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RESEARCH ARTICLE

CORRELATION BETWEEN BODY MASS INDEX AND WAIST CIRCUMFERENCE ASSOCIATED WITH INSULIN RESISTANCE IN EASTERN CAPE PROVINCE OF SOUTH AFRICA: IMPLICATIONS FOR ANTI-DIABETES CAMPAIGNS

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ABSTRACT

Background: Body mass index (BMI) is commonly used in typical rural community health centers where the majority of people live in impoverished rural South Africa. We evaluated the correlation between BMI and Waist circumference (WC) with a view to recommend substituting BMI with WC as measure of insulin resistance in rural communities.

Design and Methods: A total of 385 nondiabetic adult subjects attending community health centers in Eastern Province, South Africa, who had not eaten any break fast participated in the study. Anthropometric measures were done under trained supervision. Blood samples were collected for estimation of fasting insulin and fasting blood glucose levels. Two validated surrogate measures of insulin resistance were used: Homeostasis model assessment of insulin resistance (HOMA-IR) and Quantitative Insulin sensitivity Check Index (QUICKI.

Results: Over 45% of the people surveyed were obese with over 10% being morbidly obese. The aim was to determine whether waist circumference alone can be used as the simplest, cheapest and reliable predictor of insulin resistance and obesity. Waist circumference was found to be significantly correlated with BMI: R = 0.775, P =0.00, for women and R =0.847, P = 0.00 for men and r =0.872, P=0.001 using HOMA-IR and QUICKI (r = 0.866, P =0.01) as the surrogate indices of insulin resistance.

Conclusions: Waist circumference is significantly correlated with BMI according to surrogate indices of insulin resistance. It is recommended that waist circumference should replace BMI as indicator of insulin resistance, because measuring waist circumference is very simple and affordable instrument.

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INTRODUCTION

Defined as weight in kilograms divided by the square of height in meters, Body Mass Index (BMI) is regarded as an important measure of excess body fat. A high BMI is universally recognized as a major risk factor for cardio-metabolic disorders, Hu, FB, 2007 (Ardern *et al*., 2003). Specifically, increased visceral fat has been shown to be an important risk factor for type 2 diabetes and cardiovascular diseases among other metabolic disorders. BMI is the commonly used system of body weight indexing. The index divides patients into categories of underweight, normal weight, overweight and obese. Despite the fact that BMI is commonly used to monitor the occurrence of obesity in a population, it has limitations. BMI does not provide information on the adipose tissue distribution. It is a mathematical value that does not take into account the physiology of the individual such as the proportional distribution among adipose, osseous as well as muscle tissues, (Shields *et al*., 2012; Chan *et al*., 1994). Computing BMI requires the measurement of height and weight. The equipment for measuring height and weight may not be readily available or may be poorly calibrated in rural health centers. Thus, the health workers may have difficulty taking and maintaining accuracy of these measurements. In

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addition community members may have difficulty in conceptualizing the connection between BMI and bodyweight and struggle to compute it. Moreover, a BMI value is affected by sex, age and body constitution. Weighted evidence points to the fact that waist circumference coupled with BMI is a stronger predictor of health risk better than does BMI alone, Rexrode *et al*. 1998 (Distiller, 2012), Janssen *et al*, 2002 (Gierach *et al*., 2014), Ardern *et al*, 2003, (Gungor *et al*., 2004), Chan, *et al*, 1994 (Hanley *et al*., 2003). More recently, it has been reported that WC is better than BMI as a predictor of diabetes and pre-diabetes in India, Sharma *et al*. 2014 (Hettihewa *et al*., 2006). A study by Gierach, *et al* 2014 (Hu, 2007) in Poland found that waist circumference was significantly correlated with BMI (R=0.78, $P < 0.01$). Abdominal obesity is responsible for the development of insulin resistance, a precursor to type 2 diabetes. Recent studies show that WC is better than BMI as a precursor of diabetes and pre-diabetes. (Hettihewa *et al*., 2006) The purpose of this study is to determine whether there is a correlation between body mass index and waist circumference in relation to insulin resistance among nondiabetic Africans in the Eastern Cape Province of South Africa and whether this correlation is consistent when the sample is divided according to gender groups and indices of insulin resistance. If this correlation is consistent across gender groups with and without insulin resistance, then this would constitute evidence of the usefulness of a simpler tool, WC instead of BMI. Thus, health professionals can then be encouraged to adopt the use of waist circumference instead of BMI as a measure of pre-diabetes/insulin resistance. Early diagnosis may forestall the onset of type 2 diabetes.

Design and Methods

The study was carried out among patients attending Community Health Centers located in the King Sabata Dalindyebo Municipality and Buffalo City Metropolitan Municipality Districts of the Eastern Cape Province of South Africa. Study approvals were obtained from the Walter Sisulu University Ethics Committee and the Buffalo City Metro Health District, Eastern Cape Province. A total of 385 nondiabetic subjects aged between 20 and 75 years signed informed consent and participated in the study in 2013. Pregnant women and diagnosed diabetics were excluded from the study. The age, gender, height (m), weight (kg) and waist circumference (cm) of each subject was recorded. Weight was measured to the nearest 0.01Kg. Height was measured to the nearest 0.01m using a meter rule with subjectstanding upright against the wall and barefooted without headdress or headgear. To measure the waist circumference using a normal tailoring tape to the nearest 0.5cm, at the level of the umbilicus and the superior iliac crest, the subject was made to stand upright, feet together and arms hanging freely at the sides. The BMI was calculated as weight (kg)/height^2 (m^2). The BMI cutoffs for body weight were defined according to IDF and WHO as follows: underweight <18kg, normal weight, 18-25kg, overweight 25.1 -30kg, Class I obesity 30.1 – 35kg, Class II obesity 35.1 – 40kg, Class III obesity >40kg. SerumInsulin levels were estimated using the Enzyme-Linked-Immuno-Assay (ELISA) method with DX-EIA-2935 Insulin kit, 96 wells purchased from AEC-Amersham (PTY) Ltd. Fasting insulin levels are a measure of insulin resistance. In this study, two validated measures of insulin resistance were used: (i) Homeostasis model assessment of insulin resistance (HOMA-IR) = {fasting glucose in mmol/l x fasting insulin in µU/ml}/22.5 and Quantitative Insulin sensitivity Check Index (QUICKI) = inverse of the sum of log of fasting glucose plus the log of fasting insulin level (1/(log insulin +log glucose)as surrogate indices of insulin resistance, with QUICKI, being among the best surrogate indices in terms of the predictive power for the onset of type 2 diabetes (Gungor *et al*., 2004; Janssen *et al*., 2002; Katz *et al*., 2000; Hanley *et al*, 2004; McAuley *et al*., 2001) This long sentenceis not clear to me.Individuals were considered as insulin resistant when HOMA-IR ≥ 2.6, QUICKI≤ 0.330, fasting glucose; and ≥ 5.5mmol/l, and fasting insulin ≥ 12.0.(McAuley *et al*., 2001; Sharma *et al*., 2014; Hettihewa *et al*., 2006; Shields *et al*., 2012).

Statistical analysis

Study data were coded and entered into the SPSS (Statistical Package for Social Science) Version 23.0. Summaries of the continuous variables were presented as means and standard deviations. The mean differences in weight, height, BMI, waist circumference, and blood pressure between levels of insulin resistance and non-insulin resistance were measured with independent samples t tests. Statistical significance was set at 95% alpha level.

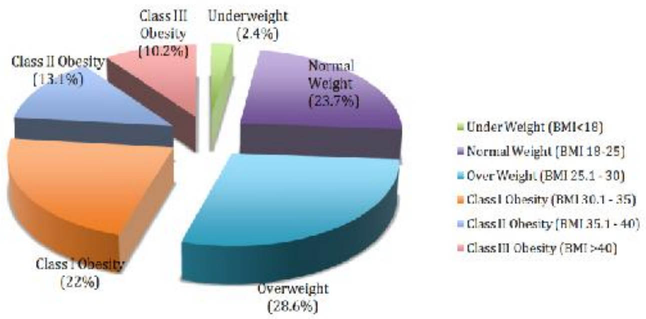

Figure 1. Distribution of body weight by BMI category. Over 45% of the people surveyed were obese with over 10% being morbidly obese. Nearly 74% of this population is either overweight or obese

RESULTS

Correlation between BMI and waist circumference was analyzed according to the following surrogate indices of insulin resistance: QUICKI, HOMA-IR with a view to determining whether waist circumference alone can be used as simplest, cheapest and reliable predictor of insulin resistance and to assess obesity instead of the commonly used BMI. Abdominal obesity is the most frequently observed component of metabolic syndrome (Hu, 2007). Heretofore, in South Africa, BMI is regarded as the most widely used method for indexing body weight (Hu, 2007). However, BMI has numerous limitations that include the fact that it measures somatic obesity rather than abdominal obesity, a major disorder in the development of metabolic syndrome. Consequently, this disorder is missed when BMI is measured. Table 1 shows that females in the study sample are heavier than males, have a greater mean BMI measurement, and a larger mean waist circumference, despite the fact that women carry less body height than men. This is in contrast to the waist circumference recommended by the International Diabetes Federation's Europid cut-off points for large waist circumference (>94 cm in men and >80 cm in women (Sumner *et al*., 2008; Rexrode *et al*., 1998). This picture may vary in different populations, but it indicates a characteristic that is worthy of further investigation into whether it has any bearing on health status between genders in this population.

women and r =0.847, P = 0.00 and cne be used as a simpler cheaper and equllay reliable predictor of insulin resistance.

Table 1. General Characteristics of the Study Population (Mean measurements)

	N	Age (Yrs.)	Body Weight (Kg)	Body Height (cm)	BMI (Kg/m^2)	Waist Circumference (cm)
Total	385	42.3	75.5	163.0	28.7	91.2
Female	282	43.9 ±16.0	78.8 ±18.9	159.7 ±7.0	30.9 ±7.5	95.2 ±17.8
Male	103	37.8 ±15.2	66.3 ±14.2	172.1 ±7.6	22.3 ±4.4	80.5 ±12.0

Table 2. Correlation between BMI and WC in the study group by Gender

BMI/WC	N	r-Correlation Coefficient	P value
Women	282	.775	.000
Men	103	.847	.000

Table 3. Relationship of demographic and vital health characteristics to fasting blood glucose (FBG)

Demographic and vital health characteristics measured	Group with elevated fasting blood glucose (> 5.5 mmol/L) (N = 70)	Group without elevated fasting blood glucose (<5.5mmol/L) (N = 315)	t value/Sig.
Age (yrs)	51.5 ±13.4	40.2 ±15.9	5.520.< .001
Height (cm)	161.4 ±9.2	163.4 ±8.9	1.577 NS
Body Weight (kg)	83.0 ±19.8	73.8 ±18.0	3.790 < .001
BMI	31.9 ±8.0	27.9 ±7.6	4.005 < .001
Waist Circumference	102.3 ±15.4	88.8 ±17.2	6.053 < .001
Blood Pressure systolic	148.9 ±24.5	137.1 ±24.6	3.621 < .001
Blood Pressure diastolic	89.9 ±12.9	84.5 ±17.0	2.488 < .05
Fasting Insulin	16.3 ±15.4	10.6 ±8.9	3.959 < .001

Note: NS statistic not significant

Table 4. Characteristics of persons with Fasting Insulin (FI) above and below 12.0 (means and standard deviations)

Variables	Group with high FI (>12) (N = 131)	Group without high FI (<12) (N = 254)	T value/Sig
Age (yrs)	41.0 ±14.7	42.9 ±16.6	1.108 NS
Height (cm)	163.1 ±8.9	162.9 ±9.1	0.234 NS
Body Weight (kg)	78.9 ±19.3	73.7 ±18.1	2.596 <. 05
BMI	29.9 ±7.9	28.0 ±7.6	2.200 <. 05
Waist Circumference	94.0 ±17.1	89.8 ±17.8	2.248 <. 05
Blood Pressure systolic	138.4 ±23.3	139.7 ±25.8	0.500 NS
Blood Pressure diastolic	86.7 ±16.7	84.8 ±16.3	1.067 NS
Fasting Blood Glucose	5.1 ±2.2	5.2 ±2.5	0.089 NS

Note: NS statistic not significant

Table 5. Correlation between BMI and WC in the presence of HOMA-IR and QUICKI (surrogate indices of insulin resistance), fasting blood glucose (FBG), and fasting insulin (FI)

Correlation between BMI & WC between gender groups	N	Insulin Resistant With IR (HOMA ≥ 2.0)	N	Noninsulin Resistant Without IR (HOMA < 2.0
Female	66	.864***	216	.749***
Male	19	.851***	84	.844***
Total	85	.872***	300	.799***
		With QUICKI < 0.330		With QUICKI ≥ 0.330
Female	182	.866**	100	.725**
Male	80	.837**	23	.853**
Total	262	.866**	123	.785**
		Elevated FBG (> 5.5 mmol/L)	N	No Elevated FBG <5.5mmol/L)
Female	58	.868**	224	.748**
Male	12	.919**	91	.826**
Total	70	.873**	315	.796**
		Elevated FI (>12)	N	No Elevated FI (<12)
Total	181	.879**	254	.780**
Female	101	.878**	181	.716**
Male	30	.823**	73	.859**
Total	181	.879**	254	.780**

Note: ** significance < .01, *** significance < .001

Table 2 shows that without controlling for any of the insulin resistance measurements in the study group in the Eastern Cape Province of South Africa, waist circumference was found to be significantly correlated with BMI: r = 0.775, P =0.00, for

Analysis in Table 3 shows that persons with high fasting insulin (FI) have significantly higher body weight, BMI, and waist circumference (p < .05 for all three vital characteristics), than their counterparts who do not have high FI measurements. Table 5 shows that BMI and WC were significantly correlated in both insulin resistant and noninsulin resistant groups according to HOMA-IR, QUICKI, Fasting Glucose and Fasting Insulin levels as indices of insulin resistance at 95% confidence interval.

DISCUSSION

'Diabesity' is the term that has been coined to emphasize the direct connection between diabetes and obesity. The health impact of diabesity is colossal as it includes long-term diabetic complications, for diabetes occurring in the context of obesity. The health impact of diabesity include long-term diabetic complications, diminished health-related functioning, with concomitant reduction in quality of life and decreased overall life expectancy (Youssef *et al*., 2011; Sumner *et al*., 2008). Thus, urgent steps to curtail diabesity must include screening, prevention as well as management of the diabesity epidemic using simple and affordable approaches. In South Africa, Dr. Larry Distiller, Director of Centre for Diabetes and Endocrinologyhas described diabesity epidemic as a "tsunami" that has hit the country, (Distiller, 2012; Youssef *et al*., 2011). Over 4 million people (over 6% of the population) suffer from diabetes with untold numbers of undiagnosed cases. The estimate is that another 5 million South Africans have insulin resistance/pre-diabetes. Thus, forestalling the progression of insulin resistance to type 2 diabetes should be a major public health thrust. The study demonstrates that WC as a predictor of insulin resistance or pre-diabetes as evidenced by the strong BMI/WC correlation can replace BMI in South Africa.

Conclusion

The study indicates, unequivocally, that waist circumference is significantly correlated with BMI. This correlation is also significant according to surrogate indices of insulin resistance. It is recommended that waist circumference should replace BMI as indicator of insulin resistance/pre-diabetes in the Eastern Cape Province of South Africa. Because measuring waist circumference is very simple and affordable instrument, compliance in forestalling onset of diabetes among pre-diabetics. Waist circumference is a strong predictor of insulin resistance or pre-diabetes with a similar level of confidence as BMI. Based on results from this study, health workers can assist patients to forestall onset of type-2 diabetes by educating them to control the waistline, since WC is a more understandable term for the layman and can be easily measured and tracked by the laymen themselves.

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Conflict of Interest: The authors declare no potential conflict of interest.

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