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Waist Circumference as a Measure of Insulin Resistance/Pre-diabetes in KwaZulu-Natal, South Africa: Implications for Forestalling Type 2 Diabetes

[1]Dr. Keratiloe N. Gwebu, [2]Prof Malcolm Cort, [3]Prof Ephraim T. Gwebu

[1] Department of Nursing, School of Health Sciences, Rusangu University, Monze, Zambia
[2]Department of Behavioral Sciences, Athens State University, Athens, AL, USA
[3]Department of Natural Sciences, School of Science and Technology, Rusangu University, Monze, Zambia
(kgwebu@ru.edu.zm) & malcolm.cort@athens.edu
& (egwebu@ru.edu.zm)

Abstract

Background. The World Health Organization reports a grim picture of the type 2 diabetes mellitus (T2DM) epidemic with sub-Saharan Africa bearing the brunt of this outbreak and South Africa is at the forefront. In South Africa, T2DM accounts for 58 deaths per day and is the fifth highest cause of death. Central to this alarming T2DM epidemic is the overweight and obesity tsunami that can be prevented. The purpose of this study was to determine whether the waist circumference cutoff for overweight proposed by the International Diabetes Federation (IDF) are applicable to KwaZulu-Natal in monitoring overweight/obesity in rural and economically disadvantaged communities. Design and methods. Two hundred and forty nine nondiabetic adult subjects attending community health centers in KwaZulu-Natal Province who had not eaten any breakfast 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. The following surrogate measures of insulin resistance were used: Homeostasis model assessment of insulin resistance (HOMA-IR) and Quantitative Insulin sensitivity Check Index (QUICKI. Anthropometric measurements were also taken. Results. The mean waist circumference for both men and women was well above the cutoffs recommended by the IDF. The weight range for men was 47 -133 kg and for women 44 -180 kg. The BMI ranges were 15- 40 for men and 18 – 75 for women. Individuals with waist circumference above the IDF-recommended cutoffs were insulin resistant based on the surrogate indices of insulin resistance. Conclusions. The epidemic of overweight and obesity is indeed a tsunami in this study population of KwaZulu-Natal and we appeal for implementation of educational campaigns to encourage people to monitor their weight gain by simply measuring waist circumference using regular and easily affordable tape measures.

Keywords: International Diabetes Federation (IDF) body mass index (BMI), waist circumference (WC), insulin resistance, fasting glucose and fasting insulin levels, homeostasis model assessment of insulin resistance (HOMA-IR),

quantitative insulin sensitivity Check Index (QUICKI), obesity, diabesity.

Introduction

Growing at alarming rate worldwide is the prevalence of type 2 diabetes mellitus, a chronic disorder of glucose metabolism. (Whiting, et al **(**1), Stumvoll, et al. (2), Forouhi, et al. (3). The 2005 report by the World Health Organization estimated that the 2% of all deaths world-wide were diabetes-related, WHO (4). Based on global projections T2DM prevalence is expected to double from 285 million in 2010 to 592 million in 2035, WHO (4). Of these estimates sub-Saharan African region bears the brunt of this increase with South Africa at the forefront (Guariguata, et al. (5), Shaw et al. (6) The prevalence rate for South Africa is 9.3, Peer et al. (7). In South Africa, T2DM accounts for 58 deaths per day and is the fifth highest cause of death (8). Central to this alarming T2DM epidemic is overweight and obesity crisis. High adiposity is independently associated with T2DM, Mbanya et al. (9), Tuei et al. (10), Peer N, Steyn, et al. (11), Motala et al. (12). A significant predictor of cardiovascular disease and T2DM is abdominal obesity as assessed by waist circumference, independent of the overall adiposity in adult population. Lee et al. (13) Moreover, the total and abdominal adiposity and metabolic profiles are independently predicted by waist circumference. Lee et al. (13).

Insulin resistance is a reduced physiological response of the peripheral tissues to insulin action. It is a major contributor to the pathophysiology of type 2 diabetes and is a hallmark of obesity and other components of metabolic syndrome (Reaven et al. (14) Waist circumference is an independent predictor of insulin resistance, Lee et al. (13). Because of the close association of abdominal obesity with both waist circumference and insulin resistance, we hypothesize that waist circumference may be a marker of insulin resistance among Blacks in South Africa. Assessing insulin resistance requires collecting blood samples and measuring both insulin and glucose levels. The cost is prohibitive for economically disadvantaged communities. Waist circumference measurements are easily affordable in these communities. The purpose of this study was to determine whether waist circumference of the IDF Europid cut-off points for large waist circumference (>94 cm in men and >80 cm in women), Alberti et al.(15) is a predictor of insulin resistance among Africans in KwaZulu-Natal, South Africa). South Africa is undergoing rapid epidemiological and economic transition and now has the highest prevalence of obesity in sub-Saharan Africa. Sartorius et al. (16) If waist circumference predicts insulin resistance, health workers can encourage and promote monitoring of one's waist as an important step in forestalling type 2 diabetes.

Methods

The University of Zululand Research Ethics Committee and the Ethics Board of the KwaZulu-Natal Ministry of Health approved the study. In addition, the research was conducted according to the Code of Ethics of the World Medical Association (Declaration of Helsinki). Participants signed written informed consent after the procedures had been fully explained in isiZulu or English.

Anthropometric Measurements.

Height and body weight were measured to the nearest 0.1 cm and 0.1kg, respectively, by use of standardized instruments. Height was measured to the nearest 0.01m using a meter rule with subject standing upright against the

wall and barefooted without headdress or headgear. Waist circumference was measured 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. Body mass index was calculated as weight (kg) divided by the square of height (m^2).

Blood glucose and Insulin Assays. Nondiabetic patients attending Esikhaleni and Khandisa Community Health Centers who had not eaten breakfast were invited to participate in the study. Blood was drawn from the volunteers by registered nurses. Glucose was measured using a glucometer (Accu Check Advantage®, Roche). In serum insulin 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, according to Manufacturer's protocol.

Insulin Resistance Computations.
Developed as a mathematical transformation of fasting glucose and fasting insulin levels
Quantitative insulin-sensitivity check index (QUICKI) is one of the best surrogate indices for predicting onset of type 2 diabetes. It is the inverse of the sum of fasting glucose plus the log of fasting insulin level.[16] The QUICKI cut-off points for insulin resistance is <0.33, Hanley et al. (17). In addition, a validated measure of insulin resistance referred to as homeostasis model assessment of insulin resistance (HOMA-IR) was used (HOMA-IR = {insulin µU/ml x glucose (mmol/l)}/22.5. A HOMA-IR cut-off for insulin resistance is ≥ 2.0. (Chen H et al. (18) Fasting insulin levels ≥ 12.0 were considered insulin resistant (Chen H et al (18). The study was designed to determine whether the IDF waist circumference cutoff points significantly predict insulin resistance using fasting insulin, HOMA-IR and QUICKI as surrogate measures of insulin resistance in KwaZulu-Natal non-diabetic adults.

Statistical Analysis
Statistical procedures were performed through the use of SPSS (Statistical Package for Social Science) Version 23.0, SPSS Inc., Chicago Il. USA. Summaries of the continuous variables were presented as means and standard deviations. The mean differences in BMI, weight, height, 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.

Results
Table 1 lists the characteristics of the subject groups that had not eaten breakfast. The mean waist circumference was 90.6 cm for men and 98.5 cm for women. Women had higher BMI and more obese than men. Based on the waist circumference, both men and women were divided into normal waist circumference and larger waist circumference subgroups (defined according to the IDF Europid as >94 cm in men, and >80 cm in women). Thus, on the average, both men and women had waist circumferences larger than the IDF Europid values of <94 for men, and < 80 cm for women, respectively. In this study, women had larger waist circumference than men even though men were taller. Since waist circumference is independently associated with an increase in insulin resistance, Shen et al. (19) our study shows that women were more insulin resistant and higher fasting insulin levels than men.

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Table 1. Characteristics of the study population

	Males			Females		
	Mean	Range	N	Mean	Range	N
Age (years)	42.5	20 -80	62	47.2	20 – 86	187
Waist circumference	90.6	60.5 – 135.0	62	98.5	61 - 134.5	187
Weight (kg)	74.6	47.2 – 132.6	62	78.7	43.6 - 180.0	187
Height (cm)	170.4	154 – 209	62	156.9	81 – 187	187
Systolic BP	136.6	60 – 219	62	134.1	90 - 196	187
Diastolic BP	77.9	53 – 103	62	79.6	56 – 120	187
Fasting Glucose	12.6	4.2 – 20.3	29	13.0	3.9 – 31.6	84
Fasting insulin	8.6	2.2 – 26.5	32	11.5	3.9 – 26.2	91
BMI	25.7	14.7 – 40.0	62	31.4	18.1 – 75.4	179

Table 2. Waist Circumference and Surrogate Indices of Insulin Indices

Gender	*WC*	*N*	*QUICKI (Mean)*	*P*	*HOMA-IR (Mean)*	*P*	*Serum Insulin*	*P*
Males (♂)	< 94	48	0.377	$p \leq 0.001$	1.244	$p \leq .01$	7.5	$p \leq 0.01$
	> 94	10	0.328		3.012		15.0	
Females (♀)	< 80	48	0.364		1.758	$p \leq .01$	9.1	$p \leq 0.08$
	> 80	143	0.344	$p \leq 0.006$	3.344		11.7	

Based on the surrogate index of insulin resistance, QUICKI, Men with waist circumference (large) >94 cm were more insulin resistant than those with waist circumference (small) <94cm at $p \leq 0.001$; and women with waist circumference >80 cm were more insulin resistant than those with waist circumference <80 cm at $p \leq 0.001$. Similarly, the surrogate index for insulin resistance, HOMA-IR, shows that men with large waists were more insulin resistant than those with small waist circumference at $p \leq .01$. Women with larger waists were more insulin resistant than those with smaller waists. Insulin levels were also higher in men and women with large waists at $p \leq 0.01$ and $p \leq 0.08$, respectively.

Discussion.

Our study examined whether waist circumference is a predictor of insulin resistance in a population in the KwaZulu-Natal Province of South Africa. It is well established that waist circumference is a predictor of morbidity. Hettihewa et al (20) and mortality. Janssen, et al. (21), independent of BMI. Janssen (22), Chen S (23), Bigaard (24) We report that the IDF Europid waist circumference cutoff points of >94cm in men and >80cm in women strongly predict insulin resistance using validated surrogate indices of QUICKI and HOMA-IR.

Limitations of the study were that this was a convenience sample consisting of individuals

seeking medical attention at a health center. The findings may not be representative of the KZN population. A stratified random sample of the KZN Province is needed.

Conclusion. In South Africa (SA) type 2 diabetes is the 5th highest cause of death, accounting for nearly 60 deaths per day. SA has the highest prevalence of obesity in sub-Saharan Africa. Obesity is independently associated with insulin resistance and type 2 diabetes. Our studies demonstrate that waist circumference (WC) is a measure of insulin resistance and obesity. WC measurements are very cheap and simple to carryout as a method to monitor one's obesity and take action to control it. Armed with these findings, we strongly recommend implementation of campaigns to teach people how to monitor knowing that a WC > 94cm for men and > 80cm for women correctly predicts insulin resistance. In this study, the mean WC for men was 91cm and 99 cm for women. Thus, on the average, all subjects were obese and insulin resistant. Based on our study, Obesity and insulin resistance are epidemic in KwaZulu-Natal. We appeal to all health care workers to implement aggressive campaigns to educate the general population to control their waist circumferences in order to prevent diabetes-related sequel of deaths, amputations, blindness, cardio-metabolic disorders and the untold cost to the South African Health Care System.

Correspondence: Ephraim T. Gwebu, School of Science and Technology, Rusangu University, P.O. Box 66039, Monze, Zambia. Tel. +260-979-582-163. E-mail: egwebu@ru.edu.zm

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Conflict of Interest: the authors declare no potential conflict of interest

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