diagnosed based on the 2011 revised criteria by the Expert Committee on the diagnosis and classification of diabetes mellitus, which recommends the diagnosis of diabetes base on:

i. Two FPG levels of 126 mg/dl (7.0 mmol/L) or higher
ii. Two 2 h PPG readings of 200 mg/dlol (11.1 mmol/L) or higher after a glucose load of 75 g or two casual glucose readings of 200 mg/dl (11.1 mmol/L) or higher
iii. Glycosylated hemoglobin (AIC) of 5.7 to 6.4%

### Ethical consideration

Approved consent was obtained from each respondent, while the study protocol was approved by the University of Uyo Medical Research and Ethics Committee. The head of civil service also granted the approval for the study.

### Statistical analysis

Descriptive statistics were computed. Means and its corresponding standard errors were computed for continuous variables (BMI, WC, WHR and MAC) and frequencies and simple percentages for categorical variables (sex, marital status, educational level and age). Moreover, chi-square test was used to compare differences in the number of males who were diabetic with that of diabetic females. The independent sample t-test was also used to compare differences in the adiposity indices of diabetic males and females.

Finally, association between adiposity indices and diabetes was tested using multiple logistic regression models which were done separately for males and females. Based on these models, odd ratio and its 95% confidence intervals were estimated. All statistical computations were performed with the Statistical Package for Social Sciences (SPSS 17.0). $P<0.05$ were considered to be statistically significant.

## RESULTS

Data collected using 3,500 subjects were used in the

**Table 1.** Demographic data of participants.

| Variable | Number of respondent | Percentage |
|---|---|---|
| **Sex** | | |
| Male | 1532 | 43.8 |
| Female | 1968 | 56.2 |
| | | |
| **Marital status** | | |
| Single | 2035 | 58.1 |
| Married | 1465 | 41.9 |
| | | |
| **Educational status** | | |
| No formal education | 172 | 4.9 |
| Lower education | 2302 | 65.8 |
| Higher education | 1026 | 29.3 |
| | | |
| **Age** | | |
| 18-35 | 2624 | 75 |
| 36-45 | 368 | 10.5 |
| 46-55 | 213 | 6.1 |
| 56 and above | 295 | 8.4 |

statistical analysis. 1532 (43.8%) and 1968 (56.2%) were the frequencies and percentages of male and females respectively. Detailed results are shown in Table 1.

The overall prevalence of 5.4% was obtained with 4.8% in males and 5.9% in females respectively. Results are shown in Table 2. The number of females who were diabetic were significantly higher than that of the males (*P*=0.002).

Moreover, the result of comparison of adiposity indices between diabetic males and females showed that the BMI and MAC of diabetic males were not significantly higher than that of the diabetic females (*P*=0.962 and *P*=0.648 respectively). Also, WC and WHR of females who were diabetic were significantly higher than that of the diabetic males (*P*=0.01 and *P*=0.034 respectively). Results are shown in Table 3.

Furthermore, result of odd ratio (OR) and 95% confidence interval (C.I) showed that obese males and females had equal chance of developing diabetes (about 2 times) than their non-obese counterparts (OR=2.410, C.I=1.728 to 7.01 for male and OR=2.410, C.I=1.51-6.402 for female). Females with abnormal WC had three times higher chances of having diabetes (OR=2.834, C.I=1.270 to 5.421) while females with abnormal WHR had two times chances of being diabetic (OR=2.435, C.I=0.951 to 6.413). These results were insignificant in males with abnormal WC and WHR as the odd ratios of males who had abnormal WC and WHR were not different from those who had normal WC and WHR (OR=1.021, C.I=0.695 to 1.845 and OR=0.729, C.I=0.547 to 1.14 respectively). Finally, abnormal MAC increases the chances of type diabetes in both males and females (OR=1.624, C.I=1.824 to 7.051 and OR=1.51, C.I=1.62 to 6.59 respectively). Results are shown in Table 4.

## DISCUSSION

The relationship between adiposity indices and incident type 2 diabetes mellitus have been extensively studied and documented especially in developed countries, but with conflicting results. This could probably be due to environmental, racial, gender or different distribution of other risk factors. Result in this study showed that, overall prevalence of type 2 diabetes mellitus (T2DM) was 5.4%, male: female prevalence was 4.8 and 5.9% respectively. All the adiposity indices used in this study were statistically significant in females, while BMI and MAC were the only adiposity indices significant in males. Female dominance in prevalence observed in this study could be attributed to the combine effect of all the anthropometric parameters (BMI, MAC, WC and WHR) which were all statistically correlated with T2DM. Similar observation was made by Brancati et al. (2000) while using data from the ARIC cohort to ascertain factors that could help to explain the higher incidence of diabetes observed in African-Americans. In that study, the high relative risk (RR) of developing diabetes was seen between African American and white women, and was attributed to the combine effect of BMI and WHR measures (Brancati et al., 2000). The result of this study underscores the risk detecting value of more than one adiposity index, as no single index can be identified as optimal choice for diabetic risk detection on its own. To this effect, the US National Institute of Health (NIH) now recommends the use of WC in conjunction with BMI as a complementary

**Table 2.** Prevalence of diabetes in relation to gender.

| Diabetes | Male {(n)%} | Female {(n)%} | Total {(n)%} |
|---|---|---|---|
| Diabetic | 73 (4.8) | 116 (5.9) | 189 (5.4) |
| Non-diabetic | 1459 (95.2) | 1852 (94.1) | 3311 (94.6) |
| Total | 1532 (43.8) | 1968 (56.2) | 3500 (100) |

$X^2$ calculated=9.78, *P*= 0.002 (*P*<0.01), significant at 1%.

**Table 3.** Comparison of adiposity indices between diabetic males and females (n= 189).

| Adiposity indices | Total (n=189) | Males (n=73) | Females (n=116) | T-test | P-value |
|---|---|---|---|---|---|
| BMI | 24.44±0.23 | 24.430±0.33 | 24.45±0.33 | -0.048 | 0.962$^{NS}$ |
| MAC | 27.90±0.35 | 27.72±0.26 | 28.04±0.59 | -0.457 | 0.648$^{NS}$ |
| WC | 79.31±0.42 | 77.70±0.53 | 80.54±0.60 | -3.43 | 0.001** |
| WHR | 0.88±0.19 | 0.86±0.005 | 0.89±0.02 | -2.13 | 0.034* |

NS= Not-significant (*P*>0.05), *significant at 5% (*P*<0.05), **significant at 1% (*P*<0.01).

indicator of health risk among normal and overweight subjects (NIH, 2000).

Similar gender effect on the association between various indices of adiposity and T2DM was observed by Raoul et al. (2006). In their studies, BMI provided the highest prevalence of T2DM in men (6.85%) while WHR and WC yielded the highest prevalence (28%) in women (Raoul et al., 2006). Also, while comparing different measures for screening non-insulin dependent diabetes mellitus, Sosenko et al. (1993) found that WHR was significantly higher in diabetes women than men as observed in this study. Scavini et al. (2003) demonstrated in a study in India that the prevalence of diabetes was higher among females than males. Diewertje et al. (2011) demonstrated that high BMI was not associated with high mortality in those with diabetes mellitus, while WC and WHR showed positive association; this association was weaker in females than males. Bray et al. (2008) noticed in his work that men had more visceral adiposity than women. Nordine et al. (1992) in their six-month preventive physical activity intervention programme, demonstrated a diverse pattern of response between boys and girls according to their BMI category. Similar to the observations in this study, Alline and colleagues observed in their studies that all anthropometric indices were associated with incident type 2 diabetes mellitus in women. In men, only WHR was statistically associated as against BMI and MAC in this study. In another large cohort of men, Youfa et al. (2005) observed that both BMI and WC predict risk of T2DM but WC appears to be a better predictor than BMI or WHR.

In all these assertion, gender act as effect modifier in the association. Frederico et al. (2011) demonstrated in their work that gender conferred large differences in visceral adipose tissue with mean of 4 to 5 L (SD 2.1) in men versus 3 to 4 L (1.8) in women. Correlation of visceral adipose tissue with metabolic syndrome was strong for men but absent in women.

Also, sex-related differences in insulin sensitivity, regardless of aetiology, has been incriminated by previous researchers, as being a strong factor in the gender difference in susceptibity to T2DM (YKI.Jervinen). A comparison of muscle glucose uptake in 30 years old men and women matched for body mass and fitness showed that cardiac muscle was equally responsive to insulin in either sex, but that skeletal muscle glucose uptake was 50% greater in female (Nuutila et al., 1995; Gale et al., 2001).

Equally, studies in multi racial population of normoglycemic men and women, aged 25 to 44 years, showed that women secreted the same amount of insulin as men in response to the OGTT, despite a higher percentage of body fat (Gale et al., 2001). After adjustment for body fat, women were significantly more sensitive to insulin than men (Donahus et al., 1997). This “female insulin advantage” suggests that men are more likely than women to develop diabetes in response to increasing obesity contrary to the result of this study.

The correlation between adiposity and incident T2DM in this study has further emphasized the usefulness of these indices in community-based epidemiological studies. These relatively inexpensive and easily obtained measures are useful for assessing diabetes in non-clinical settings. Also, previous studies showed that detecting power of individual adiposity index varies from country to country, probably because of the differences in lifestyle and effects of other confounders. This calls for a country-specific guideline on the cut-off point to be used for surveillance, prevention and intervention programme.

## Conclusion

All adiposity indices (BMI, MAC, WC and WHR) employed

**Table 4.** Multiple logistic regressions showing association between diabetes and adiposity indices across gender (odd ratio and 95% confidence interval for odd ratio).

| Adiposity indices | Gender | |
|---|---|---|
| | Male | Female |
| BMI | | |
| Odd ratio (obese/not obese) | 2.410 | 2.023 |
| Confidence Interval | 1.728-7.01 | 1.51-6.402 |
| *P*-value | 0.000** | 0.000** |
| MAC | | |
| Odd ratio (Abnormal/normal) | 1.624 | 1.510 |
| Confidence Interval | 1.824-7.051 | 1.62-6.59 |
| *P*-value | 0.015* | 0.017* |
| WC | | |
| Odd ratio (Abnormal/normal) | 1.021 | 2.834 |
| Confidence interval | 0.695-1.845 | 1.270-5.421 |
| *P*-value | 0.162 NS | 0.000** |
| WHR | | |
| Odd ratio (Abnormal/normal) | 0.729 | 2.435 |
| Confidence Interval | 0.547-1.14 | 0.951-6.413 |
| *P*-value | 0.324 NS | 0.000** |

*$P<0.05$ (significant at 5%), **$P<0.01$ (significant at 1%), NS= not significant ($P>0.05$)

in this study correlated significantly with incident type 2 diabetes mellitus in females, while in males significant association was seen with only BMI and MAC. This explains why more females than males were found to be diabetic in this study. The risk of having diabetes therefore is higher in females than males according to the result of this study.

Limitations of this study worth noting are; effect of other confounders which were not completely eliminated; this could have influenced the pattern of the result obtained. Secondly, the predicting power of the adiposity indices could be limited in situations where the developments of the disease (diabetes) have affected the level of the adiposity variables that are of interest. However, the strength of the study came from the large sample size which gives adequate representation of their entire population.

## ACKNOWLEDGEMENTS

The authors are thankful for the help provided by Eunice Udoh and Sampson Kayode Timothy in preparing and editing of the manuscript.

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