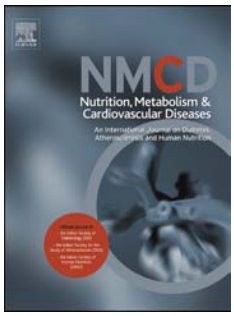
Accepted Manuscript



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PII: S0939-4753(14)00074-X

DOI: 10.1016/j.numecd.2014.02.005

Reference: NUMECD 1253

To appear in: *Nutrition, Metabolism and Cardiovascular Diseases*

Received Date: 16 December 2013

Revised Date: 6 February 2014

Accepted Date: 11 February 2014

Please cite this article as: WARE L, RENNIE K, KRUGER H, KRUGER I, GREEFF M, FOURIE C, HUISMAN H, SCHEEPERS J, UYS A, KRUGER R, VAN ROOYEN J, SCHUTTE R, SCHUTTE A, Evaluation of waist-to-height ratio to predict 5 year cardiometabolic risk in sub-Saharan African adults, *Nutrition, Metabolism and Cardiovascular Diseases* (2014), doi: 10.1016/j.numecd.2014.02.005.

- Obesity & CVD are increasing rapidly in Africa
- Low cost measures are needed to find those at risk
- Debate continues on the optimum Waist Circumference threshold for African adults.
- Waist-to-height ratio predicts current & future CVD risk in South-African adults.
- There is greater global agreement on the WHtR threshold (>0.5) for risk.

Evaluation of waist-to-height ratio to predict 5 year cardiometabolic risk in sub-Saharan African adults

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Key Words: Waist Circumference, Waist-to-height ratio, Cardiovascular disease, Hypertension, Diabetes, Dyslipidaemia, Risk factors, Subsaharan Africa, Adults.

Word count: Abstract - 250, Text – 3,183 (including authors and affiliations, corresponding author, abstract and acknowledgements).

ABSTRACT

Background and aims

Simple, low-cost central obesity measures may help identify individuals with increased cardiometabolic disease risk, although it is unclear which measures perform best in African adults. We aimed to: 1) cross-sectionally compare the accuracy of existing waist-to-height ratio (WHtR) and waist circumference (WC) thresholds to identify individuals with hypertension, pre-diabetes, or dyslipidaemia; 2) identify optimal WC and WHtR thresholds to detect CVD risk in this African population; and 3) assess which measure best predicts 5-year CVD risk.

Methods and results

Black South Africans (577 men, 942 women, aged > 30years) were recruited by random household selection from four North West Province communities. Demographic and anthropometric measures were taken. Recommended diagnostic thresholds (WC >80 cm for women, >94 cm for men; WHtR > 0.5) were evaluated to predict blood pressure, fasting blood glucose, lipids, and glycated haemoglobin measured at baseline and 5 year follow up. Women were significantly more overweight than men at baseline (mean body mass index (BMI) women 27.3 $\pm$ 7.4 kg/m^2, men 20.9 $\pm$ 4.3 kg/m^2; median WC women 81.9 cm (interquartile range 61–103), men 74.7 cm (63-87cm), all $P < 0.001$). In women, both WC and WHtR significantly predicted all cardiometabolic risk factors after 5 years. In men, even after adjusting WC threshold based on ROC analysis, WHtR better predicted overall 5-year risk. Neither measure predicted hypertension in men.

Conclusions

The WHtR threshold of >0.5 appears to be more consistently supported and may provide a better predictor of future cardiometabolic risk in Sub-Saharan Africa.

INTRODUCTION

Some of the most rapid increases in obesity and the associated cardiometabolic disease are currently occurring in sub-Saharan Africa (SSA) (1, 2) creating a growing demand for suitable tools that can be employed to determine risk. Measures of central obesity, such as waist circumference (WC) and waist-to-height ratio (WHtR), are simple to collect, appropriate for low-resource settings, and better discriminators of cardiovascular disease (CVD) risk than body mass index (BMI)(3). However, it is unclear which markers of central obesity perform best in SSA adults to predict CVD.

Current recommended diagnostic thresholds for WC in Africa from the World Health Organisation (WHO; WC_{WHO} > 94 cm for men, > 80 cm for women) (4) are based predominantly on prospective analyses in Caucasian reference populations. However, recent evidence from cross-sectional studies in SSA would suggest that these may not be appropriate for African populations (5-10) and ethnicity specific thresholds (such as those recommended for Asian populations (4)) may be required. While the recommended WHtR threshold of 0.5 has largely been determined from Caucasian and Asian populations, (11, 12), this WHtR threshold requires validation in SSA populations.

The aims of this study were: 1) To compare the accuracy of existing WC and WHtR thresholds to cross-sectionally identify individuals with hypertension, pre-diabetes, or dyslipidaemia; 2) to determine the optimal WC and WHtR thresholds for detection of these CVD risk factors in an African population; and 3) to determine whether these thresholds prospectively predict 5-year CVD risk.

METHODS

Study population

The Prospective Urban Rural Epidemiology (PURE) study is a multinational cohort study examining the environmental, societal and biological determinants of obesity and chronic health problems. Study design, methodology, and specific recruitment procedures for PURE South Africa are described in detail elsewhere (13, 14). In brief, the first South African cohort began in 2005, with 5 year follow-up (2010). Black African men and women (n = 2010, age > 30 years, no previous HIV diagnosis) were recruited from 6000 randomly selected households in two urban (n = 1004, 60 % female) and two rural (n = 1006, 65 % female) North West Province communities. Trained fieldworkers speaking the participants' home languages (predominantly Setswana) were used and all participants provided written informed consent prior to taking part in the study. Participants were followed up in 2010. The study complied with the ethical principles for medical research involving human subjects as stated in the Declaration of Helsinki (15) and was approved by the North-West University Ethics Committee.

Measurements

Height (without shoes) was measured to the nearest 0.1 cm with a stadiometer (SECA, Hamburg Germany). Weight in light clothing was measured to the nearest 0.01 kg on portable electronic scales (A&D Medical, Abingdon UK). WC was measured midway between the iliac crest and the lower margin of the last palpable rib in the mid-axillary line using a steel anthropometric tape measure (Lufkin, Apex USA). BMI and WHtR were calculated using the formulae $BMI = weight\ (kg)/height\ (m)^2$ and $WHtR = WC\ (cm)/height\ (cm)$, respectively.

Blood samples were drawn at the antecubital fossa following an overnight fast. Plasma glucose, serum high-density lipoprotein (HDL)-cholesterol and triglyceride concentrations were determined using two Sequential Multiple Analyser Computers (Cobas Integra 400 plus, Roche, Basel Switzerland; Konelab 20i, Thermo Scientific, Finland). Glycated haemoglobin (HbA1c) was analysed using the D-10 Hemoglobin Testing System (Bio-Rad Laboratories, Hercules USA). Human Immunodeficiency Virus (HIV) status was determined with the First Response (PMC Medical, Nani Daman India) rapid HIV card test using whole blood. If positive, the test was repeated with the Pareeshak (BHAT Bio-tech, Bangalore India) card test. Following 10 minutes rest, systolic (SBP) and diastolic blood pressure (DBP) were measured on the right upper arm using an automated monitor (HEM-757, Omron Healthcare, Tokyo Japan) and appropriate size cuff and participants seated with their arm supported at the level of the heart. A second BP measure taken after 5 minutes was used for analysis.

Metabolic risk factor definitions

The diagnostic criteria for elevated CVD risk were: hypertension (SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg or on antihypertensive treatment); low HDL-C (< 1 mmol/l in men, < 1.3 mmol/l in women); elevated triglycerides (TG > 1.7 mmol/l or 150 mg/dl); impaired fasting glucose (IFG > 5.6 mmol/l or 100 mg/dl); elevated HbA1c with high risk of developing diabetes (HbA1c > 6.0% or 42 mmol/mol) (WHO, International Society of Hypertension, International Diabetes Federation, American Heart Association and American Diabetes Association guidelines (16-20)).

Statistical methods

Statistical analyses were performed using Stata version 13 (StataCorp, Texas, USA). Participants that were pregnant (n = 13), tested positive for HIV (n = 320) or with missing data (n = 158), were excluded from baseline analysis. Normality of variables was checked

with visual inspection of histogram plots and the Shapiro-Wilk test. Differences between men and women in the remaining baseline sample (n = 1,519) were analysed by independent t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data for continuous variables. The Chi Square test was used for categorical variables. Analyses were considered statistically significant at $P < 0.05$. Receiver Operator Characteristic (ROC) curves and Youden's Index (J = sensitivity + specificity - 1) were used to assess diagnostic test performance (21) and identify WC and WHtR thresholds predicting baseline metabolic risk in men and women separately. Poor measures with ROC area under the curve (AUC) < 0.60 (22) were excluded.

At 5-year follow-up, 477 participants were lost to follow up (30 % had died, 26 % moved, 31 % refused, 13 % unable to contact). Participants testing positive for HIV at follow-up (n = 59), pregnant (n = 6), or with missing data were excluded leaving n = 917 with complete data. Any participant classified with a baseline metabolic risk factor was excluded from subsequent prospective analyses for that risk factor. Logistic regression models were used to estimate the odds of developing each metabolic risk factor in 2010 using the WC and WHtR diagnostic thresholds identified at baseline. Men and women were analysed separately adjusting for age, baseline smoking status, alcohol consumption and menopausal status (women only). Backwards selection procedure was used to select the covariates. Likelihood ratio tests were used to determine whether WC and WHtR diagnostic thresholds should be included in the logistic regression models. Odds ratios (ORs) and 95% confidence intervals (CIs) for each diagnostic threshold were computed for each metabolic risk factor from the multiple logistic regression models.

RESULTS

Participant characteristics

Table 1 shows baseline characteristics of the participants (577 men, 942 women). Employment levels were low and 78 % of all adults had either no education or were only educated until primary school level. Women had a higher BMI, WC and WHtR than men ($P < 0.001$) and a more unfavourable metabolic profile (higher prevalence of IFG, elevated HbA1c, elevated triglycerides and low HDL-C). Prevalence of hypertension was above 50 % in both genders, although men displayed higher mean SBP ($P < 0.001$) with higher use of tobacco (61% vs. 27%) and alcohol (60% vs. 28%). More women were on anti-hypertension medication (14 % vs. 6 %) than men, but median 'on treatment' SBP values suggest that BP management was not optimal in either group. Due to the gender differences observed, all subsequent analyses were conducted separately for men and women.

Cross-sectional analysis of WC, WHtR and cardiometabolic disease

Classification of participants as "at risk" by either WC_{WHO} (37 %, $n = 555$) or by $WHtR_{0.5}$ (44 %, $n = 674$) at baseline showed the two central obesity measures to not identify the same individuals. While most individuals with high WC also had high WHtR (97 % of women, 100 % of men), there were , fewer individuals with a high WHtR and simultaneous high WC (92 % of women and only 29% of men). More than 75 % of men with any of the metabolic risk factors had a waist circumference below the WHO threshold of 94 cm (**Table 2**). WHtR performed better to identify cases of risk in men although, with the exception of elevated triglycerides, over 50 % of men with an elevated risk factor also had a WHtR $\leq$ 0.5. In contrast, both thresholds (WC_{WHO} and $WHtR_{0.5}$) identified more than 65 % of women with elevated metabolic risk, with WHtR performing marginally better than WC for all CVD risk factors.

In men, there were no significant differences between WC and WHtR to identify risk of diabetes or dyslipidaemia but neither measure predicted hypertension (**Table 3**). In women, both WC and WHtR predicted all markers of metabolic risk, with a small but significant difference between WC and WHtR for low HDL-C (P=0.004). ROC analysis confirmed the optimal threshold for WHtR to be the recommended threshold (>0.5) in both men and women. In contrast, only the WHO WC recommendation for women (>80cm) was supported by ROC analysis while the optimal WC threshold to predict risk in men was found to be 80 cm (much lower than the WHO WC threshold of 94cm).

Prediction of 5 year metabolic risk development by WC and WHtR

Table 4 shows the OR (95 % CI) for 5-year metabolic risk by recommended and ROC identified optimal WC and WHtR thresholds in those with normal metabolic risk profile at baseline. Women with a WC>80 cm or WHtR>0.5 in 2005, had a significantly increased probability of developing all metabolic risk factors over 5 years after adjustment for age, smoking status, alcohol intake and menopausal status.

In men, the current recommended WHO threshold for waist circumference (> 94 cm) showed the worst performance in predicting 5 year cardiometabolic risk. Reducing this WC threshold to > 80 cm (WC_{PURE}) resulted in the significant prediction of impaired fasting glucose, HDL-C, and triglycerides but not HbA1c or hypertension. While WHtR could also not predict hypertension in men, WHtR>0.5 was a significant predictor of all other metabolic risk factors over 5 years.

DISCUSSION

To our knowledge, this is the first prospective study to investigate which central obesity measures best predict future CVD risk in sub-Saharan African adults. The results suggest that $WHtR_{0.5}$ significantly and most consistently predicted 5-year cardiometabolic risk. The only exception was for the prediction of hypertension in men, where neither WC nor WHtR were able to predict the outcome. This may be in part due to high hypertension prevalence in this group (only 27% of men remained hypertension-free over 5 years). Similar hypertension prevalence between men and women despite differences in levels of obesity has previously been observed in South African populations (23) suggesting the relationship between obesity and hypertension development in men is confounded by other factors such as smoking and alcohol use, both significant in our logistic regression models. Alcohol intake in particular has previously been shown to be an important predictor of hypertension development in this group (24).

Identifying optimal WC thresholds for SSA adults is challenging without large, randomly selected cohorts and previous studies have recommended a number of different thresholds. One study in black South African teachers (n = 81 men, n = 90 women, aged 25–65 years) recommended higher WC thresholds (90–96 cm for men, 92–98 cm for women) (8). Another study of black South African mothers in Soweto (n = 1180, mean age 40 $\pm$ 10.6 years, 50.1 % obese) also suggested the WC threshold should be higher at > 91.5 cm, 90.1 cm and 87.6 cm to predict metabolic syndrome, elevated BP (> 135/85 mmHg), and low HDL-C respectively (9). In both these studies, men and women had higher mean BMI and waist circumference measures than those observed in our current study, most likely contributing to the higher WC cut-point recommendations. Other studies present similar results to our own, with optimal thresholds for predicting elevated blood pressure (WC > 80-80.5 cm, WHtR > 0.53-0.57),

elevated fasting blood glucose (WC > 81.5 cm, WHtR > 0.51), and low HDL-C (WC > 77 cm, WHtR > 0.47) reported for pre-menopausal black South African women and Ghanaian women (6, 10). However, previous studies are based on cross-sectional data and, even after optimising WC threshold based on our ROC analysis (WC_{PURE}), WC could only predict 5 year risk of three of the five cardiovascular risk factors in men.

While disagreement surrounds the optimal WC threshold for predicting metabolic risk in SSA adults, our confirmation of the optimal threshold for WHtR at > 0.5 appears more consistently supported. Although limited studies have reported varied optimal WHtR thresholds ranging from 0.45-0.65 (25-28), both meta-analysis and systematic reviews confirm the WHtR threshold of >0.5 across Caucasian, Asian and Central American populations and indicate WHtR may be a better discriminator than WC or BMI for metabolic risk in adults, children, both genders and varying ethnic groups (3, 11, 12). WHtR, like WC, is cheap and easy to obtain, but can also be used with imperial or metric values, and use of the 0.5 threshold promotes a simple public health message “Keep your waist circumference to less than half your height”(29).

Limitations of this study are the generalizability of results to other populations in sub-Saharan Africa. As there are few prospective SSA population-based studies, this study both developed the thresholds in the cross-sectional data and then applied the thresholds prospectively in a sub-set of the population, who were free of the metabolic risk factor at baseline. Further application to other SSA prospective studies is needed to determine how well these thresholds predict long-term CVD risk. For this same reason, use of the lower WC threshold identified in men in this sample is not recommended and there is already great variability in the literature on an “optimal” WC threshold for identifying CVD risk. While $WHtR_{0.5}$ appears more consistently supported within and between countries, further large

prospective studies are required in SSA. Our sample did have higher unemployment rates than those reported for the province generally (45 %;(30)) possibly indicating a bias with employed persons being less available during the working week to participate in the study. Although it could be argued this population (low levels of employment; very little education) are those most vulnerable and in need of simple measures that can be used in targeting interventions to reduce non-communicable disease. A further limitation of the results is the exclusion of participants living with HIV as this does not present a real evaluation of sub-Saharan African populations. However, previous cross-sectional analysis of central obesity and CVD risk in this population including those living with HIV supports our findings (31). Furthermore, no adjustment was made for physical activity and dietary factors. These may also be important risk factors for CVD in this population. However, as the exposure of interest was the central obesity measure, we did not include physical inactivity and dietary factors in the models as they are major contributors to energy imbalance and thus central obesity.

Incorporating height into an assessment of central obesity may confer additional information about risk. Previous studies have determined a strong independent association between height and stroke risk (32), and coronary heart disease (33) whereby increased height appears protective. More recently, growth and timing of peak height velocity have also been associated with adult cardiovascular disease mortality (34). While these findings have yet to be confirmed in SSA, they may imply that adjusting central obesity measures for height provides a better indicator of the dynamic biopsychosocial factors involved in the relationship between body composition and cardiovascular risk than, for example, ethnicity adjusted WC cut-points, especially in countries undergoing rapid urbanisation and socioeconomic

transition. Incorporating height into the central obesity assessment may also be likely to reduce the variability observed between populations due to differences in height.

Conclusions

Our findings from this large cohort study investigating the prospective association between WC, WHtR and the development of metabolic risk support the use of the recommended single waist-to-height ratio threshold of 0.5 to predict the development of cardiometabolic disease in sub-Saharan African men and women. In comparison to waist circumference measures, waist-to-height ratio (>0.5) appears more consistently supported to detect cardiovascular risk across populations on the African continent.

ACKNOWLEDGEMENTS

The authors would like to thank supporting staff and participants of the PURE study, in particular:

1. PURE-South Africa: The PURE-NWP-SA research team, fieldworkers and office staff in AUTHeR, HART, and Dr Wayne Towers of CEN, North-West University, South Africa. 2. PURE International: Dr S Yusuf and the PURE project office staff at the Population Health Research Institute, Hamilton Health Sciences and McMaster University, ON, Canada.

3. Professor A Olckers and the Profiles of Resistance to Insulin in Multiple Ethnicities and Regions (PRIMER) research team.

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funding bodies. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the author(s) and therefore the NRF do not accept any liability in regard thereto. Dr Alta Schutte takes responsibility for the contents of this article.

Sources of Support: The South Africa-Netherlands Research Programme on Alternatives in Development, South African National Research Foundation [GUN numbers 2069319 and FA2006040700010]; North West University; Population Health Research Institute; and the South African Medical Research Council. The funding sources had no involvement in the conduct of the research or preparation of the article.

The authors' contributions were as follows – IMK and MG designed research; HSK, IMK, CMTF, MG, HH, JMVR, JDWS, RS, ASU, AES and RK conducted research; KR performed statistical analysis; LW, KR, AES and RS wrote the paper; AES had primary responsibility for final content. All authors read and approved the final manuscript. None of the authors had any conflict of interest to declare.

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TABLE 1
Baseline characteristics of the study group (n=1,519) by gender [1]

	Men	Women	*P*
n (%)	577 (38)	942 (62)	
Age in years	51.2 ± 10.5	50.7 ± 10.3	0.4
Weight in kg	58.6± 12.6	67.0 ± 18.6	<0.001
Height in cm	167.3 ± 7.0	156.5 ± 6.4	<0.001
BMI in kg/m^2	20.9 ± 4.3	27.3 ± 7.4	<0.001
Waist circumference in cm, median (IQR)	74.7 (12.3)	81.9 (20.6)	<0.001
Waist-to-Height Ratio	0.46 ± 0.006	0.53 ± 0.09	<0.001
Smokers, *n* (%)	350 (61)	440 (47)	<0.001
Alcohol consumers, *n* (%)	344 (60)	260 (28)	<0.001
In employment, *n* (%)	64 (12)	78 (9)	0.07
Educated to primary school or less, *n* (%)	448 (77.6)	735 (78)	0.862
Resident in rural community, *n* (%)	264 (46)	489 (52)	0.02
Cardiovascular measures, median (IQR)			
Systolic blood pressure in mmHg[*]	133.5 (29)	128.0 (31)	<0.001
Diastolic blood pressure in mmHg[*]	86.0 (19.5)	87.0 (18.0)	0.2829
Fasting blood glucose in mmol/l[†]	4.8 (1.0)	4.9 (1.0)	0.0038
HbA1c % (mmol/mol[†])	5.5 (0.5); 37 (5.5)	5.6 (0.6); 38 (6.6)	<0.001
Total triglyceride in mmol/l[‡]	0.97 (0.64)	1.15 (0.82)	<0.001
HDL cholesterol in mmol/l[‡]	1.55 (0.89)	1.44 (0.73)	0.001
Medication use, *n* (%)			
Diabetes medication	3 (0.5)	15 (1.6)	
Hypertension medication	37 (6.4)	127 (13.5)	
On treatment SBP in mmHg median (IQR)	143 (110-176)	140 (104-176)	
On treatment DBP in mmHg median (IQR)	90 (72-108)	93 (76-110)	
Metabolic risk factors, *n* (%)			
Hypertension (SBP ≥140 and/or DBP ≥90 mmHg)	297 (52)	511 (54)	0.293
Impaired fasting glucose (>5.6 mmol/l)	109 (19)	227 (24)	0.018
Elevated HbA1c (>6%, >42 mmol/l)	74 (13)	234 (25)	<0.001
Elevated triglyceride (>1.7 mmol/l)	84 (15)	222 (24)	<0.001
Low HDL-C (men<1.0 mmol/l, women<1.3 mmol/l)	90 (16)	372 (40)	<0.001

[1] Data are presented as means ±SD unless otherwise indicated, IQR is interquartile range. *P* values are for comparison between men and women.
Excluding those on antihypertensive medication[*], medication for type 2 diabetes[†], or cholesterol lowering medication[‡].

TABLE 2
Distribution of cardiovascular disease risk factors in relation to recommended diagnostic thresholds for waist circumference and waist-to-height ratio[2]

	Cardiovascular disease risk factors				
	Hypertension	Elevated triglyceride	Low HDL-C	Impaired fasting glucose	Elevated HbA1c
Measure of central obesity:	*n* (% of total cases)				
Men (n=577)					
Waist Circumference WHO					
≤94 cm (n=542)	271 (91%)	65 (77%)	75 (83%)	94 (86%)	59 (80%)
>94 cm (n=35)	26 (9%)	19 (23%)	15 (17%)	15 (14%)	15 (20%)
Waist-to-height ratio					
≤0.5 (n=454)	215 (72%)	34 (40%)	54 (60%)	67 (62%)	38 (51%)
>0.5 (n=123)	82 (28%)	50 (60%)	36 (40%)	42 (39%)	36 (49%)
Women (n=942)					
Waist Circumference WHO					
≤80 cm (n=422)	181 (35%)	60 (27%)	121 (32%)	75 (33%)	55 (24%)
>80 cm (n=520)	330 (65%)	162 (73%)	251 (68%)	152 (67%)	179 (76%)
Waist-to-height ratio					
≤0.5 (n=391)	156 (30%)	54 (24%)	117 (31%)	68 (30%)	51 (22%)
>0.5 (n=551)	355 (70%)	168 (76%)	255 (69%)	159 (70%)	183 (78%)

[2] WHO, World Health Organization; HDL-C, high density lipoprotein cholesterol; HbA1c, glycated haemoglobin

TABLE 3
Waist circumference and waist-to-height ratio thresholds for metabolic risk variables in black South African men and women[3]

	Men (n=577)							*Women (n=942)*						
	ROC AUC	*95% CI*	*P value (vs. WC)*	*Optimal threshold*	*Optimal sensitivity (%)*	*Optimal specificity (%)*	*Youden J Value**	*ROC AUC*	*95% CI*	*P value (vs. WC)*	*Optimal Threshold*	*Optimal sensitivity (%)*	*Optimal specificity (%)*	*Youden J Value**
Hypertension (SBP ≥140 or DBP ≥90 mmHg or taking antihypertensive medication)														
WC (cm)	<0.6†							0.64	0.60-0.67		78.5	68.9	53.1	0.2202
WHtR	<0.6†							0.64	0.60-0.67	0.63	0.51	67.7	56.8	0.2456
Elevated Triglycerides (≥1.7 mmol/l) or on triglyceride lowering medication														
WC (cm)	0.79	0.73-0.84		78.5	76.2	73.0	0.492	0.66	0.62-0.70		78.6	77.0	47.2	0.2425
WHtR	0.78	0.73-0.83	0.53	0.5	59.5	86.0	0.455	0.66	0.62-0.70	0.65	0.52	68.0	56.4	0.2441
Low HDL-C (<1.0 mmol/l in males; <1.3 mmol/l in females)														
WC (cm)	0.66	0.59-0.73		81.3	53.3	77.4	0.3075	0.63	0.60-0.67		81	65.6	55.8	0.2138
WHtR	0.66	0.59-0.72	0.84	0.48	52.2	75.8	0.2799	0.62	0.58-0.66	0.004	0.53	59.1	59.8	0.1896
Impaired Fasting Blood Glucose (>5.5 mmol/l) or taking glucose-lowering medication														
WC (cm)	0.63	0.57-0.69		78.5	53.2	70.3	0.235	0.62	0.58-0.66		84.3	59.5	62.0	0.2143
WHtR	0.63	0.56-0.69	0.73	0.51	36.7	86.1	0.228	0.62	0.58-0.66	0.71	0.52	65.6	55.3	0.2088
Elevated HbA1c (>6%) or taking glucose-lowering medication														
WC (cm)	0.66	0.59-0.74		79.6	58.1	72.4	0.305	0.71	0.67-0.74		85.7	63.7	69.5	0.3317
WHtR	0.64	0.56-0.72	0.12	0.5	48.7	83.9	0.326	0.71	0.67-0.75	0.22	0.56	61.5	72.7	0.3428

[3] *J=(sensitivity + specificity) - 1. †ROC AUC<0.6, data not shown. ROC, receiver operated characteristic; AUC, area under the curve; CI, confidence interval; WC, waist circumference; WHtR, waist to height ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL-C, high density lipoprotein cholesterol; HbA1c, glycated haemoglobin

TABLE 4
Prediction of 5 year metabolic risk using waist circumference and waist-to-height ratio in black South African men and women[4]

	WC_{WHO}		*$WHtR_{0.5}$*		*WC_{PURE} (Men only)*	
	OR (95% CI)	*P-value*	*OR (95% CI)*	*P-value*	*OR (95% CI)*	*P-value*
Hypertension (SBP ≥140 or DBP ≥90 mmHg or taking antihypertensive medication)						
Men (*n*=155)	†	†	†	†	†	†
Women (*n*=251)	2.3 (1.4, 4.0)	0.002	2.0 (1.2, 3.4)	0.011	-	
Elevated Triglycerides (≥1.7 mmol/l) or on triglyceride lowering medication						
Men (*n*=278)	4.1 (0.9, 18.9)	0.07	3.8 (1.5, 9.2)	0.004	3.0 (1.3, 6.8)	0.01
Women (*n*=412)	2.3 (1.3, 4.1)	0.006	2.2 (1.2, 4.0)	0.009	-	
Low HDL-C (<1.0 mmol/L in males; <1.3 mmol/l in females)						
Men (*n*=277)	4.0 (1.2, 14.0)	0.029	2.9 (1.3, 6.5)	0.009	2.6 (1.2, 5.7)	0.016
Women (*n*=348)	4.0 (2.4, 6.6)	<0.001	3.5 (2.1, 5.8)	<0.001	-	
Impaired Fasting Blood Glucose (>5.5 mmol/l) or previous diagnosis Diabetes						
Men (*n*=263)	†	†	3.6 (1.4, 9.4)	0.01	3.8 (1.5, 10.2)	0.007
Women (*n*=423)	1.9 (1.1, 3.2)	0.025	2.2 (1.2, 3.9)	0.006	-	
Elevated HbA1c (>6%)						
Men (*n*=286)	†	†	2.1 (1.1, 4.2)	0.031	1.5 (0.8, 2.9)	0.181
Women (*n*=408)	1.7 (1.1, 2.6)	0.01	2.0 (1.3, 3.0)	0.001	-	

[4] NS, No significant contribution to the model (likelihood ratio test); †ROC AUC<0.6. All models adjusted for age (years), current smoking status, reported alcohol intake (and menopausal status in women). WCWHO – women >80 cm, men >94 cm; WCPURE – men >80 cm (taken from ROC AUC analysis in this African population from the PURE study).