Determining ethnic-, gender-, and age-specific waist circumference cut-off points to predict metabolic syndrome: the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study

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Abstract

Objective: The aim was to determine receiver-operating characteristic (ROC) waist circumference (WC) cut-off points best associated with metabolic syndrome (MetS) in a cohort of South African teachers.

Design: Target population study.

Setting and subjects: Four hundred and nine urban black (Africans) and white (Caucasians) from the Kenneth Kaunda district in North West province, between the ages of 25 and 65 years old, were stratified according to gender and age (25-45 years and 46-65 years).

Outcome measures: Anthropometric, fasting overnight urine and biological markers for MetS.

Results: ROC analysis determined pathological WC cut-off points of 91 cm for African men and 84 cm for African women. It is recommended that WC cut-off points should be 97 cm for Caucasian men and 84 cm for Caucasian women. Pathological WC cut-off points significantly predicted MetS in all ethnic-, gender- and age- specific groups, especially in male groups, with odds ratios of 7.6 [95% confidence interval (CI): 3.4-17.1, p-value = 0.00) for African men and 6 (95% CI: 3-12.1, p-value = 0.00) for Caucasian men.

Conclusion: ROC-developed WC cut-off points were found to be good predictors of MetS in a South African cohort, especially in the men. Further research in prospective cohort studies is warranted to verify our findings.

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Introduction

Anthropometric measures could be the next step in accurately identifying metabolic syndrome (MetS) in Africans since waist circumference (WC) is the last parameter that still has to be accurately developed in persons of different ethnic descent.[1] Prinsloo et al[2] took up this challenge and demonstrated that increased systolic blood pressure (SBP) best predicted WC cut-off points of 90 cm in African men [odds ratio (OR) 9.5, 95% confidence interval (CI): 3.1-29.3, p-value = 0.00), and 98 cm in African women (OR 3.1, 95% CI: 1.3-7.4, p-value = 0.01). However, these cut-off points do not reflect MetS status; only the presence of specific risk factors. Consequently, these cut-off points differ from the suggested European cut-off points of 94 cm for men and 80 cm for women, recommended for identifying MetS as a whole.[3] Moreover, it is not clear whether the European cut-off points are accurate when applied to Caucasians living in Africa. In addition, Cameron et al[4] indicated the importance of developing a country-specific, rather than one universal ethnic-specific, cut-off point.

WC and body mass index (BMI) can be seen as the golden standard anthropometric measurements of health risk. It has been suggested that evaluations should include at least one of these measurements.[5] Various studies have shown that the WC is influenced by ethnicity, gender and age.[4,6,7] This should be further investigated in African age-specific populations. Anthropometric measurements have also been found to relate to target organ damage in this African population.[8] Further investigation is warranted.

Target organ damage risk increases with MetS prevalence,[9] which has been found to be high in the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) group.[10] MetS can contribute to the strain of microalbuminuria as a marker of target organ damage.[8,9,11-14] It has been found that various MetS risk factors have been associated with renal impairment with regard to target organ damage in the SABPA population.[8,15]

The aim of this study was firstly to develop a WC cut-off point for Africans and Caucasians in ethnic-, gender- and age-specific groups (25-45 years and 46-65 years) for MetS in this cohort. Thereafter, we aimed to determine whether or not the newly developed WC cut-off points were predictive of MetS, and whether or not this screening tool would be associated with target organ damage, if any, in this African and Caucasian population. Proposed hypotheses were firstly, that Africans would have higher WC cut-off points than Caucasians, and secondly, that these newly developed cut-off points would be useful predictors of MetS.

Method

This substudy, conducted between 2008 and 2009, formed part of the SABPA study, which was carried out from 2008-2012.

Study population

The study sample comprised urban African and Caucasian teachers from the Dr Kenneth Kaunda Education District in North West province. Mixed race was not genetically confirmed, but self-reported. To include the largest homogenous populations, we incorporated Caucasian and African teachers. Exclusion criteria for participation included pregnancy, lactation, a temperature > 37°C, use of alpha and beta blockers and psychotropic substance abuse. Blood donors and persons vaccinated in the three months prior to participation were also excluded. Exclusions were made in order to control effects on the homeostasis and immune profile. Thus, this sample was homogenous regarding socio-economic class and comprised 409 participants aged 25-65 years, 200 of whom were African (men, n = 101; women, n = 99) and 209 Caucasians (men, n = 101; women, n = 108). Data from clinically diagnosed patients with diabetes (10 Africans and two Caucasians) and human immunodeficiency virus (HIV)-positive participants (19 Africans) were excluded from analysis because of the effect on homeostasis and immune profile. After exclusion, the total sample comprised 378 participants who signed an informed consent form. The study was approved by the Ethics Review Board of North-West University (NWU) (Project No: NWU-00036-07S6). The study conformed to the ethical guidelines for human participants of the World Medical Association Declaration of Helsinki.

Metabolic syndrome

Participants were classified with MetS when three or more of the risk factors were present when using the Joint Statement Criteria.[1] WC was classified as a risk at ≥ 94 cm and ≥ 80 cm for Caucasian men and women respectively,[1] while the WC of Africans was classified using Prinsloo et al's suggested cut-off points of 90 cm for African men and 98 cm for African women.[2] Other components of MetS which were classified as risk factors were triglycerides ≥ 1.7 mmol/l; high-density lipoprotein (HDL) of 1 mmol/l for men and < 1.3 mmol/l for women, glucose ≥ 5.6 mmol/l, SBP ≥ 130 mmHg and diastolic blood pressure (DBP) ≥ 85 mmHg.[1]

Experimental procedure

Avoiding seasonal changes, collection of data for each participant continued over a 48-hour period in the working week from February to May 2008, and again during the same period in 2009. Each morning, Actical® accelerometer (Bio-Lynx, Québec) devices were fitted, and software programmes activated for four participants, after which they resumed their daily activities. Participants had to stay overnight at the Metabolic Unit research facility of the NWU campus to ensure well-controlled conditions. Participants were welcomed at 16h30 at the Metabolic Unit and introduced to the experimental setup to lessen the white coat effect and anticipation stress[16] before clinical measures commenced on day two. After receiving a standardised dinner, participants were encouraged to go to bed at 22h00, and to fast until all measures were completed the next morning. The following day, urine samples were obtained at 06h00, after which anthropometric measurements were taken, followed by blood pressure (BP) and blood sampling.

Anthropometric and biological measurements

All anthropometric measurements were carried out in triplicate by level 2-accredited anthropometrists. Inter- and intraobserver variability was less than 10%.

Maximum stature was measured to the nearest 0.1 cm with a stadiometer, while weight was measured to the nearest 0.1 kg on a Krups® scale with the weight evenly distributed. The abovementioned measurements were used to calculate BMI.

Circumferences were measured with the participant in a standing position, using a non-extensible and flexible anthropometric tape. Neck circumference (NC) was taken immediately superior to the thyroid cartilage perpendicular to the long axis of the neck. WC was taken at the midpoint between the lower costal rib and the iliac crest, perpendicular to the long axis of the trunk, and not at the narrowest point, for standardisation purposes.[17]

Physical activity was measured by means of the Actical® physical activity monitor, which was water-resistant, lightweight and small, using one-minute recording epochs. Actical® monitors were fitted to participants' waists and were worn for 24 hours. They were removed after participants' overnight stay at NWU.

BP measures followed after participants had rested for 10 minutes in a semi-recumbent position. BP was measured with a sphygmomanometer, using the Riva-Rocci-Korotkoff method on the non-dominant arm.[18] BP measures were repeated once, with a 3- to 5-minute resting period between measurements. The second measurement was used for MetS prevalence screening.

A fasting resting blood sample was obtained with a winged infusion set from the brachial vein branches from the dominant arm by a registered nurse. Sodium fluoride, glucose and serum samples for MetS markers, cotinine and gamma-glutamyl transferase (GGT) were handled according to standardised procedures and stored at -80°C until analysis. Analysis was performed using Konelab™ 20i Sequential Multiple Analyzer Computer (ThermoScientific, Finland) and the timed, end-point method, Unicel DXC 800® (Beckman and Coulter, Germany) at independent accredited laboratories.

After waking the participants at 06h00, an overnight (eight-hour) collected fasting urine sample was obtained as a measure of albumin to creatinine ratio. Urine was stored at 4°C after collection for 30 minutes and frozen at -80°C until analysis. Analysis involved a measurement of immunoprecipitation, enhanced by polyethylene glycol at 450 nm with the Konelab™ 20i Sequential Multiple Analyzer Computer and the timed end-point method, Unicel® DXC 800, at independent accredited laboratories.

Statistical analyses

Statistical analyses were performed with Statistica® 10 (StatSoft). Participants were stratified into African and Caucasian gender age groups of 24-45 years (African men, n = 56; Caucasian men, n = 46; African women, n = 46 and Caucasian women, n = 49), hereafter referred to as the younger group, and 46-65 years (African men, n = 26; Caucasian men, n = 54; African women, n = 42 and Caucasian women, n = 58), hereafter referred to as the older group. Normal distribution was evident when standard errors of kurtosis and skewness did not exceed the value itself by twofold. Logarithmical transformation was deemed to be appropriate for GGT. Independent t-tests determined statistically significant differences in the lifestyle factors between the different age groups of the African and Caucasian men and women. Analysis of covariance determined significant differences between Africans and Caucasians in each subgroup and were expressed as means with 95% CI independent of covariates: BMI, physical activity, cotinine and log GGT. Proportions were statistically compared with chi-square tests. Thereafter, nonparametric receiver-operating characteristic (ROC) analyses were performed to examine the ability of WC to suggest population- and age-specific cut-off points for MetS (using SPSS®, version 17 for Windows®).

In order to increase the power and to avoid type 1 errors, the sample sizes were enlarged by pooling the ethnic-, gender- and age-specific groups into ethnic- and gender-specific groups. The optimal cut-off points were obtained by means of Youden's index [maximum (sensitivity + specificity - 1]. In order to determine the risk of MetS when above the developed cut-off point, logistic regression analyses were performed within each ethnic-, gender- and age-specific group with MetS as the dependent variable, and with WC, cotinine and log GGT. Forward stepwise linear regression analyses were performed within each ethnic-, gender- and age-specific group with the albumin to creatinine ratio as the dependent variable. Considered independent variables were WC, cotinine and log GGT. Results were regarded to be statistically significant on a 5% level, i.e. when p-value is ≤ 0.05.

Results

Men: African versus Caucasian

Lifestyle

Table I depicts the basic characteristics of the male groups. There were no differences between the ethnic- and age-specific groups for BMI and cotinine with regard to lifestyle factors. Caucasian men seemed to be significantly more active than African men, while African men revealed significantly increased GGT levels, indicating possible alcohol abuse.[19]

Men and the metabolic syndrome

Fifty-nine per cent and 72% of the younger African and Caucasian men, respectively, presented with MetS. In the older groups, MetS was evident in 73% of the African, and 77% of the Caucasian, men.

MetS components, glucose and WC, were above the recommended cut-off points in all groups, although Caucasian men revealed significantly increased WC and NC above that of their African counterparts. High triglycerides were a risk factor in Caucasian men only, while BP was highest in the African men. Albumin to creatinine ratio mean levels above the cut-off point were evident in older African men only, and were significantly higher than that of their Caucasian counterparts.

Development of waist circumference cut-off points for men

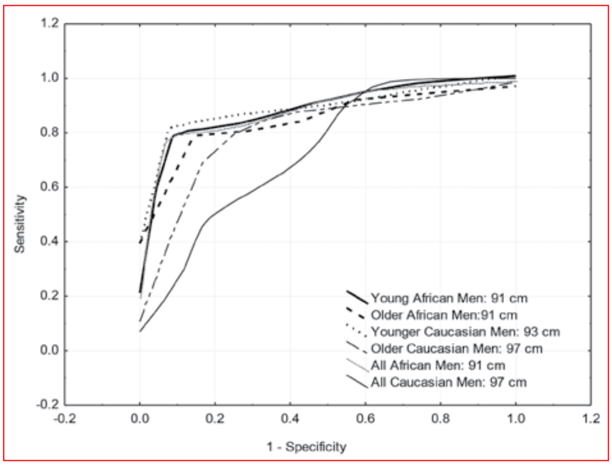
ROC analysis was used to determine the suggested cut-off values for WC for MetS. Because groups were small, the required power of 0.8 was not met. Hereafter, the selection of ethnic- and gender-specific groups increased power and significance. However, ethnic-,

Table I: Baseline characteristics of African and Caucasian men

	African men (25-45 years) (n = 56)	Caucasian men (25-45 years) (n = 46)	p-value	African men (46-65 years) (n = 26)	Caucasian men (46-65 years) (n = 54)	p-value
Lifestyle factors						
*BMI, kg/m²	27.6 ± 5.7	28.9 ± 6.2	0.24	27.6 ± 5.98	29.1 ± 4.2	0.15
*PA kcal/day	2 818.1 ± 851.4	3 482 ± 814.1	0.000	2 509.7 ± 668.5	3 482.3 ± 636.2	0.000
*GGT, U/l	75.7 ± 73.1	32.2 ± 33.1	0.000	102.9 ± 120.2	36.8 ± 26.2	0.000
*Cotinine, ng/ml	58.2 ± 86.5	33.6 ± 94.4	0.47	23.2 ± 47.5	28.6 ± 99.4	0.16
Metabolic syndrome components [analysis of covariance (95% confidence interval)]						
**Glucose, mmol/l	5.7 (5.3, 6.1)	5.9 (5.4, 6.1)	0.55	6.3 (5.6, 7)	6.2 (5.7, 6.7)	0.29
**HDL, mmol/l	1 (0.9, 1.1)	1 (0.9, 1.1)	0.62	1.1 (1, 1.2)	1.1 (1, 1.2)	0.71
**Trig, mmol/l	1.5 (1.1, 1.9)	2 (1.5, 2.5)	0.14	1.5 (1.1, 1.9)	1.7 (1.4, 1.9)	0.56
**SBP, mmHg	135 (131, 139)	127 (122, 132)	0.02	149 (141, 157)	133 (127, 138)	0.000
**DBP, mmHg	92 (89, 96)	83 (80, 88)	0.000	97 (92, 101.4)	86 (83, 90)	0.01
**WC, cm	93.1 (91.7, 94.5)	98.5 (96.7, 100.4)	0.000	98.1 (95.7, 100.5)	102.1 (100.3, 103.8)	0.02
Neck circumference as possible metabolic syndrome predictor **(cm)						
	38 (37.5, 38.5)	40.6 (40, 41.3)	0.000	38.1 (37.2, 39)	40.5 (39.9, 41.2)	0.000
Metabolic syndrome						
n (%)	33 (59)	33 (72)		19 (73)	42 (77)	
Target organ damage						
**ACR	2.6 (-1.6, 6.7)	1.7 (-3.6, 7)	0.82	3 (1.5, 4.4)	0.3 (-1, 1.4)	0.01

*: Not adjusted, mean ± standard deviation, 95% confidence interval
**: Adjusting for confounders: body mass index, physical activity, cotinine and gamma-glutamyl transferase
: ACR: albumin to creatinine ratio, BMI: body mass index, DBP: diastolic blood pressure, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, NC: neck circumference, PA: physical activity, SBP: systolic blood pressure, Trig: triglycerides, WC: waist circumference

gender- and age-specific groups were included in the analysis in order to see if a trend concerning WC was apparent when examining the different age groups. Figure 1 visually illustrates where the area under curve (AUC) was most optimal for MetS and what the cut-off points were according to Youden's index for men.



Receiver-operating characteristic curves depicting the metabolic syndrome for the African and Caucasian men, predicting pathological waist circumference. The area under the curve (95% confidence interval) was 0.9 (0.8, 1.0) for the younger African men; 0.9 (0.7, 1) for the older African men and 0.9 (0.8-1) for all of the African men. The area under curve was 0.9 (0.8-1) for the younger Caucasian men; 0.8 (0.7, 1) for the older Caucasian men and 0.9 (0.8-0.9) for all of the Caucasian men.

Figure 1: Receiver-operating characteristic curves depicting the metabolic syndrome for African and Caucasian men

The respective ROC cut-off values, yielding maximum sensitivity and specificity were found at a cut-off point of 91 cm for both the younger and the older African men, as well as for the total group of African men. The optimum cut-off points for WC were found to be 93 cm for the younger, and 97 cm for the older as well as for the total group of Caucasian men. Regardless of the small sample size, the cut-off points for African and Caucasian men were 91 cm and 97 cm, respectively.

ORs (Table II) revealed that increased risk of MetS was evident in all groups above the suggested WC cut-off points. The highest risk was in groups that were not stratified according to age (all African: OR 7.6, p-value = 0.00, and all Caucasian: OR 6.0, p-value = 0.00).

Women: African versus Caucasian

Lifestyle

Table III depicts the basic characteristics of the women. African women had significantly increased BMIs, as well as GGT levels, compared to their Caucasian counterparts. However, GGT levels were only significantly higher in the younger group. When evaluating cotinine values, older African women smoked significantly more than their Caucasian counterparts.

Table II: Logistic regression to indicate if waist circumference cut-off points predict metabolic syndrome in men

	Metabolic syndrome											
	Younger African men		Younger Caucasian men		Older African men		Older Caucasian men		All African men		All Caucasian men	
	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)
WC	4.1	2.7, 6 p-value = 0.000	4.5	2.9, 6.9 p-value = 0.000	4.1	2.7, 6 p-value = 0.000	4.5	2.9, 6.9 p-value = 0.000	7.6	3.4, 17.1 p-value = 0.000	6.0	3, 12.1 p-value = 0.000

CI: confidence interval, OR: odds ratio, WC: waist circumference
Data presented as odds ratio with 95% confidence interval and p-values for significance of odds ratio
Covariates included age, cotinine and log gamma-glutamyl transferase

Table III: Baseline characteristics of African and Caucasian women

	African women (25-45 years) (n = 46)	Caucasian women (25-45 years) (n = 49)	p-value	African women (46-65 years) (n = 42)	Caucasian women (46-65 years) (n = 58)	p-value
Lifestyle factors						
*BMI, kg/m^2	32 ± 7.6	25.9 ± 7	0.000	33.6 ± 6.8	26.6 ± 5.6	0.000
*PA, kcal/day	2 608.5 ± 758.5	2 602 ± 690.3	0.96	2 686.2 ± 827.6	2 574.7 ± 609	0.43
*GGT, U/l	43.5 ± 36	15.3 ± 13.4	0.000	50.8 ± 88.6	23.3 ± 47.7	0.000
*Cotinine, ng/ml	7.5 ± 27	27.7 ± 71.9	0.07	30.6 ± 73.2	4.1 ± 23.6	0.01
Metabolic syndrome components [analysis of covariance (95% confidence interval)]						
**Glucose, mmol/l	5.(4.7, 5.4)	5.2 (4.8, 5.4)	0.70	5.5 (4.6, 5.8)	5.8 (5.3, 6.4)	0.18
**HDL, mmol/l	1.2 (1,1.3)	1.3 (1.2, 1.4)	0.13	1.2 (1.1, 1.4)	1.5 (1.3, 1.6)	0.05
**Trig, mmol/l	0.9 (0.7, 1)	0.8 (0.6, 0.9)	0.55	1 (0.83, 1.27)	1 (0.9, 1.3)	0.72
**SBP, mmHg	125 (120, 129)	117 (112, 121)	0.04	131 (125, 137)	132 (127, 137)	0.92
**DBP, mmHg	83 (80, 86)	76 (72, 79)	0.01	84 (81, 87)	85 (82, 87))	0.72
**WC, cm	87.6 (85.2, 90)	86.1 (83.7, 88.5)	0.47	88.3 (85.7, 90.9)	93.8 (91.5, 96)	0.01
Neck circumference as possible metabolic syndrome predictor** (cm)						
	33.2 (32.5, 33.9)	33.9 (33.2, 34.6)	0.21	32.4 (31.8, 33.1)	35.2 (34.6, 35.8)	0.000
Metabolic syndrome						
n (%)	17 (37)	11 (22)		29 (69)	30 (52)	
Target organ damage						
**ACR	1.3 (1, 1.6)	0.5 (0.2, 0.9)	0.01	2.2 (0.9, 3.5)	1.1 (-0, 2.3)	0.31

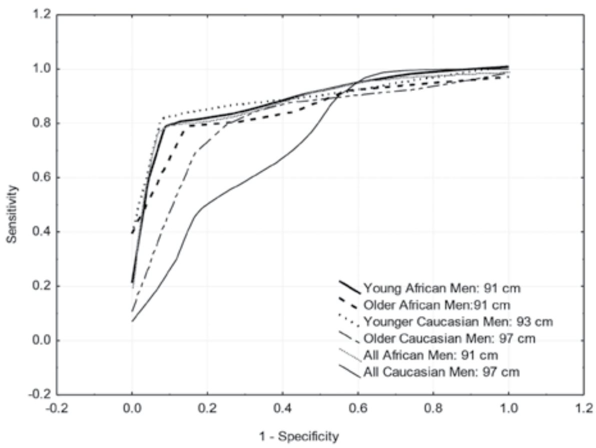
*: Not adjusted, mean ± standard deviation, 95% confidence interval
**: Adjusting for confounders: body mass index, physical activity, cotinine and gamma-glutamyl transferase
ACR: albumin to creatinine ratio, BMI: body mass index, DBP: diastolic blood pressure, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, NC, neck circumference, PA: physical activity, SBP: systolic blood pressure, Trig: triglycerides, WC: waist circumference

Women and the metabolic syndrome

Thirty-seven per cent of the African and 22% of the Caucasian woman in the younger groups could be regarded as having MetS. Of the older Africans and Caucasians, 69% and 52%, respectively, were identified as having MetS. The older groups presented with more MetS risk factor components. Glucose and SBP were above the cut-off points in both of the older groups. Significantly higher BP was demonstrated in the African group. In the older African group, significantly lower HDL values were revealed, compared to those in the older Caucasians. These values constituted MetS risk, with cut-off points below the recommended levels. The younger African woman also presented with HDL levels below the recommended cut-off points. The older Caucasian women had significantly increased WC and NC values above those of their African counterparts. ACR was significantly higher in the younger African women than it was in their Caucasian counterparts. However, these levels were below the risk threshold for this marker of target organ damage.

Development of waist circumference cut-off points for women

Figure 2 visually illustrates where the AUC was most optimal for MetS, and what the cut-off points were according to Youden's index for women. The respective ROC cut-off values were 84 cm for the younger, as well as for the overall group of African women. Eighty-one centimetres has been found to be the most optimal cut-off point for older African women. Cut-off points recommended for Caucasian women were 87 cm,



Receiver-operating characteristic curves depicting the metabolic syndrome for the African and Caucasian women, predicting pathological waist circumference. The area under the curve (95% confidence interval) was 0.7 (0.5, 0.8) for the younger African women; 0.7 (0.5, 0.9) for the older African women and 0.7 (0.6-0.8) for all of the African women. The area under the curve was 0.7 (0.5, 0.9) for the younger Caucasian women; 0.9 (0.8, 1) for the older Caucasian women and 0.8 (0.7, 0.9) for all of the the Caucasian women.

Figure 2: Receiver-operating characteristic curves depicting the metabolic syndrome for African and Caucasian women

79 cm and 84 cm, for the younger, older and overall group of Caucasian women, respectively. Here, an 84 cm cut-off point was apparent for all of the women.

We commenced with logistic regression and ORs in Table IV. The pathological WC, as determined by means of ROC analysis, determined the risk of MetS in all the groups of women. ORs revealed that increased risk of MetS was evident in African (OR: 4.4, p-value = 0.00) and Caucasian (OR: 4.5, p-value = 0.00) women. However, odds were lower when groups were not stratified according to age, as opposed to the findings concerning the men. Multiple regression analysis revealed no association between WC and ACR in any of the ethnic-, gender- and age-specific groups.

Discussion

The main aim of this study was to determine ethnic-, gender- and age-specific cut-off points for WC to predict MetS. Our main finding demonstrated that the newly developed WC cut-off points can be used to identify increased risks of MetS in all ethnic-, gender- and age-specific groups.

Men

African men were much less active and more inclined to abuse alcohol than the Caucasian men. These risk factors may be coping strategies that are utilised when living in an urban environment,[11,20] and have been associated with increased WC,[21] and subsequently with the progression of MetS.

Although older Caucasian men had more MetS risk factors, their African counterparts had significantly higher mean risk factor levels. The BP results in the Africans were of great concern. This has been corroborated by other South African studies.[22,23] African men had increased BP above that of their Caucasian counterparts, regardless of age. This could possibly be ascribed to high alcohol abuse, as seen in this urban African population.[24,25] Triglycerides were increased in both Caucasian age groups, but not in either African counterpart group, which could possibly be attributed to Africans having inherently higher lipoprotein lipase levels which clear triglycerides from the circulation.[26] The high prevalence of MetS risk factors in the African men indicated utilisation of above mean and elevated active defensive coping mechanisms[15] in the same SABPA population. Hypertension and MetS risk increases with the utilisation of defensive active coping.[20]

The present study showed a MetS prevalence of 76%. It was higher than the 12% reported by another study which also used the Joint Statement Criteria.[27] This difference could be explained by the fact that one study was urban and the other rural. Furthermore, it could implicate that there is an urban-rural difference, not only for BMI as suggested by Steyn et al,[28] but also for MetS prevalence. Conversely, the present study incorporated the cut-off points of Prinsloo et al[2] in its definition of MetS since this cut-off point had already been developed in the same population. This incorporation could also have affected the outcomes of prevalence in the present study.

With regard to anthropometry, WC and NC were elevated in both Caucasian age groups above those of the African age groups, which conforms to the findings of a South African health survey which established that African men were less likely to present as obese

Table IV: Logistic regression to indicate if waist circumference cut-off points predict the risk of metabolic syndrome in women

	Metabolic syndrome											
	Younger African women		Younger Caucasian women		Older African women		Older Caucasian women		All African women		All Caucasian women	
	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)	OR	(± 95 CI)
WC	4.1	2.7,6. p-value = 0.000	4.5	2.9, 6.9 p-value = 0.000	4.1	2.7, 6 p-value = 0.000	4.5	2.9, 6.9 p-value = 0.000	3.3	1.8, 6.2 p-value = 0.000	3.8	2.2, 6.5 p-value = 0.000

CI: confidence interval, OR: odds ratio, WC: waist circumference
Data presented as odds ratio with 95% confidence interval and p-values for significance of odds ratio
Covariates included age cotinine and log gamma-glutamyl transferase

than their Caucasian counterparts.[29] Contrary to these findings, it has been reported that African American men are more overweight than their Caucasian counterparts.[30] It has also been suggested that the health risk that accompanies WC could possibly be present at a lower WC in African men than it would be in Caucasians and the recommended cut-point set by the IDF.[31] These contradictory findings strengthen the idea of ethnic- and country-of-origin-specific research.

Lastly, African men of both age groups presented with a higher albumin to creatinine ratio than that of their age-specific counterparts with regard to kidney dysfunction. Higher renal risk in Africans has been documented by other researchers.[14,32] However, in the current study, ROC-developed WC cut-off points were not associated with ACR. This may imply that the albumin to creatinine ratio is not the best measurement of kidney dysfunction, and that the estimated glomerular filtration rate should rather be applied where different grades of renal function need to be assessed, independent of ethnicity and gender.

Women

The same trend that was observed in the African men was noted in both the African women age groups. This reveals higher GGT levels and possible alcohol abuse in African women, than in their Caucasian counterparts. In addition, older African women revealed the highest cotinine levels, which could imply that smoking was being used as an additional coping strategy. BMI levels classified both African age groups as obese, which is consistent with the findings of other South African[27,29,33-37] and African studies.[28,38] Different studies agree that overweight and obesity are highly prevalent. However, prevalence is not consistent from study to study. A study in the urban epicentre of South Africa (Johannesburg and Soweto) found a 50% obesity prevalence,[37] similar to the 47% noted in a rural KwaZulu-Natal study.[27] When considering South Africa as a whole, the prevalence was only 27%.[28] This large difference could possibly be ascribed to the researchers' finding that there was a large urban-rural difference with regard to BMI.[28] Theoretically, having a large body weight indicates health in Africans, just as losing weight is alleged to indicate suffering from a disease such as HIV.[34,35] Furthermore, Africans do not perceive this larger weight to be overweight or obese, while Caucasian women perceive themselves to be overweight, even when this may not be the case.[33] These beliefs could have contributed to the observed differences in BMI in the African and Caucasian women.

In the present study, a 59% MetS prevalence was found. It was also higher than the 30% reported in a rural study.[27] In this regard, the same reasons that were given for the men could be given for the women. The groups comprising women were healthier in terms of risk factors, than those comprising men. A low HDL level was the only present MetS risk factor in the younger African group. This low HDL could possibly be attributed to the younger Africans' obesity levels (BMI ≥ 30 kg/m^2), as appropriate levels of HDL are more easily maintained in persons with a BMI below 28.[39] The absence of MetS risk factors in the younger Caucasians could possibly be accredited to their healthier lifestyle, compared to that of the Africans. Ageing brings about physiological changes, such as decreased estradiol and a change in body fat distribution, which could increase the likelihood of developing glucose intolerance and irregularities concerning lipids and BP.[40] The aforementioned is especially true of BP in both the older groups. Lipids were not adversely affected in the older groups, except for low HDL in the older Africans, as was the case with the younger African women.

As with the men, the African women presented with the highest ACR values, compared to those for their Caucasian counterparts. However, these levels were below the level constituting risk.

Waist circumference cut-off points

The WC cut-off points for MetS differ from those set by Prinsloo et al,[2] which were developed in the same SABPA population, as well as from the findings of other studies.[27,37]The cut-off points may be different to those of Prinsloo et al[2] because they were developed for individual markers of MetS, and not in ethnic-, gender- and age-specific groups. The differences in cut-off points (compared to those reported by Motala et al) could be explained by the fact that these cut-off points were developed in a Zulu population, and in contrast to the SABPA study were conducted in a rural community.

African men

In this SABPA substudy, recommended WC cut-off points predicting MetS for African men were 91 cm for both age groups, as well as for all the overall group of African men. This is relatively similar to the 90 cm set for African men by Prinsloo et al[2] for MetS component, SBP, and differs greatly from that put forward by Motala et al.[27]

African women

Recommended WC cut-off points for MetS in African women are 84 cm and 80 cm for the younger and older groups, respectively, as well 84 cm for the overall group of African women. This differs from the 98 cm cut-off point[2] which was not developed for MetS as a whole, but instead for SBP as an individual component of MetS. This reflects that MetS is present at a lower WC, and that increased SBP may develop in relation to a greater WC. However, our cut-off point is more aligned to the 80 cm cut-off point of the International Diabetes Federation for women residing in sub-Saharan Africa, which has not yet been ethnically or age-adjusted. Conversely, on the subject of WC cut-off points for African women, Prinsloo et al,[2] Motala et al[27] and Crowther and Norris[37] gave similar recommendations, implying that lower cut-off points may overestimate the prevalence of MetS.

Caucasian men

We recommend a cut-off point of 93 cm for the younger, and 97 cm for both the older and the overall group of Caucasian men.

Caucasian women

Caucasian women presented with three different cut-off points, namely 87 cm for the younger, 79 cm for the older, and 84 cm for the overall group of Caucasian women. MetS presents at a much lower WC in older women than it does in their younger counterparts. These cut-off points are mostly consistent with the suggested European cut-off points of 94 cm and 80 cm, for men and women, respectively.[3] However, it is noteworthy, especially in the case of Caucasian women, how the cut-off points differed with regard to the age groups.

Our WC cut-off points suggest that for Caucasians, pathology occurs at a lower WC in older women and at a higher WC in older men. Overall, women develop pathology at a lower WC than do men. According to our cut-off points, older Caucasian women develop pathology at the lowest WC, while older Caucasian men develop pathology at the highest WC.

Before this interesting finding can be classified as significant, it should first be apparent in larger sample sizes and prospective studies.

Differences in cut-off points indicate the importance of ethnic-, age- and country-of-origin-specific cut-off points in accurately identifying the risk of MetS. WC above the cut-off points increases the odds of developing MetS in all groups. WC above the cut-off points had the greatest potential of predicting MetS in the male groups, especially when the groups were not classified according to age. Since the cut-off points in either ethnic group were the same, and the odds were greater in the total groups, age-specific cut-off points do not need to be recommended for men.

Women have lower odds of developing MetS at the set cut-off points than the men, although the odds of having MetS are still increased in all women groups. As a screening tool for MetS, WC is of special importance, especially in African woman because NC, developed as a screening tool for MetS in the SABPA population, cannot be used in African women groups since this measure does not increase MetS risk in African women.[41]

WC may be a better measure of MetS risk because it is a more direct measure of subcutaneous adipose tissue central obesity,[42] while NC relates to BMI and WC, and is thus an indirect measure of subcutaneous tissue.[43,44]

The strengths of this study include the inclusion of a unique, representative group of urban black Africans, as well as Caucasians, within a highly standardised experimental protocol.

A limitation of this substudy was the cross-sectional design which cannot infer causality. Furthermore, the study was limited by the sample size, as well as the subdivision into age, gender and ethnic groups. Additionally, because of the specific nature of the chosen participants (region, occupation and income), it may not be possible to apply the results to other populations. Therefore, larger sample sizes in prospective studies and more diverse ethnic groups should be investigated in order to obtain clinically applicable recommendations. Using Prinsloo et al's proposed WC cut-off points,[2] and not the recommended International Diabetes Federation cut-off points, could have affected the results of this study.

To conclude, we carefully propose a WC cut-off point, to be further researched, of 91cm for African men, 97 cm for Caucasian men and 84 cm for all women. These could be useful to ultimately help develop ethnic-specific cut-off points with which to more accurately identify persons with MetS, especially in impoverished African communities. However, prospective cohort studies are needed in larger ethnic-, gender- and age-specific samples in order to strengthen our findings and to develop cut-off points.

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Conflict of interest

There was no conflict of interest to declare.

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