Waist circumference and hip circumference as potential predictors of visceral fat estimate among type 2 diabetic patients at the Komfo Anokye Teaching Hospital (KATH), Kumasi-Ghana

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ABSTRACT

Background: Although visceral fat (VF) and its influence on cardiovascular diseases have been extensively studied among diabetic patients, there is a need for an easier, and less expensive but equally good predictor for VF. This study was conducted to assess potential anthropometric measurements that can be directly linked to visceral fat levels among diabetic patients.

Method: 405 diabetic patients attending the Diabetic clinic of the Komfo Anokye Teaching Hospital (KATH) in Kumasi-Ghana were recruited. A well-structured questionnaire was used to obtain the demographic background and brief medical history. Anthropometric measurements were obtained by direct measurement and visceral fat levels was measured using the Body Composition Monitor (Omron ® 500, Germany) which generated digital results on a screen.

Results: The total participants comprised 81 males and 324 females, with an average age of 58.5 ± 9.9 years. The females exhibited a higher mean waist circumference (101.4 ± 12.3 cm) and average hip circumference (104.6 ± 9.9 cm) than the males. The female participants also had higher body mass index (BMI) (28.3 ± 5.1 kg/m²) compared to males (26.5 ± 4.2 kg/m²). The association between VF and waist circumference was r = 0.631, p < 0.001, followed by hip circumference (r = 0.536; p < 0.001). The significant predictive abilities of waist circumference and hip circumference to identify diabetic patients with high visceral fat were AUC = 0.787; p < 0.001 and AUC = 0.786; p < 0.001, respectively.

Conclusion: Waist circumference and hip circumference promise to be potential alternative predictors of visceral fat accumulation in type 2 diabetes.

1. Introduction

Abundant research efforts have been focused on identifying which specific aspects of obesity are important predictors for the eventual development of cardio-metabolic disease. The International Diabetes Federation (IDF) has indicated that the number of adults with diabetes in the world will expand from 381.8 million to 591.9 million in 2035, with major increase in Sub-Saharan Africa (from 19.8 million in 2013 to 41.5 million) [1]. The burden of diabetes has increased globally due to low-income level of individuals and the increasing population of people who are obese and overweight [2]. About 27.5 million of this population are inhabitants of Africa, including 14.7 million in sub-Saharan Africa and 12.8 million in North Africa and Sudan [3]. In Ghana, the prevalence of diabetes is 6.3%, and according to the Ghana Diabetes Association, this is likely to be increased at a faster pace [4].

Diabetes is a group of diseases characterized by hyperglycemia, arising as a result of poor insulin production, how it works, or both [5]. Men and women differ substantially with regards to the degree of insulin resistance, body composition, and energy balance [6]. Adipose tissue distribution, in particular the presence of elevated visceral and hepatic adiposity, plays a central role in the development of insulin resistance and obesity-related complications [7]. Moreover, a study conducted in the United States of America revealed that insulin resistance in T2DM patients could worsen with the accumulation of excess visceral adipose tissue (VAT) and intermuscular adipose tissue (IMAT) [8].

Anthropometric measurements generally include height, weight, body mass index (BMI), waist circumference, hip circumference and waist-to-hip ratio [9]. These measures when compared to reference standards are capable of assessing the risk of various diseases. Waist circumference [10] and intra-abdominal (i.e. trunk or visceral) fat have been found to be important predictors...
of diseases on the basis of many investigational work [11,12], and the latter is also hypothesized to be a direct cause of the development of glucose intolerance and overt diabetes [12].

It is generally observed that women have more adiposity as compared to men [13], and less muscle mass [14], when adjustment is made for height and weight [13]. These differences are attenuated in postmenopausal women [15]. Moreover, women with T2DM may have proportionally less subcutaneous adipose tissue (SAT) and more visceral adipose tissue (VAT) than non-diabetic women [16]. Little is known about body fat composition in men with T2DM [8], thus body composition measurements have been investigated in this work.

Several studies have proven that visceral fat (VF) increases the risk of cardiovascular diseases [17–19]. Visceral fat is also known to be metabolically active and modulates numerous adipocytokines such as leptin and adiponectin, which have been associated with insulin resistance and hence diabetes [20–22]. Measurement of body fat distribution is relatively expensive, using available methods, i.e. computerized tomography, magnetic resonance imaging, or dual-energy x-ray absorptiometry (DXA), which are generally practical for visceral fat estimate [23]. There is therefore the need for an easier and less expensive but a potential predictor for visceral fat, as this will tackle both diabetes and the incidence of cardiovascular diseases. It is against this background that this cross-sectional study was done to determine the association of visceral fat and anthropometric indices among diabetic patients in Kumasi-Ghana.

2. Methodology

2.1. Study design and setting

This cross-sectional study involved 405 diabetic patients attending the Diabetic clinic of the Komfo Anokye Teaching Hospital (KATH) Kumasi, in the Ashanti Region of Ghana. With a total projected population of 4,780,380 (Ghana Statistical Service, 2010), KATH is the second largest hospital in Ghana and serves as a major referral center.

2.2. Study population

The study recruited 405 type 2 diabetes patients visiting the diabetic clinic at KATH via a simple random sampling technique. The study included diabetic patients ≥18 years. Patients with other diagnosed chronic conditions apart from diabetes, and pregnant women were excluded from the study.

2.3. Ethical approval and consent

The study was approved by the Committee on Human Research Publication and Ethics (CHRPE) of the Kwame Nkrumah University of Science and Technology (KNUST) and the Research and development unit of the Komfo Anokye Teaching Hospital (KATH), Kumasi. Written consent was obtained from all participants by explaining the aim of the project and the liberty to participate. The study was conducted in accordance with the ethical standards of the institutions and with the Helsinki Declaration and its later amendments or comparable ethical standards.

2.4. Questionnaire administration

A well-structured questionnaire was piloted and administered to all participants by Research Assistants to obtain demographic data including gender and age, and duration of diabetes.

2.5. Anthropometric and visceral fat measurement

The weight and height of the participants were measured using a body weight scale and a Stadiometer, respectively. Waist and hip circumference were measured to the nearest 0.1 cm by a tape measure, and the waist-to-hip ratio was calculated as Wcm/Hcm. The suprailiac triceps skinfold thickness (TS) was measured with skinfold caliper (Holtain, UK) to the nearest 1 mm. The Body Composition Monitor generated the estimated value for visceral fat level (VF) using the BI (Bioelectrical Impedance). Visceral fat rating of ≤12 was considered normal, and ≥13 was considered as excessive levels. Body Mass Index (BMI) was calculated as weight(kg)/(height(m))².

2.6. Data analysis

Data were analyzed using SPSS version 23. Unpaired t-test was used for the comparison of mean values and the Pearson’s correlation was used to establish relationships between selected continuous variables. The receiver operating characteristics (ROC) curve was used to obtain sensitivity, specificity, the area under curve and cutoff values of selected variables. A p-value less than 0.05 was considered statistically significant for all analysis.

3. Results

Out of the total study population of 405 diabetic patients, the average age was 58.5 ± 9.9 years, and the females were slightly older than males albeit there was no statistically significant difference (p = 0.554). There was no statistical difference between the male and female respondents with respect to fasting plasma glucose, duration of diabetes, percentage glycated hemoglobin and (HbA1c (%)) and individuals with percentage HbA1c greater than 7% (Table 1).
With the exception of waist-to-hip ratio (WHR, p = 0.924), all other anthropometric and fat distribution measurements differed significantly when stratified by gender (Table 2). Although the males had higher levels of visceral fat and were relatively taller and heavier (height and weight) than the females, the females generally exhibited significantly higher measurements of WC, BMI, HC, and TS compared to males (Table 2).

The association of WHR with visceral fat was not statistically significant (P-value), although Pearson’s r was positive (Table 3). Also, in Table 3, other anthropometric measurements of BMI, WC, HC, and TS were significantly associated with visceral fat levels of the participants. The correlation of both TS and BMI with visceral fat was relatively weak, although they were statistically significant. The strongest significant association was between WC and visceral fat, followed by HC, BMI, and TS, respectively, with visceral fat.

The cutoff for waist-to-hip ratio (> 0.945) was not significant to depict high visceral fat levels. However, the cutoffs for BMI, waist circumference, hip circumference, and suprailiac triceps skinfold thickness were statistically significant to represent higher visceral fat levels. The cutoffs, sensitivities, specificities, and the respective confidence intervals are represented in Table 4.

The most accurate anthropometric measurements for depicting visceral fat levels were waist circumference and hip circumference (AUC = 0.787 and 0.786, respectively; p < 0.001 each). The accuracy of waist-to-hip ratio was not significant and was the least (AUC = 0.527; p = 0.482). BMI and TS, though not too accurate, were statistically significant to portray visceral fat levels (Figure 1).

4. Discussion
Despite the inconsistencies in gender-related prevalence of diabetes [24,25], a number of studies have reported Type 2 diabetes to be more prevalent in females than in males [26,27]. This may explain the observation in the current study, where the female participants were more than their male counterparts. This may be attributed to the fact that women are more prone to diabetes after the age of menopause, and in older age [28]. It is therefore not surprising that the women were far more than the males in the current study, as the mean age was 58.5 ± 9.9 years (Table 1). The measured anthropometrics were significantly different for both gender, and the males exhibited a higher average weight and height than the females (Table 2). This is at par with a work done by Peters et al. [29]. However, the females exhibited a higher BMI than the males in the current study, and similar results were obtained in diabetes archives in England and Scotland where mean BMI was nearly 2 kg/m² higher in women than in men with diabetes [30,31].
Diabetic patients generally possess higher amounts of total, visceral, subcutaneous, and intermuscular adipose tissues compared to healthy people [32], and are predisposed to several complications [33,34]. The differences in the adipose distribution are greater for visceral adiposity than other types in both sexes [8]. Significantly greater levels of visceral fat was observed among the males in the current study (Table 2), and this is in agreement with two large studies conducted by Harada et al. [35,36]. Two other large studies by Couillard et al. [37], and Nordström et al. [38] explained that the higher visceral fat in males may be associated with increased glucose intolerance, and higher risk of cardio-metabolic diseases [37,38].

Visceral fat or intraperitoneal fat is composed of mesenteric and omental fat masses [39]. High cost and technical demands of MRI and CT scan in measuring visceral fat necessitates the use of simple, noninvasive anthropometric measurements such as waist circumference, triceps skinfold, hip circumference and waist-to-hip ratio in field surveys to measure visceral fat [11,40]. From the present study (Table 2), most of the anthropometric measurements tend to be significantly higher among the female subjects. These included triceps skinfold, waist circumference, hip circumference, and BMI. This may explain why excess risk of cardiovascular diseases associated with type 2 diabetes has been found to be considerably greater in women compared to men [41,42]. Women generally have more subcutaneous fat storage capacities than men. As a result, females tend to gain more weight before the less harmful subcutaneous storage becomes exhausted and excess adipose tissue is

**Figure 1.** Receiver Operating Characteristics (ROC) curve for depicting the accuracy of Waist Circumference (WC), (a) Hip Circumference (HC), (b) Body Mass Index (BMI), (c) Triceps skinfold thickness (TS), (d) and Waist-to-Hip Ratio (WHR), (e) to assess visceral fat levels.
deposited into the more visceral and ectopic tissues. Thus, sex difference in the preferential location of fat storage in women may explain some of the higher anthropometric indices recorded, and risk for cardiovascular diseases observed in women with type 2 diabetes [29].

In our study, a significant positive correlation was observed for all associations of anthropometric measurements of waist circumference, BMI, hip circumference, waist-to-hip ratio and suprailiac triceps skinfold thickness with visceral fat. Whilst some researchers established waist-to-hip ratio to be a good predictor of visceral fat [43], others called for further research to evaluate the usefulness of WHR [44]. Waist circumference has been reported to be a poor predictor of visceral estimate [45]. In agreement with this finding, the weakest association in the current study was between visceral fat and WHR \((r = 0.093, p = 0.061)\) (Table 3), and WHR was also the least accurate to depict visceral fat levels (AUC = 0.527; \(p = 0.482\)) (Figure 1(e)). This implies that WHR may not be a good anthropometric measurement to be linked to visceral fat levels [45].

Several studies have showed that BMI independently contribute to the prediction of visceral fat [46–49]. However, our finding is contrary to these studies. The association of BMI and visceral fat in the current study was weak \((r = 0.347, p < 0.001)\), and the accuracy (AUC = 0.671, \(p < 0.001\)) to predict visceral fat levels at cutoff > 27.1 kg/m\(^2\) was not good enough (Table 4, Figure 1(c)). The disparity could be due to differences in study population and study site setting. The strongest association observed in the current study was between visceral fat and waist circumference \((r = 0.631, p < 0.001)\). There were low to moderate associations of visceral fat and triceps skinfold, and hip circumference (Table 3). The association between visceral fat and hip circumference was fairly good \((r = 0.536, p < 0.001)\), and the relative ability to correctly identify diabetic patients with high visceral fat levels was high (AUC = 0.786, \(p < 0.001\)), although that of waist circumference was better (Figure 1(a,b)). This implies that hip circumference and waist circumference may be potential predictors of visceral fat levels and cardiovascular diseases in diabetic patients [50,51].

At a cutoff > 100.5 cm (Table 4), waist circumference yielded a relatively high sensitivity (83.1%), and a weak specificity of 60.5%, with AUC = 0.787; \(p < 0.001\) (Figure 1(a)). Thus, it may be established that diabetic patients with higher waist circumference than normal are likely to have larger deposits of visceral fat, which is dangerous to their health [52,53]. In the Diabetes Prevention Program’s population of 3234 patients, it was discovered that waist circumference was the strongest predictor of diabetes [54] and other cardio-metabolic risk [55] in both males and females compared to body mass index, waist-to-hip ratio and other anthropometric measurements [55–57]. In agreement with the findings in the current study, waist circumference has been proposed as a practical indicator of visceral fat [58]. Moreover, a number of studies have also identified the measurement of waist circumference as a crude anthropometric correlate of abdominal and visceral adiposity [59–61].

5. Conclusion

Waist circumference and hip circumference, which are simple and noninvasive anthropometric measurements, appear to be potential predictors of visceral fat estimate among type 2 diabetes patients. The relatively low specificity of WC and HC observed in this study necessitates future investigations to validate their use as predictors of visceral fat accumulation in type 2 diabetes.

5.1. Limitation of the study

The current study could not report separate cutoff values of the anthropometric measurements for each gender. It is therefore recommended that is considered in future studies to avoid gender bias.

Acknowledgments

The authors wish to thank the Molecular Medicine Department of the School of Medical Sciences, Kwame Nkrumah University of Science and Technology (KNUST) and the Clinical Biochemistry Department of the Komfo Anokye Teaching Hospital (KATH) for access to their laboratories.

Authors’ contributions

BAJE established the aim of the research and its objectives. FAY and ET designed the framework of the study. MEAA proofread and edited the text. SD and BOA participated in data analysis.

Data availability

The datasets obtained and/or analyzed during the current study are not publicly available due to the agreement made with the participants not to disclose their report to a third party, but are available from the corresponding author upon request.

Consent to participate

Written consent was obtained from all participants by explaining to them the aim of the project and the liberty to participate.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

No funding was obtained for this study.
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Ethics approval

The study was approved by the Committees on Human Research Publication and Ethics (CHRPE) of the Kwame Nkrumah University of Science and Technology (KNUST) and the Research and development unit of the Komfo Anokye Teaching Hospital (KATH), Kumasi.

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