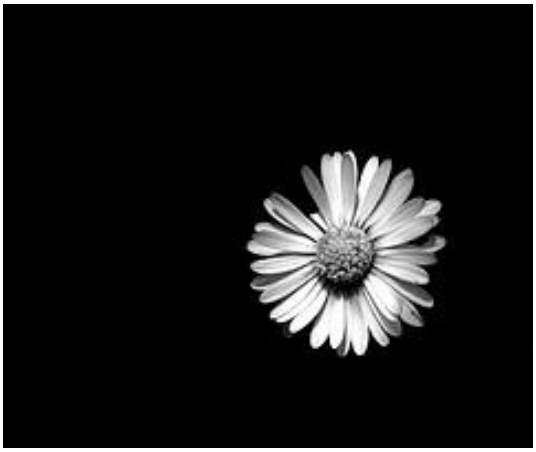
The association between central obesity and psychological distress in a group of urban Africans: the SABPA study

J. Botha

2012



The association between central obesity and psychological distress in a group of urban Africans: the SABPA study

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Thesis submitted for the degree Doctor of Philosophy at the Potchefstroom campus of the North-West University

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℘

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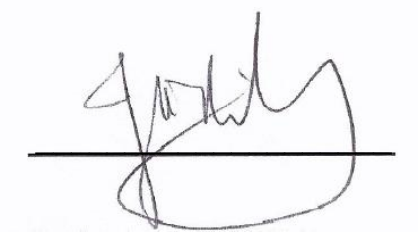
The Author

February 2012

Declaration

The co-authors of the articles which form part of this dissertation, Prof J. Hans de Ridder (promotor), Prof Leoné Malan (co-promotor), Prof Johan Potgieter (co-promotor) and Prof Faans Steyn (assistant-promotor), hereby give permission to the candidate, Me Judy Botha, to include the three articles as part of a Doctoral dissertation. The contribution, both supervisory and supportive, of these co-authors was kept within limits, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation, therefore, serves as fulfilment of the requirements for the Ph.D. degree within the School of Biokinetics, Recreation and Sport Science in the Faculty of Health Sciences at the North-West University, Potchefstroom Campus.



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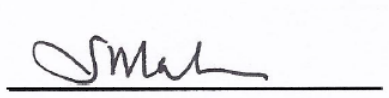

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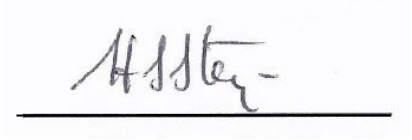

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Summary

Introduction:

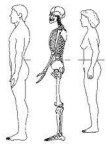
Obesity plays an important role in the development of the metabolic syndrome, with central obesity being included as a required prerequisite in the most recent definition of the metabolic syndrome by the International Diabetes Federation (IDF). The following components were included in the Joint Statement Consensus (JSC) definition: raised blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg), raised triglycerides (Trig)(≥ 1.7 mmol/L) and lowered high-density lipoprotein cholesterol (HDL)(< 1.03 mmol/L in males and < 1.29 mmol/L in females), raised fasting glucose (≥ 5.6 mmol/L), and central obesity. Population- and country-specific definitions for waist circumference is recommended, although the IDF cut points are to be used for non-Europeans until more data are available.

Aim:

Consequently, the aim of the study was to determine a population-specific waist circumference (WC) cut off, comparing the new proposed waist circumference model (NPM) with the current cut offs proposed by the Joint Statement Consensus (JSC). Association between the new proposed cut off and perception of own health in a group of urban African teachers was also investigated.

Method:

WC, sphygmomanometer blood pressure, fasting bloods (glucose, HDL and triglycerides) and ultrasound carotid intima-media thickness (CIMT) were obtained for 171 black urban teachers from the sympathetic activity and ambulatory blood pressure in Africans (SABPA) study. Perception of own health was determined via the General Health Questionnaire-28 (GHQ-28). Gender-separate receiver operating curve (ROC) analyses were performed for each of the metabolic syndrome components to determine a new population-specific waist circumference cut off. Subsequently Logistic Regression and Neural Networks analyses were performed in order to validate the NPM. Thereafter the association between the NPM and perception of own health was considered.



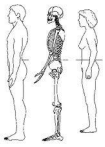
Results:

The respective blood pressure cut offs corresponded best with WC pathology, and a NPM was proposed with the new WC cut off for the males be set at 90 cm as opposed to the current 94 cm; whilst the female cut off be set at 98 cm as opposed to the existing cut off of 80 cm. Thereafter ROC analyses (not adjusting for covariates), Logistic Regression and Neural Networks statistics (both adjusting for a priori confounders, age, BMI and physical activity) validated that the NPM model was comparable to the JSC model. Both models correlated with CIMT, an indicator of structural vascular disease. When comparing the JSC and NPM WC models, only the NPM model was associated with perception of own poorer health.

Conclusion:

A new population and ethnicity-specific WC cut off was recommended (NPM). Subsequently the NPM was validated via Logistic Regression and Neural Networks statistical analyses. The NPM was comparable with the JSC cut offs which are currently in use in predicting structural vascular disease via CIMT. It is proposed that the NPM cut offs be used in this population due to the strong association between blood pressure and the proposed WC cut offs, validated by Logistic Regression and Neural Networks statistical analyses. Furthermore, associations were demonstrated between the NPM and perception of own health in a group of urban Africans.

Keywords: [central obesity, metabolic syndrome, Setswana, ROC, Logistic Regression, Neural Networks, perception of health]



Opsomming

Inleiding:

Obesiteit speel 'n belangrike rol in die ontwikkeling van die metaboliese sindroom, met obesiteit ingesluit as voorvereiste in die mees onlangse definisie van die metaboliese sindroom deur die Internasionale Diabetes Federasie (IDF). Die volgende komponente is by die *Joint Statement Consensus* (JSC)-definisie ingesluit: verhoogde bloeddruk (sistoliese bloeddruk ≥ 130 of diastoliese bloeddruk ≥ 85 mm Hg), verhoogde trigliseriedes (≥ 1.7 mmol/L) en verlaagde hoë densiteit lipoproteïen cholesterol (HDL) (< 1.03 mmol/L in mans en < 1.29 mmol/L in dames), verhoogde vastende glukose (≥ 5.6 mmol/L), en sentrale obesiteit. Populasie- en land-spesifieke definisies vir maagomtrek word voorgestel, alhoewel die IDF afsnypunte vir nie-Europeërs gebruik word totdat meer data beskikbaar is.

Doelwit:

Gevolglik was die eerste doel van die studie om 'n populasie-spesifieke maagomtrek (WC) afsnypunt te bepaal (NPM), dit te vergelyk met die afsnypunt wat tans deur die JSC voorgestel word en ondersoek daarna in te stel of die nuut voorgestelde afsnypunt verband hou met persepsie van eie gesondheid in 'n groep Afrikaan onderwysers.

Metode:

WC, sphygmomanometer bloeddruk, vastende bloed (glukose, HDL en trigliseried waardes) en karotis intima-media dikte (CIMT) is vir 171 swart stedelike onderwysers bepaal in die *sympathetic activity and ambulatory blood pressure in Africans (SABPA)*-studie. Persepsie van eie gesondheid is bepaal via die *General Health Questionnaire-28* (GHQ-28). Geslagte is afsonderlik geanaliseer deur *receiver-operating curve* (ROC) analises vir elk van die metaboliese-sindroom-komponente om 'n nuwe populasie-spesifieke maagomtrek afsnypunt te bepaal. Daarna is Logistiese Regressie en Neurale Netwerk-analises gedoen om sodoende die NPM te valideer. Laastens is die assosiasie tussen die NPM en persepsie van eie gesondheid bepaal.

Resultate:

Daar is gevind dat die onderskeie bloeddruk (BP) afsnypunte die beste korrespondeer met maagomtrek-patologie. Nuwe maagomtrek-afsnypunte is gestel op 90 cm teenoor die huidige 94 cm, terwyl die dames afsnypunt gestel word op 98 cm teenoor die huidige 80 cm. Daarna is ROC-analises (waar nie vir enige veranderlikes gekorrigeer word nie) en Neurale Netwerke-statistiek (waar daar vir a priori veranderlikes ouderdom, BMI en fisieke aktiwiteit gekorrigeer word) gebruik om die NPM te valideer. Die NPM was vergelykbaar met die JSC-model in korrelasie CIMT, 'n aanduider van strukturele vaskulêre siekte. Vervolgens, het die NPM assosiasie tussen sentrale obesiteit en persepsie van eie gesondheid uitgewys.

Gevolgtrekking:

'n Populasie en etnisiteit spesifieke WC afsnypunt is voorgestel (NPM). Daaropvolgend is die NPM via Logistiese Regressie en Neurale Netwerk statistiese analises gevalideer. Die NPM was vergelykbaar met die JSC-afsnypunte wat huidiglik in gebruik is in die voorspelling van strukturele vaskulêre siekte via CIMT. Daar word voorgestel dat die NPM-afsnypunte in hierdie populasie gebruik moet word as gevolg van die sterk assosiasie tussen bloeddruk en die voorgestelde afsnypunte, gevalideer deur Logistiese Regressie en Neurale Netwerk statistiese analises. Verder is assosiasies ook gevind tussen die NPM en persepsie van gesondheid in 'n groep stedelike Afrikane.

Sleutelwoorde: [sentrale obesiteit, metaboliese sindroom, Setswana, ROC, Logistiese Regressie, Neurale Netwerke, persepsie van gesondheid]

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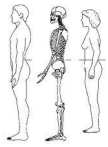

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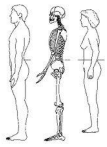

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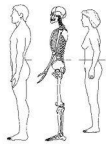

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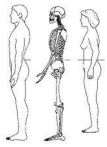

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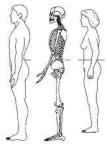

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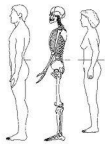
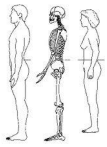


List of Abbreviations

Anthropometry:	WC	Waist Circumference
	kg	Kilogram/s
	m	Meter/s
	BMI	Body Mass Index
Physiological:	BP	Blood Pressure
	HDL	High Density Lipoprotein
	Trig	Triglyceride
	CIMT	Carotid intima-media thickness
Psychological:	GHQ-28	General Health Questionnaire-28
Organizations:	WHO	World Health Organization
	IDF	International Diabetes Federation
	JSC	Joint Statement Consensus
Statistical analyses:	NPM	New Proposed Model
	ROC	Receiver operating characteristic
	AUC	Area under the curve
	CI	Confidence Interval
	95% CI	95 % Confidence Interval
	SD	Standard Deviation
	SE	Standard Error
	LR	Logistic Regression
	OR	Odds Ratio
	NN	Neural Networks
	MLP	Multilayer perceptron



Chapter 1 Introduction and aim of study

1.1 Introduction
1.2 Aims
1.3 Hypotheses
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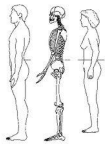
1.1 Introduction

A cluster of risk factors for cardiovascular disease and type 2 diabetes mellitus have become known as the metabolic syndrome. These factors include increased blood pressure, dyslipidaemia (raised triglycerides and lowered high-density lipoprotein cholesterol), increased fasting glucose, and central obesity (Alberti *et al.,* 2009:1640). Most patients with risk factors such as cardiovascular disease and co-morbidities such as diabetes, dyslipidaemia, and hypertension have also been found to be associated with clearly altered carotid intima-media thickness (CIMT) (Kotliar *et al*., 2008:61). In addition, the degree of its alteration increases with the number of coexisting risk factors and the time of exposure, especially in the presence of metabolic syndrome (Kotliar *et al.,* 2008:61).

The current epidemic of type 2 diabetes and metabolic syndrome could be a direct result of our energy-dense diet and affluent sedentary lifestyle, where such a lifestyle could increase the likelihood of individuals eating more than they need (Després & Lemieux, 2006:885). This positive energy balance consequently leads to abdominal obesity and insulin resistance in the presence of an unfavourable genotype and other permissive factors (Després & Lemieux, 2006:885).

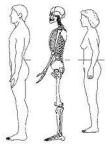


Stress, anxiety, alcohol and smoking may also contribute to the endocrine abnormalities that promote abdominal obesity (Björntorp, 1995:21; Björntorp, 2001:75). Various studies have shown that a relationship of waist circumference to metabolic abnormalities is age-, gender-, as well as ethnicity-dependent (Lemieux *et al.,* 1996:983; Han *et al.,* 1997:593; Després *et al.,* 2000:1932; Misra *et al.,* 2005:969; Després *et al.,* 2008:1041). The marked differences across racial and ethnic groups in disease risk are likely to be due, in part, to each of genetic, host susceptibility and environmental factors (Forouhi & Sattar, 2006:11, Hamer & Malan, 2010:76, Malan *et al.,* 2010:183, Hamer *et al.,* 2011:237, Malan *et al,.* 2012:549, De Kock *et al.,* 2012).

Urbanization has an effect on the traditional ideal body image among Africans, who have always been inclined towards a larger, fuller body shape. (Szabo & Le Grange, 2001:31, Malan *et al.,* 2008:323). In the traditional body image obesity was associated with dignity, health, wealth and respect (Puoane *et al.,* 2005). Black young South Africans may, however, rapidly become exposed to different belief systems due to Westernization and thereby alter their value systems regarding body size (Caradas *et al.,* 2001:112), which may in turn influence their perception of own health (Malan *et al.,* 2008:323).

Urbanization could also, with accompanying insecurities and disruption in African social relationships, contribute to experiencing poorer health or distress (Van Rooyen *et al*., 2000:779, Malan *et al.,* 2006:305, Malan *et al.,* 2008:323). A component of the Whitehall II Study examined psychological distress as a risk factor for coronary heart disease (CHD) and found that the experience of psychological distress conferred increased risk of CHD in males, although it did not consistently do so in females (Stansfeld *et al.,* 2002:248). Interestingly, the increased risk of psychological distress for CHD, in the Whitehall II Study, was not explained by health behaviours (Stansfeld *et al.,* 2002:248), although Hamer *et al.* (2011:237) found that the excess burden of sub-clinical vascular disease in black Africans can be largely explained by health behaviours and conventional risk factors.

The strength of this study lies in the current void in literature where population- and country-specific guidelines for WC have not yet been appropriated for sub-Saharan Africans; also the association between obesity and mental health have not been



investigated in the black South African population. Subsequently, the research questions we aim to answer by means of this study are: (1) Can we establish new population-specific WC cut off points in a cohort of urban African teachers? (2) Which WC cut off point model (JSC or new proposed model) (NPM) is best associated with structural vascular disease, as indicated by carotid intima-media thickness (CIMT)? and (3) Which of the two WC models will be best associated with perception of own health in this African cohort?

1.2. Aims

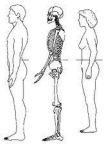
The specific aims of this study were derived from the above-mentioned research questions and are as follows:

- To establish new population-specific WC cut off points in a cohort of urban Africans.
- To determine which WC cut off point model (JSC or NPM) will be best associated with structural vascular disease, as indicated by carotid intima-media thickness (CIMT) in a cohort of urban Africans.
- To examine the association between each of the two WC models (JSC and NPM) and perception of own health in a cohort of urban Africans.

1.3. Hypotheses

The following hypotheses are proposed for this investigation:

- New population-specific WC cut off points in a cohort of urban Africans would differ from those proposed by the JSC.
- New population-specific WC cut off points would predict structural vascular disease (CIMT) in a cohort of urban Africans**.**
- New population-specific WC cut off points would predict a poorer perception of own health in a cohort of urban Africans.



1.4 Structure of the dissertation

This dissertation is presented in four main parts, namely an introduction (Chapter 1), a literature review (Chapter 2), and three research articles (Chapters 3, 4 and 5). Thereafter a summary with conclusions and recommendations will follow (Chapter 6).

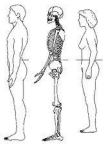
Chapter 1 introduces the problem and states the aim and hypotheses of this study.

Chapter 2, the literature review, focuses on the relationship between obesity and psychological distress.

Chapter 3 will take the form of an article: **Determining the waist circumference cut off which best predicts the Metabolic Syndrome components in urban Africans: the SABPA study**. This article was accepted for publication by Experimental and Clinical Endocrinology & Diabetes, a journal with an impact factor of 1.89 (Prinsloo, J., Malan, L., De Ridder, J.H., Potgieter, J.C. & Steyn, H.S. 2011. Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study. Experimental and Clinical Endocrinology and Diabetes, 119:599-603).

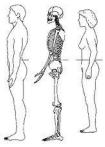
Chapter 4 consists of the second research article titled: **Comparing performances of two central obesity models to predict structural vascular disease by using ROC analyses, Logistic Regression and Neural networks: the SABPA study.**; this article was prepared for Atherosclerosis and is currently in the review process.

Chapter 5 will also take the form of an article: **Association of waist circumference with perception of own health in a group of urban African males and females: the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study.** This article was submitted to the Journal of Endocrinology, Metabolism and Diabetes of South Africa and is in rebuttal.



In chapters 3, 4 and 5, the research articles have been prepared according to the guidelines of each respective journal.

Chapter 6, the final chapter, will wrap up with the conclusion and recommendations of both research articles. Chapter 6 is followed by a list of appendices.



1.5 References

ALBERTI, K.G.M.M., ECKEL, R.H., GRUNDY, S.M., ZIMMET, P.Z., CLEEMAN, J.I., DONATO, K.A., FRUCHART, J., JAMES, W.P.T., LORIA, C.M. & SMITH, S.C. 2009. Harmonizing the Metabolic Syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Foundation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation, 120:1640-1645.*

BJORNTORP, P. 1995. Endocrine abnormalities of obesity. *Metabolism, 44(9):21-23*.

BJORNTORP, P. 2001. Do stress reactions cause abdominal obesity and comorbidities? *Obesity Reviews, 2:73-86.*

DE KOCK, A., MALAN, L., POTGIETER, J.C., STEENEKAMP, W. & VAN DER MERWE M.T. 2012. Metabolic syndrome indicators and target organ damage in urban active coping African Caucasian men: the SABPA study. *Experimental and Clinical Endocrinology and Diabetes, Jan (Epub ahead of print).*

DESPRES, J., COUILLARD, C., GAGNON, J., BERGERON, J., LEON, A.S., RAO, D.C., SKINNER, J.S., WILMORE, J.H. & BOUCHARD, C. 2000. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women: the Health, Risk Factors, Exercise Training, and Genetics (HERITAGE) family study. *Arteriosclerosis, Thrombosis, and Vascular Biology, 20:1932–1938.*

DESPRES, J. & LEMIEUX, I. 2006. Abdominal obesity and the metabolic syndrome. *Nature, 444(14):881-887.*

DESPRES, J., LEMIEUX, I., BERGERON, J., PIBAROT, P., MATHIEU, P., LAROSE, E., RODES-CABOU, J., BERTRAND, O.F. & POIRIER, P. 2008. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. *Arteriosclerosis, Thrombosis, and Vascular Biology, 28:1039-1049.*

FOROUHI, N.G. & SATTAR, N. 2006. CVD risk factors and ethnicity - a homogenous

relationship? *Atherosclerosis Supplements, 7(1):11-19.*

HAMER, M., MALAN, L., SCHUTTE, A.E., HUISMAN, H.W., VAN ROOYEN, J.M., SCHUTTE, R., FOURIE, C.M.T., MALAN, N.T. & SEEDAT, Y.K. 2011. Conventional and behavioral risk factors explain differences in sub-clinical vascular disease between black and Caucasian South Africans: The SABPA study. *Atherosclerosis, 215:237-242.*

HAMER, M. & MALAN, L. 2010. Psychophysiological risk markers of cardiovascular disease. Neuroscience and Biobehavioral Reviews, 35:76-83.

HAN, T.S., MCNEILL, G., SEIDELL, J.C. & LEAN, M.E. 1997. Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. *International Journal of Obesity Related Metabolic Disorders, 21:587–593.*

KOTLIAR, C., FORCADA, P. & FERDINAND, K.C. 2008. Noninvasive Diagnosis of subclinical atherosclerosis in cardiometabolic syndrome: a call to action. Journal of CardioMetabolic Syndrome, 60-62.

LEMIEUX, S., PRUD'HOMME, D., NADEAU, A., TREMBLAY, A., BOUCHARD, C. & DESPRE´S, J.P. 1996. Seven-year changes in body fat and visceral adipose tissue in women: Association with indexes of plasma glucose-insulin homeostasis. *Diabetes Care, 19(9):983–991.*

MALAN, L., SCHUTTE, A.E., MALAN, N.T., WISSING, M.P., VORSTER, H.H., STEYN, H.S., VAN ROOYEN, J.M. & HUISMAN, H.W. 2006. Specific coping strategies of African during urbanization: comparing cardiovascular responses and perception of health data. *Biological psychology,* 72:305-310.

MALAN, L., MALAN, N.T., WISSING, M.P. & SEEDAT, Y.K. 2008. Coping with urbanization: A cardiometabolic risk? The THUSA study. Biological Psychology, 79:323-328.

MALAN, L., MALAN, N.T., DU PLESSIS, A., WISSING, M.P., POTGIETER, J.C. & SEEDAT, Y.K. 2010. The cost of coping: a cardio-neuro-metabolic risk for black South Africans. Cardiovascular Journal of Africa, 21(4):183-185.

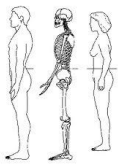
MALAN, L., HAMER, M., SCHLAICH, M.P., LAMBERT, G.W., HARVEY, B.H., REIMANN, M., ZIEMSSEN, T., DE GEUS, E.J.C.N., HUISMAN, H.W., VAN ROOYEN, J.M., SCHUTTE, R., SCHUTTE, A.E., FOURIE, C.M.T., SEEDAT, Y.K. & MALAN, N.T. 2012. Facilitated defensive coping, silent iscaemia and ECG left-ventricular hypertrophy: the SABPA study. *Journal of Hypertension, 30:543-550.*

MISRA, A., WASIR, J.S. & VIKRAM, N.K. 2005. Waist circumference criteria for the diagnosis of abdominal obesity are not applicable uniformly to all populations and ethnic groups. *Nutrition, 21:969-976.*

STANSFELD, S.A., FUHRER, R., SHIPLEY, M.J. & MARMOT, M.G. 2002. Psychological distress as a risk factor for coronary heart disease in the Whitehall II Study. *International Journal of Epidemiology, 31:248-255.*

SZABO, C.P. & LE GRANGE, D. 2001. Eating disorders and the politics of identity. In Nasser, M., Katzman, M.A. & Gordon, R.A., eds. Eating disorders and cultures in transition. Brunner Routledge, New York, 24-39.

VAN ROOYEN, J.M., KRUGER, H.S., HUISMAN, H.W., WISSING, M.P., MARGETTS, B.M., VENTER, C.S. & VORSTER, H.H. 2000. An epidemiological study of hypertension and its determinants in a population in transition: the THUSA study. *Journal of Human Hypertension, 14:779–787.*



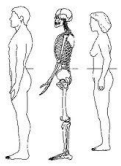
Chapter 2 The relationship between central obesity and psychological distress

2.1 Introduction
2.2 The metabolic syndrome - past and present
2.3 Population- and country-specific cut off points for central obesity
2.4 Hypertension and carotid intima-media thickness (CIMT)
2.5 Psychological distress and perception of health
2.6 Conclusion
2.7 References

2.1 Introduction

Overweight and obesity are associated with increased cardiovascular morbidity and mortality (Rao *et al.,* 2001:1102; Vega, 2001:1108). Most patients with risk factors such as cardiovascular disease and co-morbidities such as diabetes, dyslipidaemia, and hypertension have also been found to be associated with clearly altered carotid intima-media thickness (CIMT) (Kotliar *et al*., 2008:61). Lorenz *et al.* (2007:459) also confirmed in a meta-analysis that CIMT is a strong predictor of future vascular events. Consequently, CIMT measurement is regarded as an excellent tool to detect preclinical vascular disease (Kotliar *et al.,* 2008:61).

Central obesity also forms part of the constellation termed metabolic syndrome. The 2009 Joint Statement Consensus (JSC) risk factors include raised blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg), raised triglycerides (Trig)(≥ 1.7 mmol/L) and lowered high-density lipoprotein cholesterol (HDL)(< 1.03 mmol/L in males and < 1.29 mmol/L in females), raised fasting glucose (≥ 5.6 mmol/L), and central obesity (Alberti *et al.,* 2009:1640). Three abnormal findings out of five would qualify a person for



the metabolic syndrome. A single set of cut points would be used for all components except waist circumference, for which further ethnicity- and country-specific work is required (Alberti *et al.,* 2009:1640).

Culturally worthy of note in black African females is their perception regarding body weight and body image. Puoane *et al.* (2005a:6) found that socio-cultural, behavioural and environmental factors seem to influence the development of obesity in this population. It is proposed that, compared with white women, non-Westernized and some groups of Westernized black women adopt a larger ideal body size and they are more accepting towards being overweight (Faber & Kruger, 2005:238; Kruger *et al.,* 2005:493; Puoane, 2005b:92; Schutte & Olckers, 2007:651). Obesity should, however, not be viewed as a benign condition amongst any ethnic population of South Africa (Kruger *et al.,* 2005:497).

Typically, psychological co-morbidity is high in patients with obesity and is associated with a variety of medical and dietary problems, as well as demographic, social and cognitive risk factors (Van der Merwe, 2007:S14). Whether this is the case with the traditional African female is indefinite. Increased knowledge of behavioural risk factors has, however, enabled patients with obesity to be classified on a psychological basis and this needs to be considered part of a patient's clinical assessment and treatment strategy (Van der Merwe, 2007:S14).

2.2 The Metabolic Syndrome - past and present

Prior to the Joint Statement Consensus (Alberti *et al.,* 2009:1640) addressing the definition of the metabolic syndrome, different international organizations and bodies formulated various definitions for the metabolic syndrome. These included the definitions of the World Health Organization (WHO) (Alberti & Zimmet, 1998), the European Group for the Study of Insulin Resistance (EGIR) (Balkau & Charles, 1999:442), the National Education, Cholesterol Program's Adult Treatment Panel III (NCEP-ATP III, 2001) and finally, the International Diabetes Federation (IDF) (Alberti *et al.,* 2009:1640).

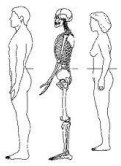


Table 1 illustrates the various organizations' criteria.

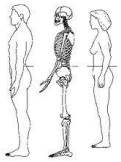
In 2009, a Joint Statement Consensus (JSC) was released by the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Foundation; International Atherosclerosis Society; and International Association for the Study of Obesity. This JSC decided that a single set of cut points would be used for all components except waist circumference (WC), for which further research is required (Alberti *et al.,* 2009:1640).

Population-specific cut offs have already been accepted for Asian populations by the International Diabetes Federation (Alberti *et al.,* 2009:1642). Sub-Saharan Africans, however, still use the cut offs proposed for the Europid and Caucasian populations, with the male cut off set at ≥ 94 cm and the female WC cut off set at ≥ 80 cm.

Table 1: Various definitions of the metabolic syndrome - 1998 to 2009.

	Classify as diabetes when:	Blood Pressure	Dyslipidaemia	Central Obesity	Other factors:
WHO (Alberti & Zimmet, 1998)	Glucose intolerance, impaired glucose tolerance or diabetes mellitus and/or insulin resistance together, and any 2 of the following:	raised arterial pressure (≥140/90 mmHg);	raised plasma triglycerides (≥1.7 $mmol^{-1}$) and/or low HDL-cholesterol (<0.9 $mg.g^{-1}$ males; <1.0 $mg.g^{-1}$ females)	central obesity (waist to hip ratio males >0.90, females >0.85) and/or BMI > 30 kg/m^2	microalbuminuria (urinary albumin excretion rate ≥ 20 µg min^{-1} or albumin:creatinine ratio ≥ 30 mg g^{-1})
European Group for the Study of Insulin Resistance (EGIR) (Balkau & Charles, 1999:442)	The presence of insulin resistance or fasting hyperinsulinaemia (the highest 25%)	hypertension (systolic/diastolic blood pressures ≥ 140/90 mmHg or treated for hypertension)	dyslipidaemia (triglycerides > 2.0 mmol/L or HDL cholesterol < 1.0 mmol/L or treated for dyslipidaemia)	central obesity (waist circumference ≥ 94 cm in males and ≥ 80 cm in females).	hyperglycaemia(fasting plasma glucose ≥ 6.1 mmol/L, but nondiabetic)
		All of these criteria must be measured before it is possible to evaluate the presence of the metabolic syndrome.			

	Classify as diabetes when:	Blood Pressure	Dyslipidaemia	Central Obesity	Other factors:
The National Education, Cholesterol Program's Adult Treatment Panel III (NCEP-ATP III) (2001)	Did not list any principal criteria	hypertension (systolic/diastolic blood pressures ≥ 135/85 mmHg or treated for hypertension)	raised plasma triglycerides (≥1.7 $mmol^{-1}$) and/or low HDL-cholesterol (<1.03 $mg.g^{-1}$ males; <1.29 $mg.gl^{-1}$ females)	central obesity (waist circumference ≥ 94 cm in males and ≥ 80 cm in females).	
Joint Statement Consenus (JSC) (Alberti *et al.*, 2009:1640)	Three abnormal findings out of 5 (raised blood pressure, dyslipidemia and raised fasting glucose) would qualify a person for the metabolic syndrome	raised blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg)	raised triglycerides (Trig)(≥ 1.7 mmol/L) and lowered high-density lipoprotein cholesterol (HDL)(< 1.03 mmol/L in males and < 1.29 mmol/L in females)	central obesity (proposed until population and ethnicity-specific guidelines are set: waist circumference ≥ 94 cm in males and ≥ 80 cm in females).	raised fasting glucose (≥ 5.6 mmol/L)



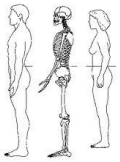
2.3 Population- and country-specific cut off points for central obesity

Differences in body composition are observed in different ethnic groups (Wagner & Heyward, 2000:1392); Blacks have increased skeletal muscle mass and bone mineral content, whereas Asians have less skeletal muscle mass, low bone mineral content, and excess body fat for a given BMI (Misra *et al.,* 2005:970). Kumar *et al.* (2006:686) found that ethnic differences in obesity measures persisted despite adjusting for age and known socio-demographic, biological and lifestyle factors.

Factors that might influence waist circumference is laxity of anterior abdominal muscles, poor posture, phases of respiration, as well as water, food and gases contained in hollow viscera (Misra *et al.,* 2005:970). Heterogeneity of composition of abdominal tissues, in particular adipose tissue and skeletal muscle, and their location-specific and changing relations with metabolic factors and cardiovascular risk factors in different ethnic groups do not, however, allow a simple definition of abdominal obesity that could be applied uniformly (Wagner & Heyward, 2000:1392; Misra *et al.,* 2005:969; Carroll *et al.,* 2008:607).

Sex differences in fat distribution are thought to be due to changes in the local levels of sex steroids/hormones i.e. androstenedione to testosterone and estrone to estradiol (Ahima, 2006:243S). Nindl *et al.* (2002:1611) demonstrated that the main gender differences in body composition are that males have more muscle mass in their upper limbs and females carry more of their fat mass in their legs.

Regarding ethnicities, Després *et al.* (2000:1932-1933) found that black females had a greater body fat content and higher levels of visceral adipose tissue than white females, suggesting a lower susceptibility to visceral obesity in black females. White men, on the other hand, had higher levels of visceral adipose tissue than black men, (Després *et al.,* 2000:1932). In a review study, Wagner and Heyward (2000:1399-1400) unequivocally found that the fat free mass of blacks and whites differ significantly; with increased bone mineral content and bone mineral density in blacks, shown by cadaver and in vivo analyses.



Consequently, population-specific and country-specific definitions for waist circumference (WC) are recommended, although the International Diabetes Federation (IDF) cut points are to be used for non-Europeans until more data are available (Alberti *et al.,* 2009:1640). Several studies have proposed new population-specific cut points (Table 2). Proposed cut offs in the various studies ranged from 71.5 cm to 96 cm for female participants and from 76 cm to 106 cm for male participants.

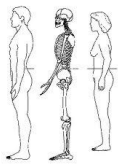
The European Society of Hypertension position statement on the metabolic syndrome in hypertension states that obesity and insulin resistance have been implicated in the pathogenesis of the metabolic syndrome (Redon *et al.,* 2009:1891). Evidence now indicates that central obesity plays a central role in the development of the metabolic syndrome and appears to precede the appearance of other metabolic syndrome components linked to insulin resistance (Fezeu *et al.,* 2007:70; Cameron *et al.,* 2008:2707; Després *et al.,* 2008:1039).

Conversely, Chambers *et al.* (2008:716) carried out a genome-wide association study and found that a common genetic variation near *MC4R* is associated with risk of adiposity and insulin resistance. In general, the metabolic syndrome components have a high degree of interaction where one component contributes to the establishment of abnormality in other components and vice versa (Redon *et al.,* 2009:1893). Redon *et al.* (2009:1893) adds that obesity and insulin resistance may play an important role in the increment of blood pressure and the development of hypertension, although the precise mechanisms involved remain partially unresolved.

Table 2: Proposed race and gender-specific waist circumference cut off points.

Source	Population / Ethnicity	Nr of Participants	Female cut-off (cm)	Male cut-off (cm)
Okusun *et al.,* 2000a:180	Nigeria; Cameroon; Jamaica; St Lucia; Barbados	3983 males; 4763 females	72; 82; 85; 86; 88	76; 81; 80; 83; 87
Okusun et al., 2000b:1279	White, black and Hispanic Americans	7613 males; 7207 females	82 - 91; 81 - 90; 83 - 92	89 - 106; 84 - 95; 87 - 97
Berber *et al.,* 2001:1794	Mexico	2426 males; 5939 females	85	90
Foucan *et al.,* 2002:992	Guadeloupe	5149 females	83.5	
Lin *et al.,* 2002:1232	Taiwan	26359 males; 29204 females	71.5	80.5
Mirmiran *et al.,* 2004:1110	Tehran	4449 males; 6073 females	79 - 96	80 - 93
Wang & Hoy, 2004:1581	Australia (Aborigines)	473 males; 442 females	91	86
Shiwaku *et al.,* 2005:52	Asia (361 Japanese; 252 Mongolians)	388 males; 364 females	73; 84	82; 92
Hara *et al.,* 2006:1123 & 1124	Japan	408 males; 284 females	78	85
Al-Lawati & Jousilhati, 2007:102	Omani Arab	696 males; 725 females	84.5	80
Bouguerra *et al.,* 2007:859	Tunisia	1244 males; 2191 females	85	85
Hayashi *et al.,* 2007:120	Japanese American	344 males; 295 females	80 - 90	87 - 90
Mansour *et al.,* 2007:1	Iraq	700 males; 300 females	99	97
Neufeld *et al.,* 2007:159	Mexico	802 females	89.3 - 91.2	
Oka *et al.,* 2007:474	Japan	1061 males; 809 females	82.3	89.8

Al-Lawati *et al.,* 2008:304	Omani Arab	680 males, 704 females	84.5	78.5
Esteghamati *et al.,* 2008:104	Iran	1046 males; 1706 females	85.5	91.5
Matoba *et al.,* 2008:590	Japan	1658 male; 1116 females	80	87
Sumner *et al.,* 2008:841	African American	68 males; 63 females	≥98	≥102
Bao *et al.,* 2008:378	Chinese	525 males; 615 females	85	90
Cameron *et al.,* 2008:1	Europid; South Asia	3525 males, 4201 females	84; 76	97; 79
Hadaegh *et al.,* 2009:1437	Iran	1614 males; 2006 females	94.5	94.5
Kim *et al.,* 2009:35	Korea	18551 males; 12525 females	77 (Hyperten.) 77 (Diabetes) 76 (MetS)	84 (Hyperten) 85 (Diabetes) 83 (MetS)
Ye *et al.,* 2009:1058	China	114 males; 176 females	82	88
Ogawa *et al.,* 2010:117	Japan	3811 males; 2161 females	80	84
Park *et al.,* 2010:511	Korea	3574 males; 5243 females	80	85
Prinsloo *et al.,* 2011:599	South Africa	80 males, 93 females	98	90



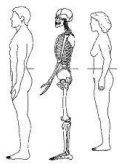
2.4 Hypertension and carotid intima-media thickness (CIMT)

Essential hypertension is frequently associated with metabolic abnormalities. These abnormalities include obesity of the central, visceral subtype, insulin resistance with or without impaired glucose tolerance and dyslipidemia, consisting of elevated very low density lipoproteins and low levels of high density lipoproteins - now widely known as the Metabolic Syndrome (Björntorp, 2002:82).

Previous studies found that the African population is a high-risk group regarding the prevalence of hypertension compared to the Caucasian population (Van Rooyen *et al.,* 2000:779; Opie & Seedat, 2005:3652; Dennison *et al.,* 2007:484; Thorogood *et al.,* 2007:326; Sliwa *et al.,* 2008:915; Malan *et al.,* 2012:542). Opie and Seedat (2005) and Seedat (2009:39) additionally proposed that sodium sensitivity be held accountable for the very high prevalence of hypertension observed in African men.

Joffe *et al.* (1992:460), on the other hand, proposed that the African population either inherit or acquire decreased pancreatic ß-cell mass and that they are more prone to the development of insulinopenic non-insulin dependent diabetes mellitus. Addo *et al.* (2007:1016) concurred and added that urban populations had a consistently higher prevalence of hypertension compared to that of rural areas, implicating differences in lifestyle. Thus, higher levels of obesity and increased salt and fat intake from consuming more processed foods and engaging in jobs with minimal physical activity were the most likely explanations according to Addo *et al.* (2007:1016). On the upside, the African population is prone to have favourable lipid profiles (low serum total cholesterol and high ratio of HDL cholesterol) as well as genetically determined low homocysteine levels that could protect them from ischaemic heart disease (Vorster, 2002:243).

Primary hypertension may also be a cause of long-term activation of the sympathetic nervous system (Björntorp, 2001:73; Van Lill *et al.,* 2011:355; Hamer & Malan, 2010:76 Malan *et al.,* 2012:546). Stress initially activates the HPA axis and the sympathetic nervous system where central obesity and insulin resistance (metabolic syndrome) may be a consequence of HPA axis activation (Björntorp, 2002:83), whilst higher central



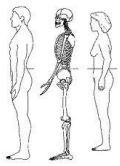
nervous system activity was associated with hypertension (Van Lill, 2011:355; Malan *et al.,* 2012:546).

Yanai *et al.* (2008) proposed visceral obesity, insulin resistance, oxidative stress, endothelial dysfunction, activated renin-angiotensin system, increased inflammatory mediators, and obstructive sleep apnoea to be possible factors to develop hypertension in the metabolic syndrome. These factors may induce sympathetic overactivity, vasoconstriction, increased intravascular fluid, and decreased vasodilatation, leading to development of hypertension in the metabolic syndrome (Yanai *et al.,* 2008).

Risk factors such as cardiovascular disease and co-morbidities such as diabetes, dyslipidaemia, and hypertension have been found to be associated with clearly altered carotid intima-media thickness (CIMT) (Kotliar *et al*., 2008:61). CIMT assessment allows evaluation of structural changes of the vessel in a particular site of interest, the intimal space, where the atherosclerotic process is initiated. In addition, the degree of its alteration increases with the number of coexisting risk factors and the time of exposure, especially in the presence of metabolic syndrome, which includes central obesity (Kotliar *et al.,* 2008:61). Consequently, CIMT is increasingly used for risk stratification in individuals and as an end point in intervention studies (Lorenz *et al.,* 2007:459).

CIMT is measured via the Rudy Meijer protocol, also known as the Meier Carotid Arc, where the arc is designed to assist and guide the sonographer through a single or multi-angle IMT scan protocol of the carotid artery. When used appropriately, this approach will give a set of reproducible CIMT images, over time, from specific segments of the carotid artery (Liang *et al.,* 2000:127., 2000; Meijer, 2008)

The CIMT measurement method, after a long period of refinement, has been tested in numerous population-based studies and several intervention trials. Lorenz *et al.* (2007:459) also confirmed in a meta-analysis that CIMT is a strong predictor of future vascular events. Hence, CIMT measurement is an excellent tool to detect preclinical vascular disease (Kotliar *et al.,* 2008:61).



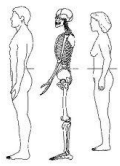
2.5 Psychological distress and perception of health

Mortality rates from cardiovascular disease indicate that stroke may be a feature of urbanization of black South Africans (Vorster, 2002:243, Thorogood *et al.,* 2007:325, Connor *et al.,* 2007:269). African urbanization is associated with inevitable stress, dietary changes, and acculturation (Opie & Seedat, 2005:3565, Malan *et al.,* 2008:323, Rose & Bond, 2008:268; Malan *et al.,* 2010:183, Malan *et al.,* 2012:542).

Few studies found that the more urbanized African communities were, the higher the rate of obesity and the less prudent their diets became (Vorster *et al.,* 2000:511, Puoane, 2002:1038). Urbanization could also, with accompanying insecurities and disruption in African social relationships, contribute to experiencing poorer health or distress (Malan *et al.,* 2006:305). In the second national victims of crime survey in South Africa, Burton *et al.* (2004:46) found that feelings of safety have declined markedly since 1998 – adding to chronic stress and decreased mental health (Clark *et al.,* 2007:22).

The importance of acute mental stress as a trigger for cardiac catastrophes (acute myocardial infarction, sudden death) and of depressive illness as a cause of coronary heart disease, is now firmly established (Brunner *et al.,* 2002:2659; Esler *et al.,* 2008:175). Overgaard *et al.* (2004:1072) found that psychological overload is associated with weight gain. Under stressful circumstances, the hypothalamus secretes corticotrophin-releasing hormone (CRH), which stimulates the release of adrenocorticotropic hormone (ACTH) and subsequently, cortisol (Gudielka *et al.,* 2006). Bjorntorp (2001) revealed that cortisol binds to glucocorticoid receptors, which have a particularly high density in visceral fat depots – especially intra-abdominal fat depots - leading to accumulation of fat in this area. Consequently, the stress of coping with urbanisation may be linked to increased waist circumference and the progression of the metabolic syndrome (Bjorntorp, 2001).

In addition, Rose and Bond (2008:268) found in a younger cohort that both life event stress and perceived stress were consistently associated with substance abuse. Conversely, Rose and Bond (2008:268) revealed that coping ability and mastery offered some protection from substance abuse. Sjögren and Samsonowitz (1985) concur and



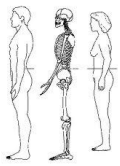
observed that alcohol abuse may be utilized as a coping strategy in the African male. Crutzen *et al.* (2010:44), in contrast, found that stress was not related to alcohol use or alcohol-related problems, and neither did drinking motives moderate the relationship between stress and alcohol use. Psychosocial stress associated with living in urban areas with high income disparity have, however, been associated with greater inter-individual tension and likelihood of inter-personal violence; both associated with increased substance use and misuse (Galea *et al.,* 2005:130).

High scores of psychic and somatic anxiety, tension, irritability and feelings of guilt, as measured by the Karolinska Scales of Personality, were found in women with resolved alcohol use disorders who had received treatment (Ostlund *et al.,* 2007:24). Shapira and Courbasson (2011) also found that depression, anxiety and low self-esteem are frequently associated with substance use disorders.

Hamer *et al.* (2011:237) demonstrated an emerging burden of disease among urban black Africans in South Africa, a phenomenon largely explained by transition from traditional African lifestyles to more westernized behaviour. In comparison with Caucasian counterparts, an excess burden of disease was seen in black Africans demonstrated by increased smoking and alcohol abuse (serum gamma glutamyl transferase) (GGT) (Hamer *et al.,* 2011:237).

Serum GGT has long been used as a conventional biomarker of liver function and a marker of excessive alcohol use (Whitfield, 2007:1, Ozer *et al.,* 2008:197) and is determined by several factors: alcohol intake, body fat content, plasma lipid/lipoproteins, glucose levels, and various medications (Grundy, 2007:4, Whitfield, 2007:1). GGT appears to be largely a reflection of ectopic liver fat or secondary hepatic inflammation (Grundy, 2007:5). Alatalo *et al.* (2008:1097) expand by adding that the effect of moderate alcohol consumption on liver enzymes (including GGT) increases with increasing BMI. Breitling *et al.* (2009:802) also found an interaction between smoking and alcohol consumption as determinants of elevated GGT levels, especially in men.

Another social consequence of living in an urban environment is an assimilation of Western cultural norms regarding body shape, in stark contrast to the traditional African



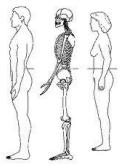
female body shape (Senekal *et al*., 2001). Traditionally, the ideal body image among Africans has always been inclined towards a larger, fuller body shape. Also, in African religious and cultural symbolism, female body fatness is closely linked to fertility (Gordon 2001:9-10). However, a sway from the traditional African perception of body size to westernized ideals have also been reported elsewhere (Senekal *et al*., 2001; Morris, 2008).

Stress experienced during acculturation has been identified as a causative factor for eating disorders, where acculturation is explained as the simultaneous 'push and pull' of opposing pressures to acculturate to a new culture and pressures against this acculturation from the culture of origin (Morris, 2008). Acculturation may consequently be the motivation for the rejection of traditional body size norms and accepting westernized ideals. Acculturative stress due to opposing cultures is manifested in uncertainty, anxiety and depression (Sam & Berry, 2010:473-474), although different individuals of the same culture have different approaches to acculturation.

The African notion of 'community' as embodied in the idea of 'Ubuntu', implies that a person is defined in the context of social bonds and cultural traditions rather than individual traits (Mabovula, 2011:38). Acculturative stress would surely be a factor where the African culture is in direct opposition to the westernized culture of individualism where "thin is in"; consequently emphasizing the uniqueness of the African female and possible psychological distress (Malan *et al.,* 2008:323).

2.6 Conclusion

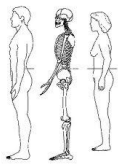
Fezeu *et al.* (2007:70) investigated prevalence of the metabolic syndrome in a sub-Saharan African setting and found that central obesity may be a key determinant. In support of this hypothesis, greater visceral adiposity has been found as an increased risk for hypertension in Japanese Americans (Hayashi *et al.,* 2004:992). Hypertension was also a major risk factor in people of African descent, regardless of country of residence (Agyemang & Bhopal, 2003; Van der Merwe & Pepper, 2006; Du Plessis *et al*., 2010, Hamer & Malan, 2010:76, Malan *et al.,* 2012:543).



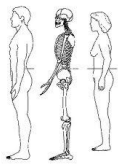
Urbanization and accompanying psychological stress, have also been associated with increased substance use and misuse (Galea *et al*., 2005:130). Of note, is that South Africa has one of the higher levels of consumption of alcohol, about 6 litres of alcohol per person per year, leading to very serious health and social consequences (Saxena, 2011).

Acculturative stress in general has been manifested in uncertainty, anxiety and depression (Sam & Berry, 2010:473-474). Adding the African notion of 'Ubuntu', which is directly opposing the western individualism, acculturative stress would surely lessen the coping ability (Malan *et al.,* 2012:543) and add to the psychological distress (De Kock *et al.,* 2012) of the African people.

In conclusion, African urbanization is associated with inevitable stress and subsequent substance abuse (Opie & Seedat, 2005:3565, Malan *et al.,* 2008:323, Rose & Bond, 2008:268; Malan *et al.,* 2010:183, Hamer *et al.* 2011:237; Malan *et al.,* 2012:542). Björntorp (2001:83) proposed that stress causes central obesity, whilst evidence now indicates that central obesity plays a central role in the development of the metabolic syndrome and appears to precede the appearance of other metabolic syndrome components linked to insulin resistance (Fezeu *et al.,* 2007:70; Cameron *et al.,* 2008:2707; Després *et al.,* 2008:1039). Cardiovascular disease and co-morbidities such as diabetes, dyslipidaemia, and hypertension have been found to be associated with clearly altered carotid intima-media thickness (CIMT) (Kotliar *et al*., 2008:61). As a result, CIMT is increasingly used for risk stratification in individuals and as an end point in intervention studies (Lorenz *et al.,* 2007:459).



The strength of this study lies in the current void in literature where population- and country-specific guidelines for WC have not yet been appropriated for sub-Saharan Africans; also the association between obesity and mental health have not been investigated in the black South African population. Subsequently, the research questions that was aimed to answer by means of this study are: (1) Can new population-specific WC cut off points be established in a cohort of urban African teachers? (2) Which WC cut off point (JSC or new proposed)(NPM) is best associated with structural vascular disease, as indicated by carotid intima-media thickness (CIMT)? and (3) Which of the two WC cut offs will be best associated with perception of own health in this African cohort?



2.7 References

ADDO, J., SMEETH, L. & LEON, D.A. 2007. Hypertension in sub-Saharan Africa: a systematic review. *Hypertension, 50:1012-1018.*

AGYEMANG, C. & BHOPAL, R. 2003. Is the blood pressure of people from African origin adults in the UK higher or lower than that in European origin white people? A review of cross-sectional data. *Journal of Human Hypertension, 17:523-534.*

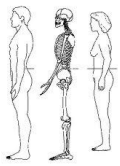
AHIMA, R.S. 2006. Adipose tissue as an endocrine organ. *Obesity, 14(Suppl 5):242S-249S.*

ALATALO, P.I., KOIVISTO, H.M., HIETALA, J.P., PUUKKA, K.S., BLOIGU, R. & NIEMELA, O. 2008. Effect of moderate alcohol consumption on liver enzymes increases with increasing body mass index. *American Journal of Clinical Nutrition, 88:1097-1103.*

ALBERTI, K.G. & ZIMMET, P.Z. 1998. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a who consultation. Diabetes Medicine, 15:539–553.

ALBERTI, K.G.M.M., ECKEL, R.H., GRUNDY, S.M., ZIMMET, P.Z., CLEEMAN, J.I., DONATO, K.A., FRUCHART, J., JAMES, W.P.T., LORIA, C.M. & SMITH, S.C. 2009. Harmonizing the Metabolic Syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Foundation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation, 120:1640-1645.*

AL-LAWATI, J., BARAKAT, N.M., AL-LAWATI, A. & MOHAMMED, A.J. 2008. Optimal cut-points for body mass index, waist circumference and waist-to-hip ration using the Framingham coronary heart disease risk score in an Arab population of the Middle East. *Diabetes and Vascular Disease Research, 5:304-309.*



AL-LAWATI, J.A. & JOUSILHATI, P. 2007. Body mass index, waist circumference and waist-to-hip ratio cut-off points for categorisation of obesity among Omani Arabs. *Public Health Nutrition, 11(1):102-108.*

BALKAU, B. & CHARLES, M.A. 1999. Comment on the provisional report from the WHO consultation. *Diabetic Medicine, 16:442-443.*

BAO, Y., LU, J., WANG, C., LI, H., ZHANG, X., ZHU, J., LU, H., JIA, W. &XIANG, K. 2008. Optimal waist circumference cut-offs for abdominal obesity in Chinese. *Atherosclerosis, 201:378-384.*

BERBER, A., GOMEZ-SANTOS, R., FANGHANEL, G. & SANCHEZ-REYES, L. 2001. Anthropometric indexes in the prediction of type 2 diabetes melltus, hypertension and dyslipidemia in a Mexican population. *International Journal of Obesity, 25:1794-1799.*

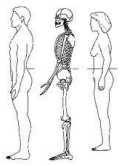
BJORNTORP, P. 2001. Do stress reactions cause abdominal obesity and comorbidities? *Obesity Reviews, 2:73-86.*

BJORNTORP, P. 2002. Hypertension and the metabolic syndrome: closely related central origin? *International Congress Series, 1241:81-86.*

BOUGUERRA, R., ALBERTI, H., SMIDA, H., SALEM, L.B., RAYANA, C.B., EL ATTI, J., ACHOUR, A., GAIGI, S., SLAMA, C.B., ZOUARI, B. & ALBERTI, K.G.M.M. 2007. Waist circumference cut-off points for identification of abdominal obesity among the Tunisian adult population. *Diabetes, Obesity and Metabolism, 9:859-868.*

BREITLING, L.P., RAUM, E., MULLER, H., ROTHENBACHER, D. & BRENNER, H. 2009. Synergism between smoking and alcohol consumption with respect to serum gamma-glutamyltransferase. *Hepatology, 49:802-8.*

BRUNNER, E.J., HEMINGWAY, H., WALKER, B.R., PAGE, M., CLARKE, P., JUNEJA, M., SHIPLEY, M.J., KUMARI, M., ANDREW, R., SECKL, J.R., PAPADOPOULOS, A., CHECKLEY, S., RUMLEY, A., LOWE, G.D.O., STANSFELD, S.A. & MARMOT, M.G. 2002. Adrenocortal, autonomic, and inflammatory causes of the metabolic syndrome: nested case-control study. *Circulation,* 106:2659-2665.



BURTON, P., DU PLESSIS, A., LEGGETT, T., LOUW, A., MISTRY, D. & VAN VUUREN, H. 2004. National victims of crime survey South Africa 2003. http://search.sabinet.co.za/WebZ/images/ejour/ismono/ismono_n101b.pdf:sessionid=0:bad=http://search.sabinet.co.za/ejour/ejour_badsearch.html:portal=ejournal: Date of access: 07 August 2009. 164p.

CAMERON, A.J., BOYKO, E.J., SICREE, R.A., ZIMMET, P.Z., SODERBERG, S., ALBERTI, K.G.G.M., TUOMILEHTO, J., CHITSON, P. & SHAW, J.E. 2008. Central obesity as a precursor to the metabolic syndrome in the AusDiab study and Mauritius. *Obesity (Silver Spring), 16:2707-2716.*

CARADAS, A.A., LAMBERT, E.V. & CHARLTON, K.E. 2001. An ethnic comparison of eating attitudes and associated body image concerns in adolescent South African school girls. *Journal of Human Nutrition and Dietetics, 14920:111-120.*

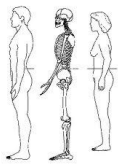
CARROLL, J.F., CHIAPA, A.L., RODRIQUEZ, M., PHELPS, D.R., CARDARELLI, K.M., VISHWANATHA, J.K., BAE, S. & CARDARELLI, R. 2008. Visceral fat, waist circumference and BMI: impact of race/ethnicity. Obesity, 16(3):600-607.

CHAMBERS, J.C., ELLIOTT, P., ZABANEH, D., ZHANG, W., LI, Y., FROGUEL, P., BALDING, D., SCOTT, J. & KOONER, J.S. 2008. Common genetic variation near *MC4R* is associated with waist circumference and insulin resistance. *Nature Genetics, 40:716-718.*

CLARK, C., RYAN, L., KAWACHI, I., CANNER, M.J., BERKMAN, L. & WRIGHT, R.J. Witnessing community violence on residential neighbourhoods: a mental health hazard for urban women. *Journal of urban health: bulletin of the New York academy of medicine,* 85(1):22-38.

CONNOR, M.D., WALKER, R., MODI, G. & WARLOW, C.P. 2007. Burden of stroke in black populations in sub-Saharan Africa. *Lancet Neurology, 6:269-78.*

CRUTZEN, R., KNIBBE, R.A. & MYSYUK, Y. 2010. Unravelling the role of drinking motives in the relationship between stress and alcohol use and its related problems. *Mental Health and Substance Use: dual diagnosis, 3(1):38-46.*



DE KOCK, A., MALAN, L., POTGIETER, J.C., STEENEKAMP, W. & VAN DER MERWE M.T. 2012. Metabolic syndrome indicators and target organ damage in urban active coping African Caucasian men: the SABPA study. *Experimental and Clinical Endocrinology and Diabetes, Jan (Epub ahead of print).*

DENNISON, C.R., PEER, N., STEYN, K., LEVITT, N.S. & HILL, M.N. 2007. Determinants of hypertension care and control among peri-urban Black South Africans: the HiHi study. *Ethnicity & Disease, 17:484–491.*

DU PLESSIS, A., MALAN, L. & MALAN, N.T. 2010. Coping and metabolic syndrome indicators in urban black South African men: the SABPA study. Cardiovascular *Journal of Africa, 21(5):268-273.*

ESLER, M.E., SCHWARZ, R. & ALVARENGA, M. 2008. Mental stress is a cause of cardiovascular diseases: from scepticism to certainty. *Stress and health,* 24:175-180.

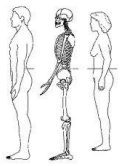
ESTEGHAMATI, A., ASHRAF, H., RASHIDI, A. & MEYSAMIE, A. 2008. Waist circumference cut-points for the diagnosis of metabolic syndrome in Iranian adults. *Diabetes Research and Clinical Practice, 82:104-107.*

EXECUTIVE SUMMARY OF THE THIRD REPORT OF THE NATIONAL CHOLESTEROL EDUCATION PROGRAM (NCEP) EXPERT PANEL on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001; 285:2486–2497.

FABER, M. & KRUGER, H.S. 2005. Dietary intake, perceptions regarding body weight, and attitudes toward weight control of normal weight, overweight, and obese black females in a rural village in South Africa. *Ethnicity & disease,* 15:238-245.

FEZEU, L., BLAKAU, B., KENGNE, A., SOBNGWI, E. & MBANYA, J. 2007. Metabolic syndrome in a sub-Saharan African setting: central obesity may be the key determinant. *Atherosclerosis, 193(1):70-76.*

FOUCAN, L., HANLEY, J., DELOUMEAUX, J. & SUISSA, S. 2002. Body mass index (BMI) and waist circumference (WC) as screening tools for cardiovascular risk factors in Guadeloupean women. *Journal of Clinical Epidemiology, 55:990-996.*



GALEA, S., RUDENSTINE, S. & VLAHOV, D. 2005. Drug use, misuse, and the urban environment. *Drug and Alcohol Review, 24:127-136.*

GOLDBERG, D.P. & HILLIER, V.F. 1979. A scaled version of the General Health Questionnaire. *Psychological Medicine, 9(1):139-145.*

GORDON, R.A. 2001. Eating disorders East and West: a culture-bound syndrome unbound. (*In* Nasser, M., Katzman, M.A. & Gordon, R.A., *eds*. Eating disorders and cultures in transition. New York: Brunner Routledge. p. 1-23.)

GRUNDY, S.M. 2007. Gamma-glutamyl transferase, another biomarker for metabolic syndrome and cardiovascular risk. *Arteriosclerosis, Thrombosis and Vascular Biology, 27:4-7.*

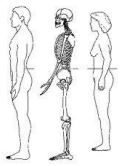
HADAEGH, F., ZABETIAN, A., SARBAKHSH, P., KHALILI, D., JAMES, W.P.T. & AZIZI, F. 2009. Appropriate cutoff values of anthropometric variables to predict cardiovascular outcomes: 7.5 years follow-up in an Iranian population. *International Journal of Obesity, 33:1437-1445.*

HAMER, M., MALAN, L., SCHUTTE, A.E., HUISMAN, H.W., VAN ROOYEN, J.M., SCHUTTE, R., FOURIE, C.M.T., MALAN, N.T. & SEEDAT, Y.K. 2011. Conventional and behavioral risk factors explain differences in sub-clinical vascular disease between black and Caucasian South Africans: The SABPA study. *Atherosclerosis, 215:237-242.*

HAMER, M. & MALAN, L. 2010. Psychophysiological risk markers of cardiovascular disease. Neuroscience and Biobehavioral Reviews, 35:76-83.

HARA, K., MATSUSHITA, Y., HORIKOSHI, M., YOSHIIKE, N., YOKOYAMA, T., TANAKA, H. & KADOWAKI, T. 2006. A proposal for the cutoff point of waist circumference for the diagnosis of metabolic syndrome in the Japanese population. *Diabetes Care, 29(5):1123-1124.*

HAYASHI, Y., BOYKO, E.J., LEONETTI, L., MCNEELY, M.J., NEWELL-MORRIS, L., KAHN, S.E. & FUJIMOTO, W.Y. 2004. Visceral adiposity is an independant predictor of



incident hypertension in Japanese Americans. *Annals of Internal Medicine, 140:992-1000.*

HAYASHI, T., BOYKO, E.J., MCNEELY, M.J., LEONETTI, D.L., KAHN, S.E. & FUJIMOTO, W.Y. 2007. Minimum waist and visceral fat values for identifying Japanese Americans at risk for the metabolic syndrome. *Diabetes Care, 30(1):120-127.*

JOFFE,B.I., PANZ, V.R., WING, J.R., RAAL, F.J. & SEFTEL,H.C. 1992. Pathogenesis of non-insulin-dependent diabetes mellitus in the black population of southern Africa. *The Lancet, 340(8817):460–462.*

KIM, H., KIM, C., PARK, J. & LEE, K. 2009. Lower waist-circumference cutoff point for the assessment of cardiometabolic risk in Koreans. *Diabetes Research and Clinical Practice, 85:35-39.*

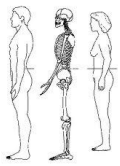
KOTLIAR, C., FORCADA, P. & FERDINAND, K.C. 2008. Noninvasive Diagnosis of subclinical atherosclerosis in cardiometabolic syndrome: a call to action. Journal of CardioMetabolic Syndrome, 60-62.

KRUGER, H.S., PUOANE, T., SENEKAL, M. & VAN DER MERWE, M-T. 2005. Obesity in South Africa: challenges for government and health professionals. *Public health nutrition,* 8(5):491-500.

KUMAR, B.N., MEYER, H.E., WANDEL, M., DALEN, I. & HOLMBOE-OTTESEN, G. 2008. Ethnic differences in obesity among immigrants from developing countries, in Oslo, Norway. *International Journal of Obesity, 30:684-690.*

LIANG, Q., WENDELHAG, I., WIKSTRAND, J. & GUSTAVSSON, T. 2000. A multiscale dynamic programming procedure for boundary detection in ultrasonic artery images. *IEEE Transactions on Medical Imaging, 19:127-142.*

LIN, W.Y., LEE, L.T., CHEN, C.Y., LO, H., HSIA, H.H., LIU, I.L., LIN, R.S., SHAU, W.Y. & HUANG, K.C. 2002. Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. *International Journal of Obesity, 26:1232-1238.*



LORENZ, M.W., MARKUS, H.S., BOTS, M.L., ROSVALL, M. & SITZER, M. 2007. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. *Circulation, 115:459-467.*

MABOVULA, N.N. 2011. The erosion of African communal values: a reappraisal of the African Ubuntu philosophy. *Inkanyiso: Journal of Humanities and Social Sciences, 3(1):38-47.*

MALAN, L., SCHUTTE, A.E., MALAN, N.T., WISSING, M.P., VORSTER, H.H., STEYN, H.S., VAN ROOYEN, J.M. & HUISMAN, H.W. 2006. Specific coping strategies of African during urbanization: comparing cardiovascular responses and perception of health data. *Biological psychology,* 72:305-310.

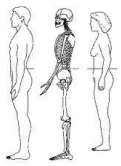
MALAN, L., MALAN, N.T., WISSING, M.P. & SEEDAT, Y.K. 2008. Coping with urbanization: A cardiometabolic risk? The THUSA study. Biological Psychology, 79:323-328.

MALAN, L., MALAN, N.T., DU PLESSIS, A., WISSING, M.P., POTGIETER, J.C. & SEEDAT, Y.K. 2010. The cost of coping: a cardio-neuro-metabolic risk for black South Africans. Cardiovascular Journal of Africa, 21(4):183-185.

MALAN, L., HAMER, M., SCHLAICH, M.P., LAMBERT, G.W., HARVEY, B.H., REIMANN, M., ZIEMSSEN, T., DE GEUS, E.J.C.N., HUISMAN, H.W., VAN ROOYEN, J.M., SCHUTTE, R., SCHUTTE, A.E., FOURIE, C.M.T., SEEDAT, Y.K. & MALAN, N.T. 2012. Facilitated defensive coping, silent iscaemia and ECG left-ventricular hypertrophy: the SABPA study. *Journal of Hypertension, 30:543-550.*

MANSOUR, A.A., AL-HASSAN, A.A., & AL-JAZAIRI, M.I. 2007. Cut-off values for waist circumference in rural Iraqi adults for the diagnosis of metabolic syndrome. *Rural and Remote Health, 7(765):1-6.*

MATOBA, Y., INOGUCHI, T., NASU, S., SUZUKI, S., YANASE, T., NAWATA, H. & TAKAYANAGI, R. 2008. Optimal cut points of waist circumference for the clinical diagnosis of metabolic syndrome in the Japanese population. *Diabetes Care, 31(3):590-592.*



MEIJER, R. 2008. http://www.meijermedicalultrasound.com/media/doc/MMU%20%20ARC%20instructions%202010.pdf Last visited on 21 March 2012

MIRMIRAN, P., ESMAILLZADEH, A. & AZIZI, F. 2004. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. *European Journal of Clinical Nutrition, 58:1110-1118.*

MISRA, A., WASIR, J.S. & VIKRAM, N.K. 2005. Waist circumference criteria for the diagnosis of abdominal obesity are not applicable uniformly to all populations and ethnic groups. *Nutrition, 21:969-976.*

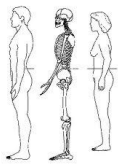
MORRIS, P.F. 2008. Acculturative stress and eating disorders in black adolescent females in KwaZulu-Natal, South Africa. Johannesburg: WITS. (Dissertation - Ph.D.) 285 p.

NEUFELD, L.M., JONES-SMITH, J.C., GARCIA, R. FERNALD, L.C.H. 2007. Anthropometric predictors for the risk of chronic disease in non-diabetic, non-hypertensive young Mexican women. *Public Health Nutrition, 11(2):159-167.*

NINDL, B.C., SCOVILLE, C.R., SHEEHAN, K.M., LEONE, C.D. & MELLO, R.P. 2002. Gender differences in regional body composition and somatotropic influences of IGF-I and leptin. *Journal of Applied Physiology, 92:1611-1618.*

OGAWA, D., KAHARA, K., SHIGEMATSU, T., FUJI, S., HAYAKAWA, N., OKAZAKI, M. MAKINO, H. 2010. Optimal cut-off point of waist circumference for the diagnosis of metabolic syndrome in Japanese subjects. *Journal of Diabetes Investigation, 1(3):117-120.*

OKA, R., KOBAYASHI, J., YAGI, K., TANII, H., MIYAMOTO, S., ASANO, A., HAGASHITA, T., MORI, M., MORIUCHI, T., KOBAYASHI, M., KATSUDA, S., KAWASHIRI, M., NOHARA, A., TAKEDA, Y., MABUCHI, H. & YAMAGISHI, M. 2007. Reassessment of the cutoff values of waist circumference and visceral fat area for identifying Japanese subjects at risk for the metabolic syndrome. *Diabetes Research and Clinical Practice, 79:474-481.*



OKUSUN, I.S. (a), ROTIMI, C.N., FORRESTER, T.E., FRASER, H., OSOTIMEHIN, B., MUNA, W.F. & COOPER, R.S. 2000. Predictive value of abdominal obesity cut-off points for hypertension in Blacks from West African and Caribbean island nations. *International Journal of Obesity, 24:180-186.*

OKUSUN, I.S.(b), TEDDERS, S.H., CHOI, S. & DEVER, G.E.A. 2000. Abdominal obesity values associated with established body mass indexes in white, black and hispanic Americans. A study from the Third National Health and Nutrition Examination Survey. *International Journal of Obesity, 24:1279-1285.*

OPIE, L.H. & SEEDAT, Y.K. 2005. Hypertension in Sub-Saharan African populations. *Circulation, 112:3562-3568.*

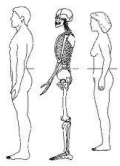
OSTLUND, A., HENSING, G., JAKOBSSON, A., SUNDH, V. & SPAK, F. 2007. A cross-sectional study of personality traits in women previously treated or untreated for alcohol use disorders. Substance Abuse Treatment, Prevention, and Policy, 2:24.

OVERGAARD, D., GAMBORG, M., GYNTELBERG, F. & HEITMANN, B.L. 2004. Psychological workload is associated with weight gain between 1993 and 1999: analyses based on the Danish Nurse Cohort Study. *International journal of obesity,* 28:7072-1081.

OZER, J., RATNER, M., SHAW, M., BAILEY, W. & SCHOMAKER, S. 2008. The current state of serum biomarkers of hepatotoxicity. *Toxicology, 245:194-205.*

PARK, Y., KWON, H., LIM, S.Y., LEE, J., YOON, K., SON, H., YIM, H.W. & LEE, W. 2010. Optimal waist circumference cutoff value reflecting insulin resistance as a diagnostic criterion of metabolic syndrome in a nondiabetic Korean population aged 40 years and over: The Chungju Metabolic Disease Cohort (CMC) Study. *Yonsei Medical Journal, 51(4):511-518.*

PRINSLOO, J., MALAN, L., DE RIDDER, J.H., POTGIETER, J.C. & STEYN, H.S. 2011. Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study. *Experimental and Clinical Endocrinology and Diabetes, 119:599-603.*



PUOANE, T., STEYN, K., BRADSHAW, D., LAUBSCHER, R., FOURIE, J., LAMBERT, V. & MBANANGA, N. 2002. Obesity in South Africa: the South African demographic and health survey. *Obesity research, 10(10):1038-1048.*

PUOANE, T., FOURIE, J.M., SHAPIRO, M., ROSLING, L., TSHAKA, N.C. & OELOFSE, A. 2005a 'Big is beautiful' – an exploration of urban black women in South Africa. *South African journal of clinical nutrition,* 18(1):6-15.

PUOANE, T., BRADLEY, H. & HUGHES, G.D. 2005b. Obesity among black South African women. *Human ecology special issue*, (13):91-95.

RAO, S.V., DONAHUE, M., PI-SUNYER, F.X. & FUSTER, V. 2001. Results of expert meetings: obesity and cardiovascular disease:obesity as a risk factor in coronary artery disease. *American heart journal,* 142:1102-1107.

REDON, J., CIFKOVA, R., LAURENT, S., NILSSON, P., NARKIEWICZ, ERDINE, S. & MANCIA, G. 2009. The metabolic syndrome in hypertension: European society of hypertension position statement. *Journal of Hypertension, 26:1891-1900.*

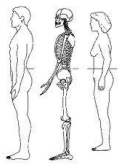
ROSE, D.N. & BOND, M, J. 2008. Identity, stress and substance abuse among young adults. *Journal of Substance Use, 13(4):268-282.*

SAM, D.L. & BERRY, J.W. 2010. Acculturation: when individuals and groups of different cultural backgrounds meet. Association for Psychological Science, 5(4):472-481.

SAXENA, S. 2011. Worldwide alcohol trends. Last visited 16 January 2012. http://www.who.int/mediacentre/multimedia/podcasts/2011/alcohol_20110315/en/

SCHUTTE, A.E., SCHUTTE, R., HUISMAN, H.W., VAN ROOYEN, J.M., MALAN, L., OLCKERS, A. & MALAN, N.T. 2009. Classifying Africans with the Metabolic Syndrome. *Hormone & Metabolic Research, 41:79-85.*

SCHUTTE, A.E. & OLCKERS, A. 2007. Metabolic syndrome risk in black South African women compared to Caucasian women. Hormone and Metabolic Research, 39:651-657.



SEEDAT, Y.K. 2009. Perspectives on research in hypertension. *Cardiovascular Journal of Africa, 20(1):39-42.*

SENEKAL, M., STEYN, N.P., MASHEGO, T.B. & NEL, J.H. 2001. Evaluation of body shape, eating disorders and weight management related parameters in black female students of rural and urban origins. *South African Journal of Psychology, 31(1):45-54.*

SHAPIRA, L.B. & COURBASSON, C.M. 2011. Depression and anxiety: predictors of eating disorder symptoms and substance addiction severity. *Mental Health and Substance Use, 4(3):222-238.*

SHIWAKU, K., ANUURAD, E., ENKHMAA, B., NOGI, A., KITAJIMA, K., YAMASAKI, M., YONEYAMA, T., OYUNSUREN, T. & YAMANE, Y. 2005. Predictive values of anthropometric measurements for multiple metabolic disorders in Asian populations. *Diabetes Research and Clinical Practice, 69:52-62.*

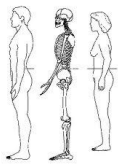
SJÖGREN, L. & SAMSONOWITZ, V. 1985. Coping strategies and relapse in alcohol abuse. *Drug and Alcohol Dependence, 15:283-301.*

SLIWA, K., WILKINSON, D., HANSEN, C., NTYINTYANE, L., TIBAZARWA, K., BECKER, A. & STEWART, S. 2008. Spectrum of heart disease and risk factors in a black urban population in South Africa (the Heart of Soweto Study): a cohort study. *The Lancet, 371:915–922.*

SUMNER, A.E., SEN, S., RICKS, M., FREMPONG, B.A., SEBRING, N.G. & KUSHNER, H. 2008. Determining the waist circumference in African Americans which best predicts insulin resistance. *Obesity, 16:841-846.*

SZABO, C.P. & LE GRANGE, D. 2001. Eating disorders and the politics of identity. In Nasser, M., Katzman, M.A. & Gordon, R.A., eds. Eating disorders and cultures in transition. Brunner Routledge, New York, 24-39.

THOROGOOD, M., CONNOR, M., TOLLMAN, S., LEWANDO, H.G., FOWKES, G. & MARSH, J. 2007. A cross-sectional study of vascular risk factors in a rural South African population: data from the Southern African Stroke Prevention Initiative (SASPI), *BMC Public Health 7:326.*



VAN DER MERWE, M. 2007. Psychological correlates of obesity in women. *International Journal of Obesity, 31:S14-S18.*

VAN DER MERWE, M. & PEPPER, M.S. 2006. National prevalence of obesity: obesity in South Africa. *Obesity Reviews, 7:315-322.*

VAN LILL, L., MALAN, L., VAN ROOYEN, J., STEYN, F., REIMANN, M. & ZIEMSSEN, T. 2011. Baroreceptor sensitivity, cardiovascular responses and ECG left ventricular hypertrophy in men: the SABPA study. *Blood pressure, 20(6):355-61.*

VAN ROOYEN, J.M., KRUGER, H.S., HUISMAN, H.W., WISSING, M.P., MARGETTS, B.M., VENTER, C.S. & VORSTER, H.H. 2000. An epidemiological study of hypertension and its determinants in a population in transition: the THUSA study. *Journal of Human Hypertension, 14:779–787.*

VEGA, G.L. 2001. Results of expert meetings: obesity and cardiovascular disease: obesity, the metabolic syndrome, and cardiovascular disease. *American heart journal,* 142:1108-1116.

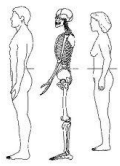
VORSTER, H.H., WISSING, M.P., VENTER, C.S., KRUGER, H.S., MALAN, N.T., DE RIDDER, J.H., VELDMAN, F.J., STEYN, H.S., MARGETTS, B.M. & MACINTYRE, U. 2000. The impact of urbanization on physical, physiological and mental health of Africans in the North West Province of South Africa: the THUSA study. *South African journal of science,* 95:505-513.

VORSTER, H.H. 2002. The emergence of cardiovascular disease during urbanisation of Africans. *Public Health Nutrition, 5(1A):239-243.*

WAGNER, D.R. & HEYWARD, V.H. 2000. Measures of body composition in blacks and whites: a comparative review. *American Journal of Clinical Nutrition, 71:1392-402.*

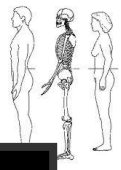
WANG, Z. & HOY, W.E. 2004. Body size measurements as predictors of type 2 diabetes in Aboriginal people. *International Journal of Obesity, 28:1580-1584.*

WHITFIELD, J.B. 2007. Serum y-Glutamyltransferase and risk of disease. *Clinical Chemistry, 53(1):1-2*.



YANAI, H., TOMONO, Y., ITO, K., FURUTANI, N., YOSHIDA, H. & TADA, N. 2008. The underlying mechanisms for development of hypertension in the metabolic syndrome. *Nutrition Journal, 7:10.*

YE, Y., BAO, Y., HOU, X., PAN, X., WU, H., LI, H., WANG, C., TNAG, J., LU, H., XIANG, K. & JIA, W. 2009. Identification of waist circumference cutoffs for abdominal obesity in the Chinese population: a 7.8 year follow-up study in the Shanghai urban area. *International Journal of Obesity, 33:1058-1062.*



Chapter 3

Determining the Waist Circumference Cut off which Best Predicts the Metabolic Syndrome Components in Urban Africans: The SABPA Study

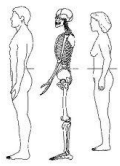
J. Prinsloo, L. Malan, J.H. de Ridder, J. Potgieter and H.S. Steyn

Experimental and Clinical Endocrinology and Diabetes, 199:599-603.

Abstract:

Various studies have shown that the relationship between waist circumference (WC) and abdominal obesity is age, gender as well as ethnicity dependent. WC criteria for Sub Saharan Africans have not been defined by the International Diabetes Federation (IDF). The aim was to determine which WC cut off best predicted Metabolic Syndrome (MetS) in a group of urban African teachers (80 males and 93 females). We determined sphygmomanometer blood pressure, WC, glucose, high density lipoprotein cholesterol (HDL) and triglyceride (TRIG) values. The males′ MetS profile was less favourable as their glucose, TRIG and blood pressure levels were higher than the proposed cut off for MetS. The females could be classified as obese, based on their mean BMI (32.78 ± 6.36) and WC (93.48 ± 15.68). Receiver operating characteristic (ROC) WC cut off points of 90, 91, 94 and 96 cm for the respective MetS components in males (blood pressure, HDL, glucose and TRIG) were suggested. In the females, cut off points of 92, 98, 94 and 94 cm for TRIG, blood pressure, HDL and glucose respectively, were put forward. Odds ratios revealed that increased blood pressure best predicted ROC WC in both males (OR 9.59; 95 % CI 3.14–29.32) and females (OR 3.11; 95 % CI 1.30–7.42) irrespective of age. We suggest that the optimal cut off point for the males be set at 90 cm, as opposed to the current 94 cm; whilst the female cut off be set at 98 cm as opposed to the existing cut off of 80 cm. Larger sample groups are recommended to justify our data.

Keywords: [metabolic syndrome; central obesity; Setswana; black Africans; ROC]



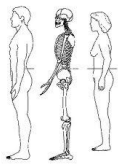
Introduction

Body fat distribution is an important risk factor for obesity-related diseases and Zhang et al. (2008) observed that anthropometric measures of abdominal adiposity were strongly and positively associated with all-cause, cardiovascular disease (CVD), and cancer mortality independently of body mass index (BMI).

A cluster of risk factors for CVD and type 2 diabetes have become known as the metabolic syndrome (MetS) (Alberti et al., 2009). The 2009 Joint Statement Consensus (JSC) risk factors include raised blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg), raised triglycerides (Trig)(≥ 1.7 mmol/L) and lowered high-density lipoprotein cholesterol (HDL)(< 1.03 mmol/L in males and < 1.29 mmol/L in females), raised fasting glucose (≥ 5.6 mmol/L), and central obesity (Alberti et al., 2009). Alberti et al. (2009) decided that a single set of cut points would be used for all components except waist circumference, for which further work is required. Population-specific and country-specific definitions for waist circumference (WC) are recommended, although the International Diabetes Federation (IDF) cut points are to be used for non-Europeans until more data are available (Alberti et al., 2009). Several studies have proposed new population-specific cut points (Okusun et al., 2000; Berber et al., 2001; Sumner et al., 2008).

Conversely, evidence now indicates that central obesity plays a central role in the development of the MetS and appears to precede the appearance of other metabolic syndrome components linked to insulin resistance (Cameron et al., 2008; Després et al., 2008.

However, various studies have shown that the relationship of WC to abdominal obesity is age-, gender, as well as ethnicity-dependent (Han et al., 1997; Després et al., 2000; Misra et al., 2005). Due to a distinct lack of information for Sub-Saharan Africans we aimed to investigate new population specific WC cut off points best correlating with different MetS components in a cohort of urban African teachers.



Materials and Methods

Our sub-study formed part of the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study. The study was a multidisciplinary target-population study, conducted from February to May 2008 avoiding seasonal changes. Permission to participate was granted by the North-West Department of Education and the South African Teachers Union, as well as the Ethics Committee of the North-West University (project nr: NWU-00036-07S6). The study conformed to the ethical guidelines of the World Medical Association Declaration of Helsinki (revised 2004).

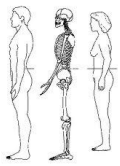
Study population

Urban black African (hereafter referred to as African) teachers, (101 males and 99 females, aged 25-65 years) were recruited and included as participants from schools in the Dr. Kenneth Kaunda District in North-West Province.

Exclusion criteria for this study included ear temperature >37°C, alpha- or beta blockers usage, donated blood or vaccinated in the previous 3 months. We also excluded users of diabetic (N=7) and anti-depressant medication (N=1) as well as HIV positive status (N=19) participants in our sub-study.

Experimental procedure

Each morning of the working week the ambulatory blood pressure (Cardiotens®, Meditech, Budapest, Hungary) as well as Actical® accelerometers (Montréal, Québec) apparatuses were fitted to four participants. Suitable blood pressure (BP) cuff sizes were fastened to each subjects' non-dominant arm. The procedure was explained to the participants in order to obtain successful inflation rates. The Cardiotens® apparatus is validated by the British Hypertension Society (BHS) and measures ambulatory BP oscillometrically at intervals of 30 minutes during the day and every 60 minutes at night (Kohara et al., 1995). The Cardiotens® and Actical® software programmes were activated and participants resumed their daily activities. The participants also received an ambulatory diary card in which they reported any symptoms that may have occurred during the measuring period such as dizziness, fatigue, light physical activity, visual disturbances and stress.



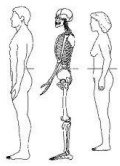
At 16:30 they were transported to the Metabolic Unit Research Facility of the North-West University for an overnight stay, where participants were welcomed and introduced to the experimental setup to lessen anticipation for the stress test. At 18:00 they received a standardized dinner. Last beverages were given at 20:30.

After an overnight fast and the last blood pressure reading at 06:00, the Cardiotens® and Actical apparatuses were disconnected. The ambulatory BP data were downloaded and analysed with the Cardiovisions 1.15 software program (Meditech, Budapest, Hungary). The anthropometric measurements were taken in triplicate by qualified anthropometrists according to International Society for the Advancement of Kinanthropometry (ISAK) standards (Marfell-Jones et al., 2006). Participants rested for 5 minutes in a semi-recumbent position before the first measurement was taken. BP was measured with a sphygmomanometer using the Riva-Rocci/Korotkoff method on the non-dominant arm. Two duplicate measures were taken with a 3 minute resting period between each measurement and the last measurement was used for the non-parametric receiver operating characteristic (ROC) curve (Zweig and Campbell, 1993). Fasting blood samples (70 ml) were obtained by a registered nurse.

Assessment of anthropometric and biological variables

All anthropometric measurements were performed by ISAK level 2 accredited anthropometrists, with subjects in minimal clothing and without shoes. The waist circumference was taken in triplicate at the end of normal expiration at the narrowest point of the abdomen between the lower costal (10^{th} rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk (Marfell-Jones et al., 2006). The subject assumed a relaxed standing position with the arms folded across the thorax (Marfell-Jones et al., 2006).

BMI (kg/m^2) was calculated. The body weight measured by a KRUPS scale with the participant wearing minimal clothes and with the weight evenly distributed, to the nearest 0.1 kg (Marfell-Jones et al., 2006). Height was measured with a stadiometer to the nearest 0.1cm while the participant's head was in the Frankfort plane, the heels together and the buttocks and upper back touching the stadiometer (Marfell-Jones et al., 2006).



Fasting blood samples were obtained with a winged infusion set from the brachial vein branches from the right arm by a registered nurse. Serum glucose, HDL and Trig were handled according to standardised procedures and stored at -80^{o}C. Analyses were done with the Konelab^{TM} 20i sequential multiple analyser computer (SMAC) (Thermo Scientific, Vantaa, Finland) and Unicel DXC 800 (Beckman and Coulter, Germany) at accredited independent laboratories.

Statistical analyses

Data analyses were performed with SPSS, v17 for Windows. Firstly, gender-specific descriptive statistics (including mean and standard deviation) were done for the Africans. Thereafter, a non-parametric receiver operating characteristic (ROC) curve (Zweig and Campbell, 1993), was computed together with the area under this curve (AUC) to explore the association between waist circumference and the different MetS components using different cut off points. Sensitivity and specificity values were computed to determine the cut off point that would maximize the sum of the number of true positive and true negative predictions. Subjects were grouped according to their suggested cut off points for all MetS components (glucose, HDL, triglycerides and blood pressure). Sensitivity and specificity values and also odds ratios (OR's) with 95% Confidence Intervals (CI's) were calculated to highlight the odds of each component predicting pathological waist circumference.

Sensitivity analyses

Sensitivity analyses, addressing age as a known important covariate for WC and BP (Alberti et al., 2009), was calculated and tested whether age influences the discriminatory power of the ROC WC cut off point (Faraggi, 2003).

Results

Initially, gender-specific descriptive analyses were done for the Africans (including mean and standard deviation) (**Table 1**). The mean ambulatory blood pressure successful inflation rate for males in the 22-23h period was 82.75 % (± 9.7) and for females 74.59 % (± 14.88). These values are in accordance to the European Hypertension Society required level of > 70% in a 24h period.

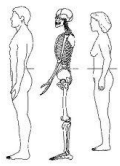
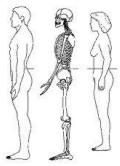


Table 1: Baseline characteristics of African males and females.

	Males (N = 81)	Females (N = 90)
Age, yrs	42.64 ± 8.34	45.32 ± 8.10
Lifestyle and Anthropometric variables		
BMI, kg/m^2	27.67 ± 5.94	32.78 ± 7.29
Physical activity, kcal/h	2723.28 ± 823.31	2665.83 ± 800.83
GGT, U/L	76.28 ± 72.51	48.06 ± 69.75
Cotinine, ng/ml	24.06 ± 47.60	18.06 ± 55.25
Metabolic Syndrome Components		
Glucose, mmol/L	6.01 ± 2.12	5.03 ± 1.10
HDL, mmol/L	1.08 ± 0.38	1.21 ± 0.31
Triglycerides, mmol/L	1.81 ± 1.70	0.99 ± 0.54
Ambulatory SBP, mmHg	138.00 ± 16.91	128.60 ± 15.17
Ambulatory DBP, mmHg	87.94 ± 11.43	78.87 ± 8.98
Sphygmomanometer SBP, mmHg	140 ± 21	130 ± 17
Sphygmomanometer DBP, mmHg	94 ± 15	84 ± 10
Waist circumference, cm	93.49 ± 16.41	93.48 ± 15.68

Table 1 caption:

Values are arithmetic mean ± SD. Where; BMI, body mass index; GGT, Gamma Glutamyl Transferase; HDL, High Density Lipoprotein; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure.



In **Table 1**, the males' MetS profile was less favourable as their glucose levels, Trig, **ambulatory and sphygmomanometer blood pressure** were higher than the proposed cut off for MetS. The females could be classified as obese, based on their mean body mass index (32.78 ± 6.36) and WC (93.48 ± 15.68). Despite their level of obesity, Trig, **ambulatory and sphygmomanometer blood pressure** and plasma glucose were within the normal range. Even though the current WC cut off for females is set at 80cm (Alberti et al., 2009), this apparently healthy group of females had a mean WC of 93cm.

ROC curves were used to determine the suggested cut off value for the WC by using increased glucose, HDL, Trig and hypertension as reference of morbidity in the African male (**Figure 1**) and female (**Figure 2**) group. The respective ROC cut off values, yielding maximum sensitivity and specificity ranged between 90 - 96cm in males and between 92 - 98 cm in females.

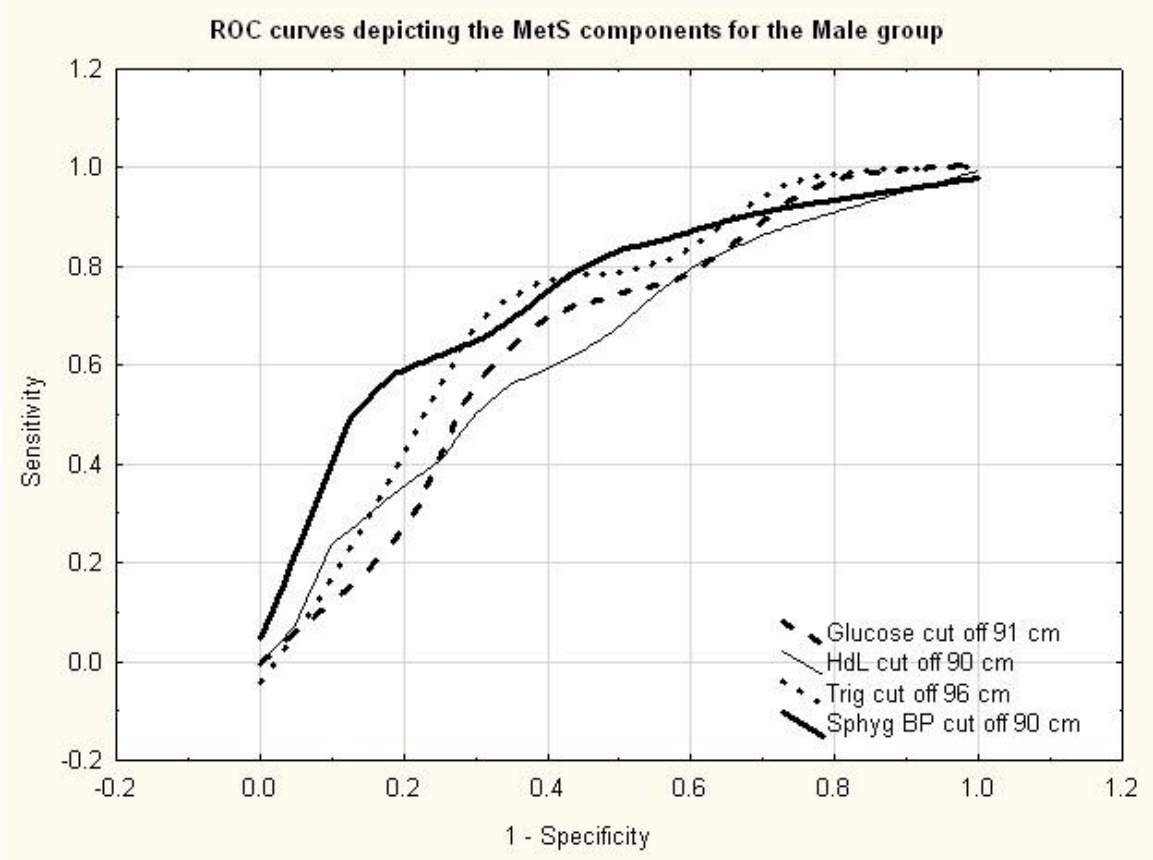
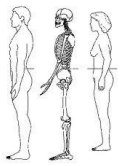


Figure 1: ROC curves depicting the MetS components for the Male group: Glucose, HDL, Trig and BP in predicting pathological WC. The area under the curve (AUC)



(95%CI) was 0.66 (0.54; 0.78) for Glucose, 0.64 (0.50; 0.78) for HDL, 0.71 (0.60; 0.83) for Trig and 0.75(0.62; 0.88) for Sphyg BP.

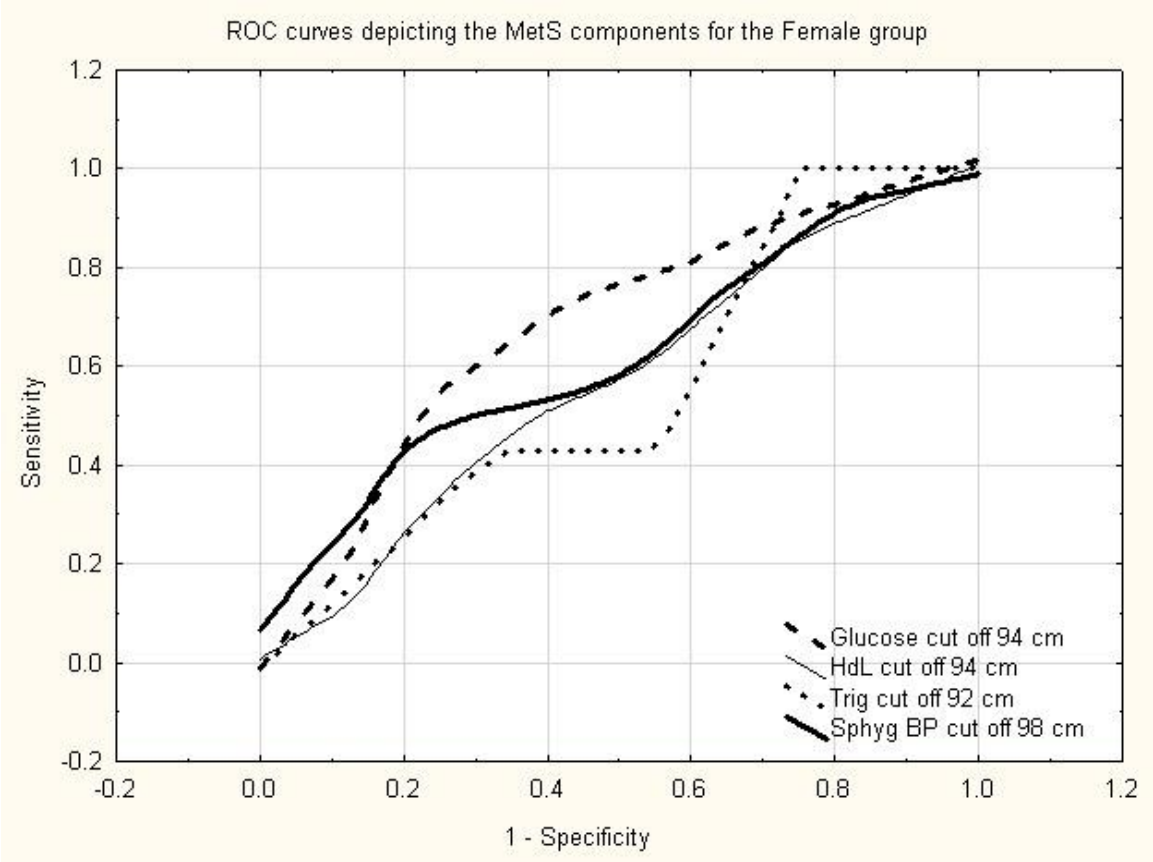
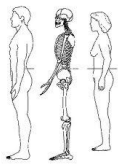


Figure 2: ROC curves depicting the MetS components for the Female group: Glucose, HDL, Trig and BP. The area under the curve (AUC) (95%CI)was 0.68 (0.53; 0.83) for Glucose, 0.57 (0.44; 0.70) for HDL, 0.55 (0.35; 0.75) for Trig and 0.62 (0.51; 0.74) for Sphyg BP.

Odds ratios were calculated in **Table 2** in order to obtain the best MetS predictor for pathological WC. It was found that increased blood pressure best predicted WC pathology (OR of 9.50 with 95% CI 3.14 to 29.32) according to the suggested ROC cut off. This means that the odds of the high WC group to the low WC group within the high blood pressure group is 9.5 times larger than that obtained in the low blood pressure group, but can be as low as 3.23 and as high as 29.32 with high probability. Glucose (OR of 3.23 with 95% CI 1.27 to 8.24) and Trig (OR of 4.41 with 95% CI of 1.68 to 11.92) predicted pathological WC in males. In females, only increased blood pressure had a



higher odds of 3.11 (95% CI 1.30 to 7.42) predicting WC pathology. Sensitivity analyses demonstrated weak associations between age and WC for the ROC BP cut off points in all gender groups.

Table 2: Odds ratios with WC ROC cut off as dependent variable for each of the Metabolic Syndrome components.

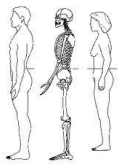
	Waist circumference					
	Males (N = 81)			Females (N = 90)		
	OR	± 95 CI	p	OR	± 95 CI	p
Glucose	3.23	1.27; 8.24	0.01	2.80	0.84; 9.39	0.10
HDL	1.70	0.64; 4.87	0.28	1.61	0.66; 3.93	0.30
Triglycerides	4.41	1.68; 11.92	0.00	0.63	0.13; 3.00	0.56
Sphygmomanometer BP	9.50	3.14; 29.32	0.00	3.11	1.30; 7.42	0.01

Table 2 caption:

Data presented as odds ratio (OR) with 95% Confidence Interval and p-values for significance of OR. Where; HDL, High Density Lipoprotein.

Discussion

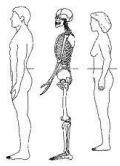
The aim of this study was to determine a WC cut off point which will best predict the MetS components in a cohort of urban African male and females. We have demonstrated that the suggested ROC WC cut off for the particular MetS components (blood pressure, HDL, glucose and Trig) in males varied between 90-96 cm whereas the females' cut offs varied between 92-98 cm. Currently, we carefully want to suggest a cut off for males at 90 cm, and recommend a WC cut off for females at 98 cm. More research however is needed to verify our findings as we obtained data from a small sample group comprising 101 African males and 99 females.



Even though the current WC cut off for females is set at 80 cm (Alberti et al., 2009), this apparently healthy group of females has a mean WC of 93 cm. This might put forward the hypothesis of metabolically healthy obese females as first put forward by Walker et al. (1989). Björntorp (1997) established that centralisation of body fat is associated with the complications of obesity. Central obesity has been identified as the culprit that contributes to the development of glucose intolerance and hyperinsulinaemia in obesity (Després et al., 2001). Van der Merwe and Pepper (2006) found that, when compared to white urban women, matched for BMI and body composition, black women have less central obesity, which may account for the proposed higher WC cut off of 98 cm in this group of females.

The OR's highlighted the raised BP values as the variable with the highest odds of presenting with pathological WC in both the males (9.50 ± 3.14; 29.32) and the females (3.11 ± 1.30; 7.42). Blood pressure is a major risk factor in people of African descent, regardless of country of residence (Cappuccio et al., 1997; Wild and Mckeigue, 1997; Agyemang and Bhopal, 2003). Other South African studies corroborated these findings (Van der Merwe and Pepper, 2006; Vorster, 2002; Du Plessis et al., 2010; Sliwa et al., 2008). Due to the impact of blood pressure on disease risk in this ethnic group, we suggest that the WC cut off be considered to correspond with 90 cm in males and 98 cm in females.

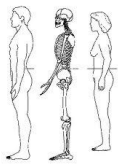
Glucose, Trig and blood pressure levels in the males were all higher than those proposed by the Joint Statement (Alberti et al., 2009). Calculated odds ratio strengthen these findings and glucose (3.23 ± 1.27; 8.24), as well as Trig (4.41 ± 1.68; 11.92) should both support blood pressure as contributors presenting with pathological WC in males. Conversely, raised glucose, Trig and blood pressure, together with substance abuse (both alcohol and smoking), present in the males (Table 1), are major risk factors for cardiovascular disease and stroke (Kannel and Mcgee, 1979; Ezzati et al., 2003; Connor et al., 2005; Kudielka et al., 2006). Duckrow et al. (1987) found that both chronic and acute raised glucose levels, are associated with decreased regional cerebral blood flow and the mechanism for this effect does not appear to adapt to chronic hyperglycemia.



Mostly, stroke incidence in developing countries, such as South Africa, is likely accounted for by the adoption of a more urbanised lifestyle (Vorster et al., 2005; Brainin et al., 2007; Astrup et al., 2008). Coping with a stressful environment revealed increased abdominal obesity, hypertension prevalence, vascular responsiveness and glucose levels in African males (Vorster et al., 2000; Malan et al., 2006; Malan et al., 2008). The burden of chronic stress and accompanying changes in personal behaviours (smoking, over-eating, drinking, disturbed sleeping patterns; otherwise referred to as "lifestyle") have been associated with the concept of allostatic overload (McEwen, 2008). Chronic allostatic load produce a chronic wear and tear on the cardiovascular system that can result, over time, in disorders such as stroke and heart attacks (McEwen, 2008). Under stressful circumstances, the hypothalamus secretes corticotrophin-releasing hormone (CRH), which stimulates the release of adrenocorticotropic hormone (ACTH) and subsequently, cortisol (Gudielka et al., 2006). Bjorntorp (2001) revealed that cortisol binds to glucocorticoid receptors, which have a particularly high density in visceral fat depots – especially intra-abdominal fat depots - leading to accumulation of fat in this area. Consequently, the stress of coping with urbanisation may be linked to increased waist circumference and the progression of the metabolic syndrome (Bjorntorp, 2001).

One limitation of our study was the use of cross-sectional data and therefore causality cannot be inferred. Another limitation was that the study sample was not selected from the whole African population. The participants included Setswana-speaking Africans, only one of the eleven ethnic groups residing in South Africa and it is recommended that the findings be verified in other African communities. Increasing sample sizes will strengthen recommended WC cut off points for age, gender- and ethnicity specific groups.

In conclusion, population-specific and country-specific definitions for waist circumference (WC) are recommended. Currently, it is suggested that the optimal cut off point for the males be set at 90 cm, as opposed to the current 94 cm. In addition, it is proposed that the female cut off be set at 98 cm as opposed to the existing cut off of 80 cm. If taken into account the less favourable MetS profile of the African males and the high OR of



blood pressure, glucose and triglycerides predicting WC, earlier screening could lessen cardiometabolic morbidity and mortality.

Acknowledgements

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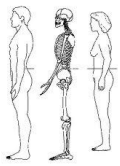
Disclosure

No conflict of interest

Author Contribution

Prof L Malan (principal investigator); Me J Prinsloo, Prof JH de Ridder, HS Steyn and Prof JC Potgieter (staff members) (Potchefstroom). JP planned, analysed the data, wrote and edited the manuscript; LM planned, analysed the data and edited the manuscript; JHdR and JCP edited the manuscript; HSS analysed the data and edited the manuscript.



5. References

Agyemang C, Bhopal R. Is the blood pressure of people from african origin adults in the uk higher or lower than that in european origin white people? A review of cross-sectional data. J Hum Hypertens 2003; 17: 523-534

Alberti KGMM, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, Fruchart J, James PT, Loria CM, Smith SC. Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international arteriosclerosis society; and international association for the study of obesity. Circulation 2009; 120: 1640-1645

Astrup A, Dyerberg J, Selleck M, Stender S. Nutrition transition and its relationship to the development of obesity and related chronic diseases. Obes Rev 2008;9(1):48-52

Berber A, Gomez-Santos R, Fanghanel G, Sanchez-Reyes L. Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidemia in a Mexican population. Int J Obes 2001; 25: 1794-1799

Björntorp P. Do stress reactions cause abdominal obesity and comorbidities? Obesity Rev 2001; 2: 73-86

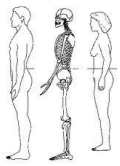
Björntorp P. Obesity. Lancet 1997; 350: 423-426

Brainin M, Teusch, Y, Kalra L. Acute treatment and long-term management of stroke in developing countries. Lancet Neurol 2007; 6: 553-561

Cameron AJ, Boyko EJ, Sicree RA, Zimmet PZ, Soderberg S, Alberti KGGM, Tuomilehto J, Chitson P, Shaw JE. Central obesity as a precursor to the metabolic syndrome in the Ausdiab study and Mauritius. Obesity (Silver Spring) 2008; 16: 2707-2716

Cameron AJ, Sicree RA, Zimmet PZ, Alberti KGMM, Tonkin AM, Balkau B, Tuomilehto J, Chitson P, Shaw JE. Cut-points for waist circumference in Europids and South Asians. Obesity 2009; 455: 1-8

Cappuccio FP, Cook DG, Atkinson RW, Strazullo P. Prevalence, detection and management of cardiovascular risk factors in different ethnic groups in South London. Heart 1997; 78: 555-563



Connor M, Rheeder P, Bryer, A, Meredith M, Beukes M, Dubb A, Fritz V. The South African stroke risk in general practice study. SAMJ 2005; 95: 334-339

Després J, Couillard C, Gagnon J, Bergeron J, Leon AS, Rao DC, Skinner JS, Wilmore JH, Bouchard C. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women: the health, risk factors, exercise training, and genetics (heritage) family study. Arterioscler Thromb Vasc Biol 2000; 20: 1932–1938

Després J, Lemieux I, Bergeron J, Pibarot P, Mathieu P, Larose E, Rodes-Cabau J, Bertrand OF, Poirier P. Abdominal obesity and the metabolic syndrome: contribution to global cardiometabolic risk. Arterioscler Thromb Vasc Biol 2008; 28: 1039-1049

Després J, Lemieux I, Prud'homme D. Treatment of obesity: need to focus on high risk abdominally obese patients. BMJ 2001; 322(7288): 716-720

Du Plessis A, Malan L, Malan NT. Coping and metabolic syndrome indicators in urban black South African men: the SABPA study. Cardiovasc J Afr, 2010; 21(5): 268-273

Duckrow RB, Beard DC, Brennan RW. Regional cerebral blood flow decreases during chronic and acute hyperglycemia. Stroke 1987; 18: 52-58

Ezzati M, Vander Hoorn S, Rodgers A, Mathers CD, Murray CJ. Estimates of global and regional potential health gains from reducing multiple major risk factors. Lancet 2003; 362: 271-280

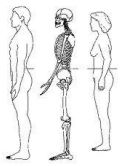
Faraggi D. Adjusting receiver operating curves and related indices for covariates. The Statistician 2003; 52(2): 179-192

Han TS, Mcneill G, Seidell JC, Lean ME. Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. Int J Obes Relat Metab Disord 1997; 21: 587–593

Kannel WB, Mcgee DL Diabetes and cardiovascular risk factors: the Framingham study. Circulation 1979; 59(1): 8-13

Kohara K. Nishida W, Maguchi M, Hiwida K. Autonomic nervous function in non-dipper essential hypertensive participants: evaluation by power spectral analysis of heart rate variability. Hypertension 1995; 26: 808

Kudielka BM, Bellingrath S, Hellhammer DH. Cortisol in burnout and vital exhaustion: an overview. G Ital Med Lav Ergon 2006; 28(1): 34-42



Malan L, Malan NT, Wissing MP, Seedat YK. Coping with urbanization: a cardiometabolic risk? Biol Psychol 2008; 79(3): 323-328

Malan L, Schutte AE, Malan NT, Wissing MP, Vorster HH, Steyn HS, Van Rooyen JM, Huisman HW. Specific coping strategies of Africans during urbanization: comparing cardiovascular responses and perception of health data. Biol Psychol 2006; 72: 305-310

Marfell-Jones M, Olds T, Steward A, Carter JEL. International standards for anthropometric assessment. New Zealand: ISAK 2006: 137

McEwen, BS. Central effects of stress hormones in health and disease: understanding the protective and damaging effects of stress and stress mediators. EurJ Pharmacol 2008; 583: 174-185

Misra A, Wasir JS, Vikram NK. Waist circumference criteria for the diagnosis of abdominal obesity are not applicable uniformly to all populations and ethnic groups. Nutrition 2005; 21: 969-976

Okusun IS, Rotimi CN, Forrester TE, Fraser H, Osotimehin B, Muna WF, Cooper RS. Predictive value of abdominal obesity cut-off points for hypertension in blacks from West African and Caribbean island nations. Int J Obes 2000; 24: 180-186

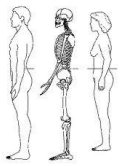
Sliwa K, Wilkinson D, Hansen C, Ntyintyane L, Tibazarwa K, Becker A, Stewart S. Spectrum of heart disease and risk factors in a black urban population in south africa (the heart of soweto study): a cohort study. Lancet 2008; 371: 915-922

Sumner, AE, Sen S, Ricks M, Frempong BA, Sebring NG, Kushner H. Determining the waist circumference in African Americans which best predicts insulin resistance. Obesity 2008; 16: 841-846

Van Der Merwe M, Pepper MS. National prevalence of obesity: obesity in South Africa. Obes Reviews 2006; 7: 315-322

Vorster HH, Venter CS, Wissing MP, Margetts BM. The nutrition and health transition in the north west province of South Africa: a review of the THUSA (Transition and Health during Urbanisation of South Africans) study. Public Health Nutr 2005; 8(5): 480-490

Vorster HH, Wissing MP, Venter CS, Kruger HS, Malan NT, De Ridder JH, Veldman FJ, Steyn HS, Margetts BM, Macintyre U. The impact of urbanization on physical, physiological and mental health of Africans in the north west province of South Africa: the THUSA study. S Afr J Sci 2000; 95: 505-513



Vorster HH. The emergence of cardiovascular disease during urbanisation of africans. Public Health Nutr 2002; 5(1a): 239-243

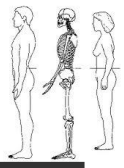
Walker ARP, Walker BF, Walker AJ, Vorster HH. Low frequency of adverse sequelae of obesity in South African rural black women. Int J Vitam Nutr Res 1989; 59: 224–228

Wild SH, Fischbacher C, Brock A, Griffiths C, Bhopal R. Mortality from all causes and circulatory disease by country of birth in England and Whales 2001-2003. J Public Health 2007; 29(2): 191-198

Wild S, Mckeigue P. Mortality by country of birth in England and Whales, 1970-1992. BMJ 1997; 314: 689-762

Zhang C, Rexrode KM, Van Dam RM, Li TY, Hu FB. Abdominal obesity and the risk of all-cause, cardiovascular, and cancer mortality" sixteen years of follow-up in us women. Circulation 2008; 117: 1658-1667

Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clin Chemistry 1993; 39(4): 561-577



Chapter 4

Comparing performances of two central obesity models to predict structural vascular disease by using ROC analyses, Logistic Regression and Neural Networks: the SABPA study.

J. Botha [a], J.H. de Ridder., J.C. Potgieter, H.S. Steyn, L. Malan

Abstract:

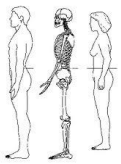
Objectives: A new proposed model (NPM) for waist circumference (WC) cut points, driven by increased blood pressure, was recently demonstrated. This study aimed to demonstrate whether the NPM can be used in an African population by comparing the NPM and the Alberti Joint Statement Consensus (JSC) model via ROC analyses, Logistic Regression (LR) and Neural Networks (NN).

Methods: Urban African gender groups (N=171) were stratified into the JSC model and the NPM. Ultrasound carotid intima media thickness (CIMT), blood pressure (BP) and fasting bloods (glucose, high density lipoprotein (HDL) and triglycerides) were obtained in a well-controlled setting.

Results: The NPM male model predicted structural vascular disease (ROC AUC: 0.65, LR ROC AUC: 0.71, NN ROC AUC: 0.71) equal to the JSC model (0.65, 0.71, 0.69). Similarly, the female JSC model (0.61, 0.82, 0.81) and NPM model (0.62, 0.84, 0.82) equally predicted structural vascular disease. In both the male NPM and the JSC (WC > 90-94 cm) the CIMT's were >1 mm, with BP in the hypertensive range.

Conclusion: The results indicated that overall, validation of the NPM model was comparable with the current JSC model in their prediction of CIMT, an indicator for structural vascular disease.

Keywords: [central obesity; anthropometry; ethnicity; ROC; Logistic Regression; Neural Networks]

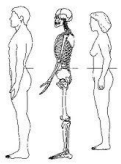


1. Introduction

Obesity affects virtually all organ systems and results in a wide range of metabolic and endocrine abnormalities [1]. Obesity and insulin resistance have been implicated in the pathogenesis of the metabolic syndrome [2]. The metabolic syndrome, according to the 2009 Joint Statement Consensus (JSC) [3], includes several risk factors: raised blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mm Hg), raised triglycerides (Trig)(≥ 1.7 mmol/L) and lowered high-density lipoprotein cholesterol (HDL)(< 1.03 mmol/L in males and < 1.29 mmol/L in females), raised fasting glucose (≥ 5.6 mmol/L), and central obesity [3]. Alberti et al. [3] further determined that a single set of cut points would be used for all components except waist circumference. Population-specific and country-specific definitions for waist circumference (WC) have been recommended, although the International Diabetes Federation (IDF) cut points are to be used for non-Europeans until more data are available [3].

Prinsloo et al. [4] recently suggested a new population-specific cut off for a group of urban African males (≥ 90 cm) and females (≥ 98 cm), namely the new proposed model (NPM). The NPM recommended cut offs, especially those for the females', differed considerably from those proposed by Alberti et al [3] (males ≥ 94 cm; females ≥ 80 cm). Prinsloo et al. [4] further demonstrated that sphygmomanometer blood pressure (BP) was the variable with the highest odds of presenting with pathological WC in black African males and females alike. Kotliar et al. [5] and Redon et al. [2] suggested that hypertension is a systemic, chronic, inflammatory disease which may induce structural and functional vessel impairment with a high risk for subclinical structural vascular disease. Ultrasound carotid intima-media thickness (CIMT) is a non-invasive marker of early structural vascular disease and indicates a profile caused by multiple risk factors over time on arterial walls [6]. Hypertension, impaired fasting glucose, smoking and obesity may be important factors for atherosclerosis [5,7].

The impact of metabolic syndrome on CIMT has not yet been determined. Ethnicity-specific WC cut off points, as part of the metabolic syndrome may impact on CIMT. Therefore we needed to demonstrate whether the NPM can be utilized in an African population through valid computational analyses. The aims were to compare



performances of the two models (JSC and NPM) via receiver operating characteristic (ROC), logistic regression analyses and multilayer perceptron neural networks to predict structural vascular disease. We propose, taking the high prevalence of hypertension among people of African descent into account, and considering that the ethnicity-specific proposed WC (NPM) is based on hypertension, that the NPM will better predict structural vascular disease in this African cohort.

2. Methods

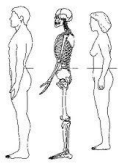
This sub-study formed part of the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA) cohort study, conducted from February to May 2008. Permission to participate was granted by the North-West Department of Education and the South African Teachers Union, as well as the Ethics Committee of the North-West University (project nr: NWU-00036-07S6). The study conformed to the ethical guidelines of the World Medical Association Declaration of Helsinki (revised 2004). All participants signed an informed consent form.

2.1 Study population and sample

Male and female urban black African (hereafter referred to as African) school teachers, (N=*200*, aged 25-65 years) were recruited and included as participants from governmental organizations in the Dr. Kenneth Kaunda District in North-West Province. Exclusion criteria for this study included ear temperature >37.5°C, alpha- or beta blockers usage, donated blood or vaccinated in the previous 3 months. Clinically confirmed diabetics (n=7), use of anti-depressant medication (n=1) and HIV-infected (n=13) participants were also excluded. The final participant sample comprised 171 Africans (n=81 males and females n=90).

2.2 Experimental procedure

On every working day of the week, for the extent of the project, the Actical® physical activity monitors (Minimitter, Quebec, Canada) apparatus were fitted at 07:00, to four



participants for 24 hours. Software programmes were activated and participants resumed their daily activities.

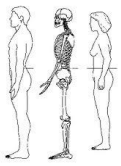
At 16:30 the participants were transported to the Metabolic Unit Research Facility of the North-West University for an overnight stay, where they were welcomed and introduced to the experimental setup. After an overnight fast, the Actical® apparatuses were disconnected at 06:00. Anthropometric measurements were taken in triplicate by anthropometrists according to the standard of the International Society for the Advancement of Kinanthropometry (ISAK) [8].

Two mercury sphygmomanometer blood pressure readings using Korotkoff IV or V for blood pressure (BP) followed while the participants rested for five minutes in a semi-recumbent position, with a three-minute rest between measurements. The second measurement was used for statistical analyses. BP measurements were taken by a medical doctor and registered nurse. Fasting blood samples were obtained by a registered nurse.

2.3 Anthropometric measurements

All anthropometric measurements were performed by ISAK level 2 accredited anthropometrists, with subjects in minimal clothing and without shoes. The waist circumference was taken in triplicate at the end of normal expiration at the narrowest point of the abdomen between the lower costal (10^{th} rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk [8]. The subject assumed a relaxed standing position with the arms folded across the thorax [8].

Body mass index (BMI) was calculated. The body weight measured via a KRUPS scale with the participant wearing minimal clothes and with the weight evenly distributed, to the nearest 0.1 kg [8]. Height was measured with a stadiometer to the nearest 0.1cm while the participant's head was in the Frankfort plane, the heels together and the buttocks and upper back touching the stadiometer [8].



2.4 Biochemical analysis

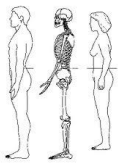
Fasting blood samples were obtained with a winged infusion set from the brachial vein branches from the dominant arm by a registered nurse. Serum gamma glutamyl transferase and cotinine were used as markers of alcohol abuse and smoking-, respectively. Sodium fluoride glucose, serum HDL and triglycerides were handled according to standardized procedures and were stored at -80^{o}C. Analyses were done using the Konelab^{TM} 20i sequential multiple analyzer computer (SMAC) (Thermo Scientific, Vantaa, Finland) and Unicel DXC 800 (Beckman & Coulter, Germany) at accredited laboratories.

2.5 Carotid Intima-media thickness (CIMT)

High resolution ultrasound carotid intima-media scan [9] determined structural vascular disease. CIMT images, from at least two optimum angles of the left and the right common carotid artery segments were acquired using Sonosite Micromaxx ultrasound system (Sonosite Inc., Bothell, WA, USA) and 6-13 MHz linear array transducer, using the Rudy Meijer protocol. The images were digitized and imported into the Artery Measurement Systems (AMS) automated software for dedicated analysis of CIMT. A maximal 10 mm segment with good image quality was chosen for analysis. The program automatically identifies the borders of the CIMT of the near and far wall. Intra-observer variability was 0.04 mm between 2 measurements made four weeks apart on 10 participants. A mean CIMT of >1.0 mm was used as an estimate of high risk.

2.6 Statistical Analyses

Data analyses were performed with Statistica version 10 [10]. In the African cohort, gender-specific descriptive statistics (including mean and standard deviation) were done in both the JSC and NPM models for the at risk (high) and normal (low) groups. Next, each model's high and low WC groups were compared by means of t-tests. Thereafter, a non-parametric receiver operating characteristic (ROC) curve [11], was computed together with the area under this curve (AUC) to explore the association between structural vascular disease, i.e., CIMT and each of the 2 WC models, separate for each

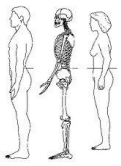


gender group. The ROC analyses were utilized as a sensitivity analysis without confounders.

The area under the ROC curve (AUC) is an overall summary of diagnostic accuracy [12]. It is a measure of the ability to discriminate between CIMT distributions for the normal and at risk groups, using the JSC or NPM WC models. Larger values of AUC indicate a greater discriminatory ability. An AUC value of 0.5 and smaller indicates that a model is unable to distinguish between the two groups, while a value of 1.0 is obtained for complete discrimination, i.e. for perfect accuracy [12].

In ROC analyses, sensitivity is defined as True Positives / [True Positives + False Negatives], ranging from one, when all cases at risk are read as abnormal (no False Negatives), to zero, when all are called normal (no True Positives) [13]. Thus, high sensitivity corresponds to high negative predictive value [14]. Specificity on the other hand, defined as True Negatives / [True Negatives + False Positives] counters by moving from zero (all cases not at risk are normal, no False Positives) to one (all cases at risk are normal, no True Negatives) [13]. High specificity corresponds to high positive predictive value [14].

Logistic Regression (LR) analyses were then performed as it is useful for situations in which you would want to be able to predict the outcome based on values of confounders or independent variables which can be continuous, categorical or both [15]. Hosmer and Lemeshow [16] and Kleinbaum [17] add that LR assumes that measures of dependent variables are independently and randomly sampled and all independent variables in the model are relevant. Categorical CIMT, where mean CIMT ≥1 mm was classified as atherosclerosis and <1 mm as no atherosclerosis, was used in the LR analyses as dependent variable for structural vascular disease [18-19]. For each WC model (JSC and NPM), gender separate, used dichotomized WC, and a priori confounders age, BMI and physical activity were entered as independent variables. The predicted probabilities from these LR models are depicted as ROC curves, with subsequent AUC, sensitivity and -specificity values.



Next, Neural Networks (NN) analyses were performed in order to validate the results obtained with the logistic regression analyses. NN resemble biological neuronal systems and are used to calculate an output variable on the basis of independent input variables [20]. It learns how to transform data into a desired response, so they are widely used for pattern classification. With one or two hidden layers they can approximate virtually any input-output map, with back propagation computing the sensitivity, and update each weight proportional to the sensitivity [15].

Unlike classic statistical linear models and correlative methods, NN consists of multiple indirect interconnections between input and output variables and employ non-linear mathematical equations and statistical techniques to successively minimize the variance between actual and predicted outputs [20]. This eventually yields a model from which the predictions can be entered into ROC analyses in order to obtain AUC values, sensitivity and -specificity.

Data entered into the NN for each WC model (JSC and NPM), gender separate, used dichotomized WC and a priori confounders (age, BMI and physical activity) as independent variables, with the dichotomized CIMT as dependent variable. The data of the confounders were scaled by dividing each value by the group mean and this value was logarithmically transformed. A multilayer perceptron (MLP) model was used.

3. Results

Tables 1 (male) and 2 (female) describes the characteristics for the total African cohort. Lifestyle risk factors, metabolic syndrome components and mean CIMT are included in each model's respective high and low WC groups.

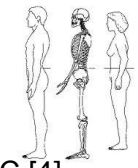


Table 1: Comparing males' high and low JSC [3] WC cut off and the high and low NPM WC [4].

	2009 JSC Males (N=43) < 94 cm	2009 JSC Males (N=38) ≥ 94 cm	NPM Males (N=36) < 90 cm	NPM Males (N=45) ≥ 90 cm
Age (years)	41.37 ± 9.33	44.08 ± 6.90	40.50 ± 9.79	44.36 ± 6.60*
Lifestyle variables				
Physical Activity (kCal)	2350.24 ± 654.08	3145.41 ± 797.02*	2341.32 ± 705.58	3028.85 ± 788.40*
Gamma-glutamyl transferase (μ/L)	66.72 ± 86.10	87.10 ±52.21	71.08 ± 93.41	80.45 ± 50.78
Cotinine, ng/ml	25.42 ± 48.84	22.53 ± 46.76	25.81 ± 46.94	22.67 ± 48.61
Physiological variables				
Body Mass Index (kg/m^2)	23.52 ± 3.15	32.37 ± 4.73*	23.06 ± 3.10	31.36 ± 5.03*
Glucose (mmol/L)	5.48 ± 1.38	6.61 ± 2.61*	5.38 ± 1.24	6.52 ± 2.52*
High Density Lipoprotein (mmol/L)	1.21 ± 0.40	0.94 ± 0.31*	1.22 ± 0.42	0.97 ± 0.32*
Triglycerides (mmol/L)	1.61 ± 2.04	2.03 ± 1.17	1.64 ± 2.20	1.94 ± 1.16
Systolic Blood Pressure (mmHg)	133 ± 18	147 ± 23*	132 ± 16	146 ± 23*
Diastolic Blood Pressure (mmHg)	89 ± 13	99 ± 16*	89 ± 12	97 ± 16*
CIMT mean	0.98 ± 0.17	1.13 ± 0.25*	0.97 ± 0.17	1.11 ± 0.24*

All data indicated as arrhythmetic mean ± standard deviation. Statistically significant difference indicated with *, $p \leq 0.05$

From Table 1 it is evident that for both lifestyle and physiological variables, the male high WC groups in both models demonstrated increased physical activity and CIMT, as well as higher increases in metabolic syndrome components compared to the low WC groups (glucose, high density lipoprotein, blood pressure).

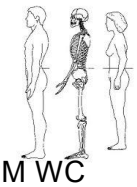


Table 2: Comparing females' high and low JSC [3] WC cut off and the high and low NPM WC [4].

	2009 JSC Females (N=17) < 80 cm	**2009 JSC Females (N=73) ≥ 80 cm**	**NPM Females (N=58) < 98 cm**	**NPM Females (N=32) ≥ 98 cm**
Age (years)	42.77 ± 6.54	45.92 ± 8.35	44.31 ± 7.28	47.16 ± 9.25
Lifestyle variables				
Physical Activity (kCal)	1957.67 ± 383.15	2830.74 ± 783.68*	2325.34 ± 487.42	3282.97 ± 891.26*
Gamma-glutamyl transferase (µ/L)	39.99 ± 44.65	49.71 ± 73.99	39.00 ± 35.02	63.91 ± 105.22
Cotinine, ng/ml	20.31 ± 48.72	17.56 ± 56.90	18.26 ± 61.36	17.68 ± 42.72
Physiological variables				
Body Mass Index (kg/m^2)	25.70 ± 3.50	34.43 ± 6.95*	29.26 ± 4.53	39.16 ± 7.04*
Glucose (mmol/L)	4.26 ± 0.57	5.20 ± 1.12*	4.79 ± 0.67	5.47 ± 1.54*
High Density Lipoprotein (mmol/L)	1.34 ± 0.23	1.12 ± 0.32	1.25 ± 0.30	1.16 ± 0.34
Triglycerides (mmol/L)	0.72 ± 0.26	1.05 ± 0.56*	0.90 ± 0.41	1.16 ± 0.67*
Systolic Blood Pressure (mmHg)	121 ± 11	132 ± 18*	124 ± 14	140 ± 19*
Diastolic Blood Pressure (mmHg)	80 ± 7	85 ± 11	81 ± 9	89 ± 10*
CIMT mean	0.93 ± 0.18	1.01 ± 0.15	0.98 ± 0.16	1.04 ± 0.15

All data indicated as arrhythmetic mean ± standard deviation. Statistically significant difference indicated with *, $p \leq 0.05$

Table 2 illustrates that, even though the two cut offs differ widely, each female model's high WC groups demonstrated higher physical activity and CIMT, and increased metabolic syndrome components compared to the low WC groups (glucose, triglycerides, blood pressure). The NPM distinguishes better between non-pathological and pathological diastolic blood pressure measurements than the JSC model.

ROC curves were used as a sensitivity analysis to assess the associations between each of the 2 WC models separately and CIMT (categorical), yielding an area under the curve (AUC) with accompanying ± 95% CI, sensitivity and -specificity in the African male (Figure 1a) and female (Figure 1b) groups.

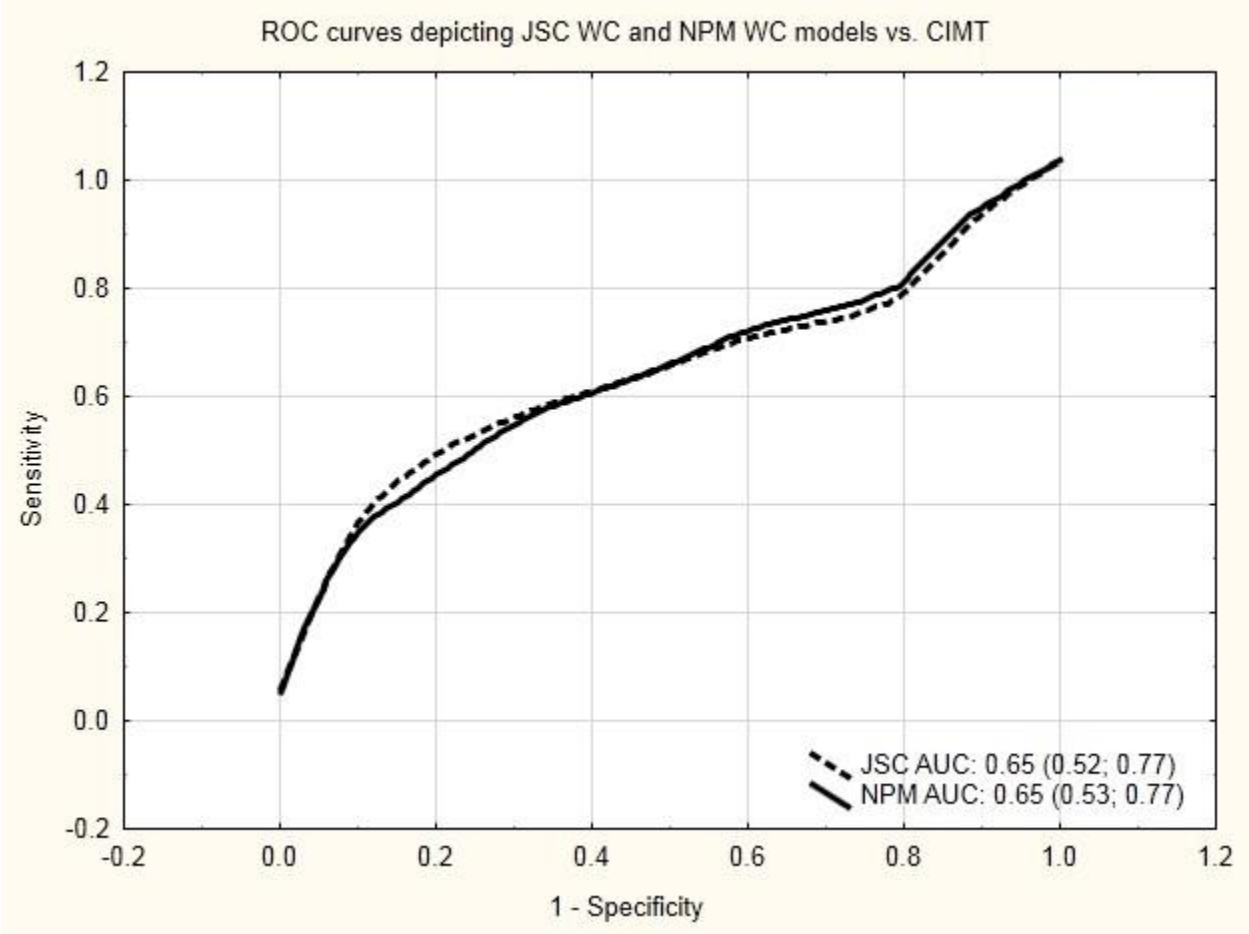


Figure 1a: ROC curves depicting the association between the 2 WC models (JSC and NPM) vs. CIMT for the Male group.

Legend Figure 1a: ROC curves depicting the 2 WC models (JSC and NPM) vs. CIMT for the Male group, AUC (± 95% CI). The JSC model yielded a sensitivity and -specificity of 0.47 and 0.88, whilst the NPM model yielded sensitivity and -specificity values of 0.60 and 0.71.

In Figure 1a, both models (both JSC and NPM) seem to equally predict structural vascular disease.

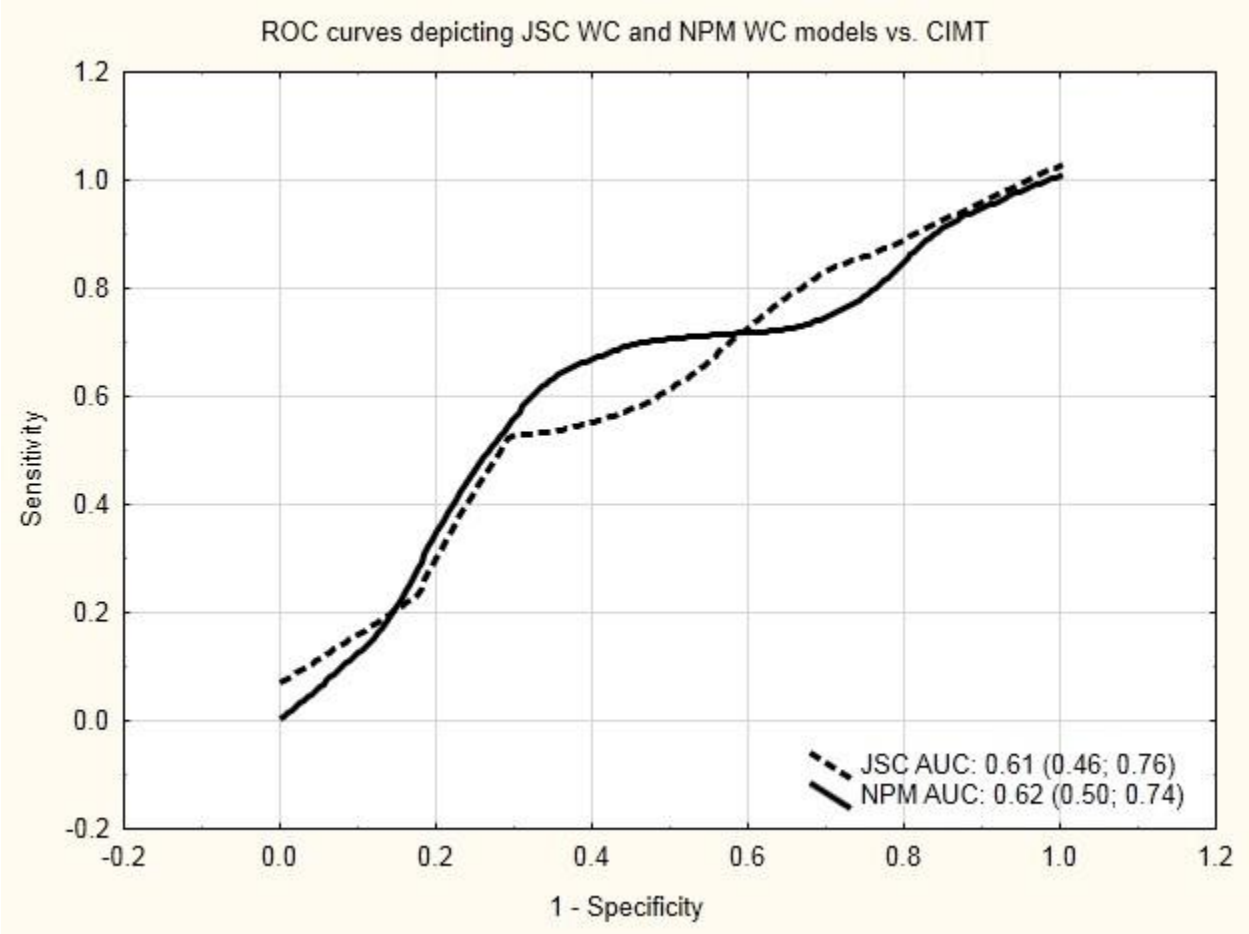
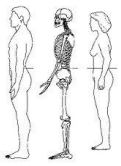


Figure 1b: ROC curves depicting the association between the 2 WC models (JSC and NPM) vs. CIMT for the Female group.

Legend Figure 1b: ROC curves depicting the association between the 2 WC models (JSC and NPM) vs. CIMT for the Female group, AUC (± 95% CI). The JSC model yielded a sensitivity and -specificity of 0.52 and 0.77, whilst the NPM model yielded sensitivity and -specificity values of 0.69 and 0.66.

Figure 1b demonstrates that both the JSC and the NPM models equally discriminate between structural vascular disease. However, the lower limits of the CI's smaller or equal to 0.5 suggest the possibility of no distinction between the groups for both models.



Logistic regression (LR) analyses were performed for each of the 2 WC models. The analyses were done separately for each gender group and the associations between each of the 2 WC models (JSC and NPM) and categorized CIMT were assessed. Each WC model (with cut offs) and a priori confounders, age, BMI and physical activity (scaled), were entered into the model, with the dichotomized CIMT as dependent variable. The MLP NN analyses, with the same confounders as in the LR analyses, were also done for each of the models with CIMT as dependent variable. Details of the different models and their predictive validity analyses are given in the appendix.

Consequently, 1000 unique stratified samples of size 16 (8 from each group) for males and 18 (9 from each group) for females were selected and excluded from the data. The relevant model was built for each of the 1000 samples using the remaining cases and the group membership of the withheld cases (about 30% of all cases) were predicted. The sensitivity and -specificity as well as the percentage of miss-classified cases were recorded for each sample and averaged to find the cross-validation estimates of sensitivity and -specificity (Table 3).

Table 3: Comparison of the performance of LR and NN models.

Model	Sensitivity	Specificity	% Miss-classified
LR, male JSC	53.6 ± 16.9	67.0 ± 17.2	39.7 ± 11.0
LR, male NPM	53.2 ± 17.9	66.9 ± 17.3	40.0 ± 10.8
LR, female JSC	73.2 ± 15.1	72.2 ± 14.4	27.3 ± 9.7
LR, female NPM	72.6 ± 14.9	75.4 ± 14.7	26.0 ± 9.6
NN, male JSC	59.7 ± 25.0	53.0 ± 25.1	43.7 ± 11.1
NN, male NPM	59.3 ± 23.6	52.7 ± 24.1	44.0 ± 10.5
NN, female JSC	70.5 ± 15.7	72.3 ± 17.6	28.6 ± 10.1
NN, female NPM	67.6 ± 17.3	66.2 ± 17.1	33.1 ± 9.6

Table 3 caption: Variables indicated as mean ± Standard Error of Mean, LR, Logistic Regression, NN, Neural Networks

Table 3 compares the LR and NN analyses with regard to sensitivity, -specificity and percent miss-classified. All the analyses, taking note of the means ± SEM, were comparable in predicting structural vascular disease.

In Figure 2a (male) and Figure 2b (female) LR analyses revealed comparable AUC values (JSC males:0.71; NPM males:0.71; JSC females:0.82; NPM females:0.84) with the NN analyses (JSC males:0.69; NPM males:0.71; JSC females:0.81; NPM females:0.82).

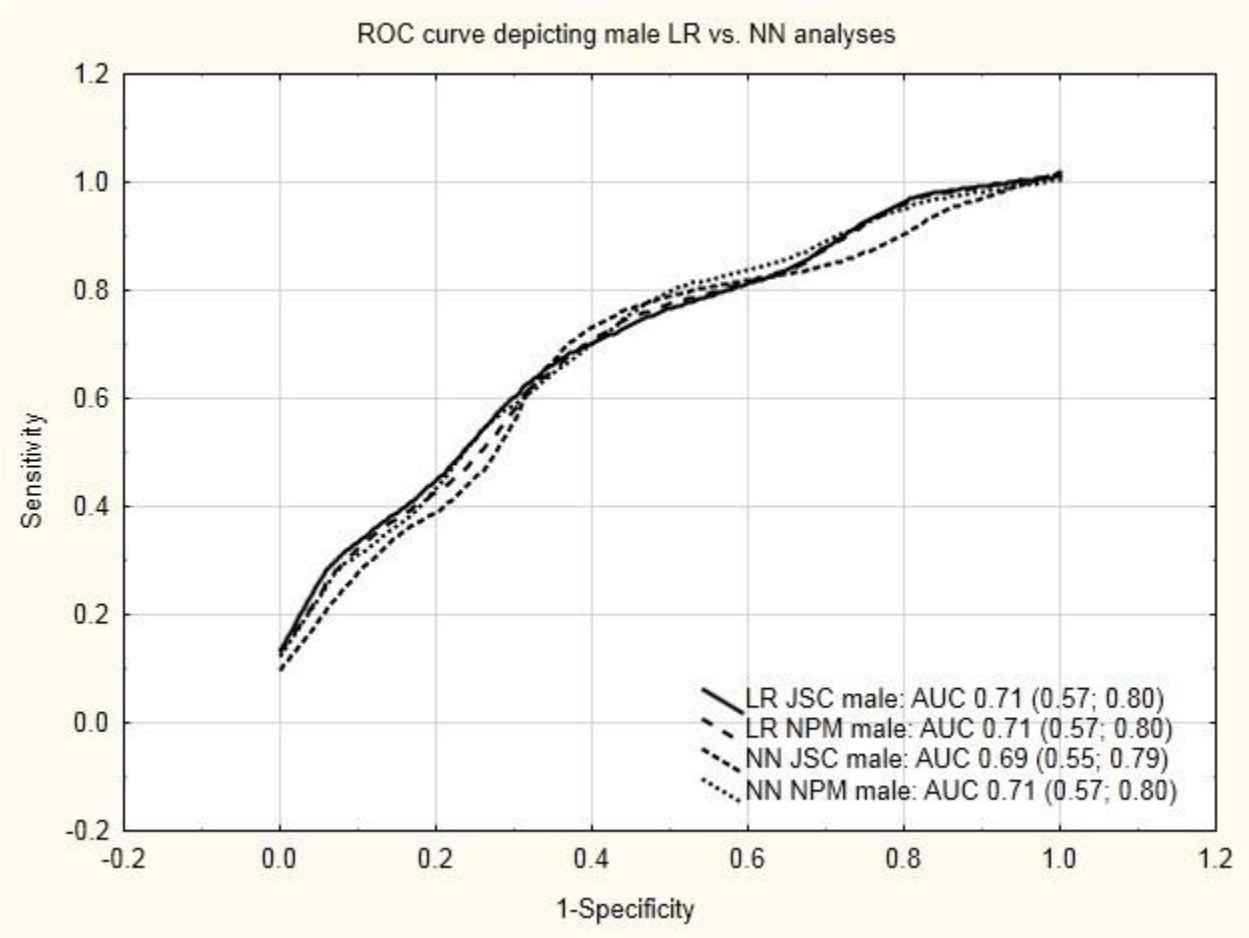


Figure 2a: LR and NN analyses ROC curves depicting the association between the 2 WC models (JSC and NPM) and CIMT (≥1 mm) for the Male group.

Legend Figure 2a: LR and NN analyses ROC curves depicting the 2 WC models (JSC and NPM) vs. CIMT for the Male group, AUC (± 95% CI. The LR JSC model yielded a sensitivity and -specificity of 0.61 and 0.74, whilst the LR NPM model yielded sensitivity and -specificity values of 0.66 and 0.68. The NN JSC model, on the other hand yielded a sensitivity and -specificity of 0.44 and 0.90, whilst the NPM model yielded sensitivity and -specificity values of 0.54 and 0.80.

In Figure 2a, within both statistical methods and models (both JSC and NPM) the results were comparable.

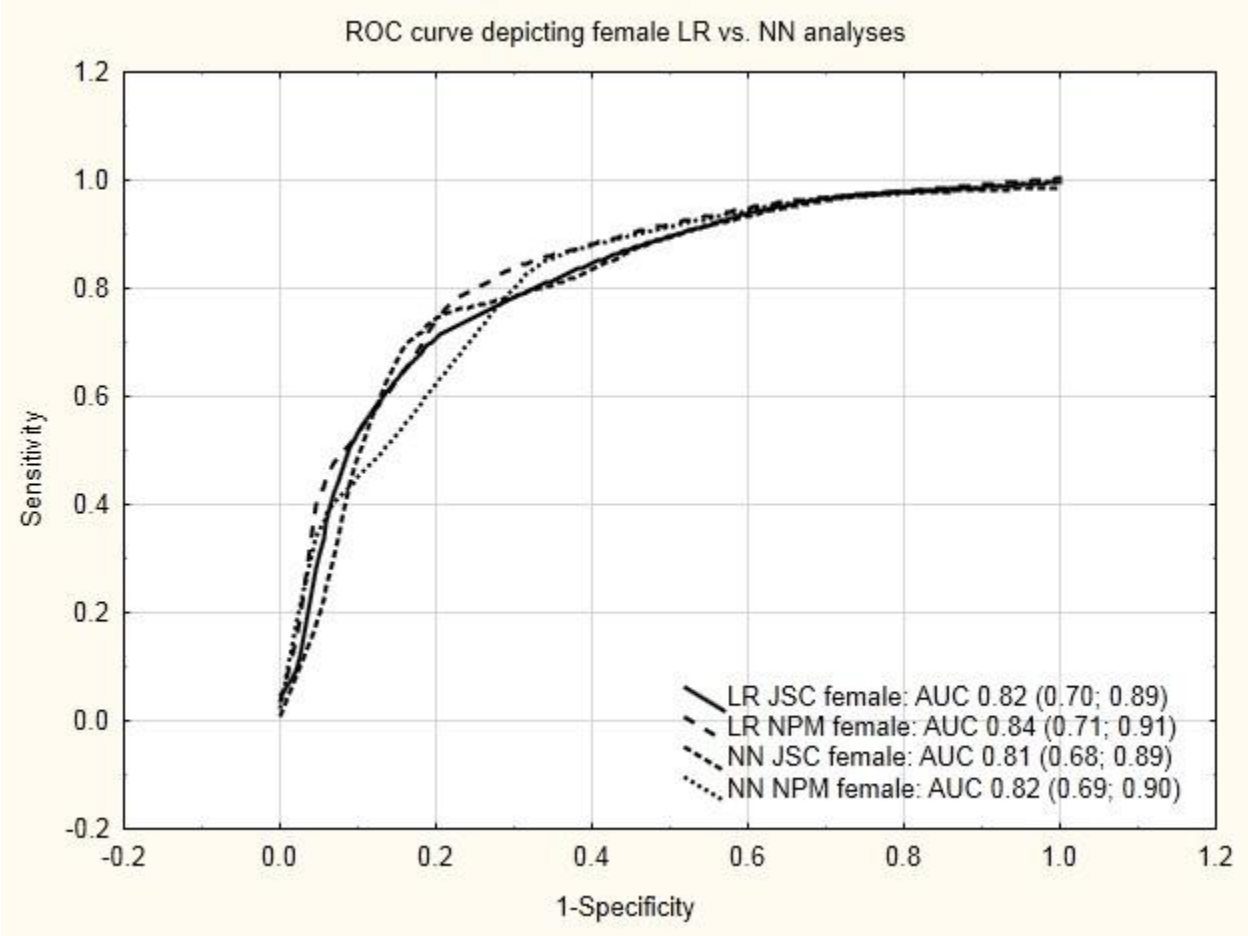
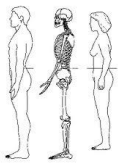


Figure 2b: LR and NN analyses ROC curves depicting the 2 WC models (JSC and NPM) and CIMT (≥1 mm) for the Female group.



Legend Figure 2b: LR and NN analyses ROC curves depicting the 2 WC models (JSC and NPM) vs. CIMT for the Female group, AUC (± 95% CI). LR JSC model revealed a sensitivity value of 0.71 and -specificity value of 0.82, whilst the LR NPM model showed a sensitivity value of 0.78 and -specificity value of 0.82. The NN JSC model demonstrated sensitivity and -specificity values of 0.78 and 0.82, whilst the NN NPM model showed sensitivity and -specificity values of 0.85 and 0.80.

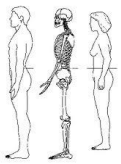
The LR statistics in Figure 2a reveal that both female models were comparable in predicting CIMT pathology in this group, indicating that the NPM has equal success in differentiating structural vascular disease.

4. Discussion

The main purpose of this study was to apply a receiver operating curve, logistic regression and neural networks in order to compare a new, population-specific, proposed waist circumference cut off model (NPM) with the current IDF cut off points (JSC) [3] by weighing both models against structural vascular disease, as indicated by CIMT.

Our main findings demonstrated that both male and female WC cut off models are comparable in predicting structural vascular disease. ROC analyses, where no adjustments were made for confounders, illustrated that both the JSC and NPM models for both genders were comparable. Cross-validation estimates, where 1000 unique stratified samples were selected and excluded from the data, revealed that the JSC and NPM models were comparable. Consequently, the LR and NN analyses, which were adjusted for confounders (age, BMI and physical activity), demonstrated that both the JSC and NPM models were comparable in predicting structural vascular disease as demonstrated by CIMT.

In another study, Kurt et al. [15] compared LR and NN and demonstrated that multilayer perceptron NN surpassed LR in order to compare the analyses' prediction of coronary artery disease. Our study had smaller sample groups of 81 and 90 participants. In



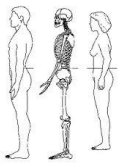
comparison, Kurt et al. [15] had a sample group of 1245, which may account for the different statistical outcomes.

Cameron et al. [21] suggested that central obesity plays a central role in the development of the metabolic syndrome and appears to precede the appearance of the other metabolic syndrome components. Furthermore, the metabolic syndrome is associated with an increased risk of cardiovascular outcomes [22], where carotid intima-media thickness (CIMT) is a strong predictor of future cardiovascular events [23]. In both the male high JSC and NPM models it was clear that CIMT ≥1 mm as well as hypertensive blood pressure values were increased.

Conversely, as part of the metabolic syndrome criteria, population-specific and country-specific definitions for waist circumference (WC) are recommended [3]. A recent investigation of an African cohort found sphygmomanometer blood pressure (BP) values to be the variable with the highest odds of presenting with pathological WC in both males and females [4]. Therefore a newly proposed optimal WC cut off model (NPM) was suggested where the cut off point for males be set at 90 cm, as opposed to the current 94 cm and the female WC cut off measurement be set at 98 cm as opposed to the existing 80 cm cut off [4].

The female NPM cut off differentiated between the diastolic blood pressure in the descriptive statistics, whereas the JSC failed to do so. This may be expected as the population-specific WC cut off is based on blood pressure. Previous studies found that the African population is a high-risk group regarding the prevalence of hypertension, consequently having higher blood pressure compared to the Caucasian population [24-28], adding to the significance of the ethnicity and population-specific proposed WC cut off [4].

The results of the study must be viewed in light of its limitations. The study sample was not representative of the entire African population. Larger sample sizes may also yield better results when comparing statistical methods. The participants included Setswana-speaking Africans, only one of the eleven ethnic groups residing in South Africa, and we recommend that the findings be verified in other African communities.



In conclusion, we applied logistic regression and neural networks to compare two proposed waist circumference cut off models in a group of urban African males and females. The results indicate that overall, validation of the NPM model was comparable to the current JSC model, based on logistic regression and neural networks statistical analyses. Both WC models were compared with CIMT, a marker for structural vascular disease.

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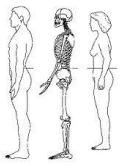
Disclosure

No conflict of interest

Author Contribution

Prof L Malan (principal investigator); Me J Botha, Prof JH de Ridder, Prof JC Potgieter and Prof HS Steyn (staff members) (Potchefstroom). JB and LM planned the manuscript; JB analysed the data and HSS assisted and reviewed the analyses of the data; JB wrote the manuscript; JHdR, LM, JCP, HSS edited the manuscript.



References

[1] Sharma AM. Obesity and cardiovascular risk. Growth Hormone & IGF Research 2003;13:S10-S17.

[2] Redon J, Cifkova R, Laurent S, et al. on behalf of the Scientific Council of the European Society of Hypertension. The metabolic syndrome in hypertension: European Society of hypertension position statement. J Hypertens 2008;26:1891-900.

[3] Alberti KGMM, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Arteriosclerosis Society; and International Association for the Study Of Obesity. Circulation 2009;120:1640-5.

[4] Prinsloo J, Malan L, De Ridder HJ, Potgieter JC, Steyn FS. Determining the waist circumference cut off which best predicts the Metabolic Syndrome components in urban Africans: The SABPA study. Exp Clin Endocrinol Diabetes 2011;119:599-603.

[5] Kotliar C, Forcada P, Ferdinand KC. Noninvasive Diagnosis of subclinical atherosclerosis in cardiometabolic syndrome: a call to action. J Cardiomet Syndr 2008:60-2.

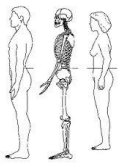
[6] Simon A, Gariepy J, Chironi G, Megnien J, Levenson J. Intima-media thickness: a new tool for diagnosis and treatment of cardiovascular risk. J Hypertens 2002;20(2):159-69.

[7] Puato M, Palatini P, Zanardo M, et al. Increase in carotid intima-media thickness in grade 1 hypertensive subjects: White-coat versus sustained hypertension. Hypertension 2008;51:1300-5.

[8] Marfell-Jones M, Olds T, Stewart A, Carter JEL. International Standards for Anthropometric Assessment. ISAK, New Zealand, 2006.

[9] Liang Yl, Teede H, Kotsoupoulos D, et al. Non-invasive measurements of the arterial structure and function: repeatability, interrelationships and trial sample size. Clin Sci 1998;95:669-97.

[10] StatSoft, Inc. Statistica (data analysis software system), version 10. www.statsoft.com, 2011.



[11] Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. Clin Chemistry 1993;39(04):561-77.

[12] Zou KH, O'Malley AJ, Mauri L. Receiver-Operating Characteristic analysis foe evaluating Diagnostic Tests and Predictive Models. Circulation 2007;115:654-7.

[13] Brismar J. Understanding Receiver-Operating-Characteristic Curves: A Graphic Approach. AJR 1991;157:1119-21.

[14] Florkowski CM. Sensitivity, Specificity, Receiver-Operating Characteristic (ROC) Curves and Likelihood Ratios: Communicating the Performance of Diagnostic Tests. Clin Biochem Rev 2008;29(Suppl. i):S83-S87.

[15] Kurt I, Ture M, Kurum AT. Comparing performances of logistic regression, classification and regression tree, and neural networks for predicting coronary artery disease. Exp S Appl 2008;34:366-74.

[16] Hosmer DW, Lemeshow S. Applied logistic regression. New York: John Wiley & Sons; 2000. p.373.

[17] Kleinbaum DG. Logistic regression: a self-learning text. New York: Springer-Verlag; 1994. p.312

[18] Prati P, Vanuzzo D, Casaroli M, et al. Determinants of carotid plaque occurrence. Cerebrovasc Dis 2006; 22:416-422.

[19] Sharma K, Blaha MJ, Blumenthal RS, Musunuru K. Clinical and research applications of carotid initma-media thickness. Am J Cardiol 2009; 103:1316-20.

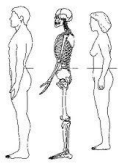
[20] Linder R, Mohamed EI, De Lorenzo A, Poppl SJ. The capabilities of artificial neural networks in body composition research. Acta Diabetol 2003; 40:S9-S14.

[21] Cameron AJ, Boyko EJ, Sicree RA, et al. Central obesity as a precursor to the metabolic syndrome in the AusDiab study and Mauritius. Obesity 2008;16:2707-16.

[22] Girman CJ, Dekker JM, Rhodes T, et al. An exploratory analysis of criteria for the metabolic syndrome and its prediction of long-term cardiovascular outcomes: the Hoorn study. Am J Epidem 2005;162(5):438-47.

[23] Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. Circulation 2007; 115:459-67.

[24] Van Rooyen JM, Kruger HS, Huisman HW, et al. An epidemiological study of hypertension and its determinants in a population in transition: the THUSA study. J Hum Hypertens 2000;14:779–87.

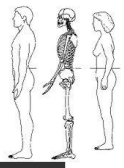


[25] Opie LH, Seedat YK. Hypertension in Sub-Saharan African populations. Circulation 2005; 112:3562-8.

[26]Dennison CR, Peer N, Steyn K, Levitt NS, Hill MN. Determinants of hypertension care and control among peri-urban Black South Africans: the HiHi study. Ethnicity & Disease 2007;17:484–91.

[27] Thorogood M, Connor M, Tollman S, Lewando HG, Fowkes G, Marsh J. A cross-sectional study of vascular risk factors in a rural South African population: data from the Southern African Stroke Prevention Initiative (SASPI), BMC Public Health 2007;7:326.

[28] Sliwa K, Wilkinson D, Hansen C, et al. Spectrum of heart disease and risk factors in a black urban population in South Africa (the Heart of Soweto Study): a cohort study. The Lancet 2008;371:915–22.



Chapter 5

Association of waist circumference with perception of own health in a group of urban African males and females: the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study.

Judith-Cecilia Botha, Leoné Malan, Johan.C. Potgieter, Hendrik. S. Steyn, Johannes. H. de Ridder

Abstract:

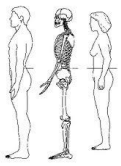
Objectives: Current waist circumference (WC) cut off points of the Joint Statement Consensus (JSC) (male ≥94 cm, female ≥80 cm) were compared with a newly proposed WC cut point model (NPM) (male ≥90 cm, female ≥94 cm). In this study we aimed to compare the two models in terms of its predictive value with regards to the perception of own health.

Method: We determined BP and fasting bloods (glucose, high density lipoprotein (HDL) and triglycerides) as metabolic syndrome markers for 171 urban teachers. Perception of own health was determined via the General Health Questionnaire-28 (GHQ-28).

Results: NPM was an improved discriminator between the WC groups regarding perceived mental health as reflected in the GHQ-subscales. In the male group, higher scores were obtained by the NPM high WC (≥90 cm) compared to the low WC groups (<90 cm) for somatic symptoms, social dysfunction and GHQ total score. Compared to the high WC NPM (≥98 cm) females, the low WC (<98 cm) obtained significantly higher anxiety and sleeplessness subscale scores.

Conclusion: Results suggest that in this African cohort, when adding perception of health as a discriminatory variable between models, the NPM distinguished better between WC groups based on their perception of own health than the JSC model.

Keywords: [waist circumference; anthropometry; perception of health; ethnicity]



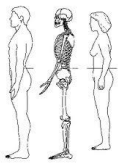
1. Introduction

A cluster of risk factors for cardiovascular disease and type 2 diabetes mellitus has become known as the metabolic syndrome. The recent Joint Statement Consensus (JSC) model for metabolic syndrome factors includes raised blood pressure, dyslipidaemia (raised triglycerides and lowered high-density lipoprotein cholesterol), raised fasting glucose, and central obesity.[1] Currently, the International Diabetes Federation (IDF) cut points are to be used for non-Europeans until more data are available. The IDF suggested a cut off point of ≥94 cm for males and ≥80 cm for females. Alberti et al.[1], however, proposed that population- and country-specific recommended waist circumference thresholds for abdominal obesity be used. A recent investigation of an African cohort found sphygmomanometer blood pressure (BP) values to be the variable with the highest odds of presenting with pathological WC in both males and females.[2] Therefore a newly proposed optimal WC cut off model (NPM) was suggested where the cut off point for males be set at 90 cm, as opposed to the current 94 cm, and the female WC cut off measurement be set at 98 cm as opposed to the existing 80 cm cut off.[2]

Obesity is a well-known cause of cardiovascular disease burden and premature death, but associations with psychological morbidity remain uncertain.[3] Several studies showed that poor mental health was associated with obesity.[4-7] Au contraire, other studies found no association between mental health and obesity.[3,8]

Van der Merwe[9] stated that psychological co-morbidity in patients with obesity is associated with a variety of medical and dietary problems as well as demographic, social and cognitive risk factors. Björntorp and Rosmond[10] proposed that psychosocial and socioeconomic handicaps could be expected to be followed by frequent stress reactions and an increase in alcohol- and smoking habits, and often show robust associations with depressive and anxiety traits. In the current South African context, the rapid rate of urbanization with its accompanying insecurities and disruption in social relationships, could contribute to psychological distress and a perception of poorer own health.[11]

Urbanization is a critical factor influencing the traditional ideal body image among Africans, who have always been inclined towards a larger, fuller body shape.[12] In this



"Big is beautiful" group, obesity was traditionally associated with dignity, health, wealth and respect.[13] However, in view of massive socio-economic changes and increased social integration taking place, black young South Africans are rapidly being exposed to different belief systems. This may alter their value systems regarding body size[14], which may in turn influence their perception of own health.

Consequently we aimed to compare two models of central obesity, JSC[1] and the NPM[2], and its associations with perception of own health in a cohort of urban Africans.

2. Methods

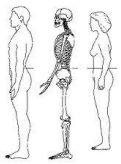
This sub-study formed part of the Sympathetic activity and Ambulatory Blood Pressure in Africans (SABPA) prospective cohort study, conducted from February to May 2008. Permission to participate was granted by the North-West Department of Education and the South African Teachers Union, as well as the Ethics Committee of the North-West University (project nr: NWU-00036-07S6). The study conformed to the ethical guidelines of the World Medical Association Declaration of Helsinki (revised 2004). All participants signed an informed consent form.

2.1 Study population and sample

Male and female urban black African (hereafter referred to as African) school teachers, (N=200, aged 25-65 years) were recruited and included as participants from governmental organizations in the Dr. Kenneth Kaunda District in North-West Province. Exclusion criteria for this study included ear temperature >37,5°C, alpha- or beta blockers usage, donated blood or vaccinated in the previous 3 months. Clinically confirmed diabetics (n=7), users of anti-depressant medication (n=1) and HIV-infected (n=13) participants were also excluded. The final participant sample comprised 171 Africans (n=81 males and females n=90).

2.2 Experimental procedure

On every working day of the week, for the extent of the project, the physical activity monitors (Actical®) apparatuses were fitted at 07:00, to four participants for 24 hours. Software programmes were activated and participants resumed their daily activities.



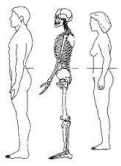
At 16:30 they were transported to the Metabolic Unit Research Facility of the North-West University for an overnight stay where participants were welcomed and introduced to the experimental setup. The first half of a psychosocial battery was completed under supervision of trained field workers and at 18:00 participants received a standardized dinner. After dinner the last part of the psychosocial battery questionnaires were completed and last beverages were given at 20:30.

After an overnight fast, the Actical® apparatuses were disconnected. Anthropometric measurements were taken in triplicate by anthropometrists according to the standard of the International Society for the Advancement of Kinanthropometry (ISAK).[15] Two mercury sphygmomanometer blood pressure readings using Korotkoff IV or V for blood pressure (BP) followed while the participants rested for five minutes in a semi-recumbent position, with a three-minute rest between measurements. The second measurement was used for statistical analyses. BP measurements were taken by a registered nurse. Fasting blood samples were obtained by a registered nurse.

2.3 Anthropometric measurements

All anthropometric measurements were performed by ISAK level 2 accredited anthropometrists, with subjects in minimal clothing and without shoes. The waist circumference was taken in triplicate at the end of normal expiration at the narrowest point of the abdomen between the lower costal (10^{th} rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk.[15] The subject assumed a relaxed standing position with the arms folded across the thorax.[15]

Body mass index (BMI) was calculated by the kg/m^2 formula. The body weight measured by means of a KRUPS scale with the participant wearing minimal clothes and with the weight evenly distributed, to the nearest 0.1 kg.[15] Height was measured with a stadiometer to the nearest 0.1 cm while the participant's head was in the Frankfort plane, the heels together and the buttocks and upper back touching the stadiometer.[15]



2.4 General Health Questionnaire-28 (GHQ-28)[16]

The General Health Questionnaire (GHQ-28) is a 28-item self-report measure aimed at distinguishing people with some form of psychological disturbance from those who are relatively healthy.[16] The GHQ has four subscales (Somatic Symptoms, Anxiety and Insomnia, Social Dysfunction, and Severe Depression), each of which consists of seven items. Subjects reported on their own perception of health during the past few weeks. Each item was scored via bimodal scoring on a 0-0-1-1 scale.[16] The value of response possibilities one (1) and two (2) are equal to nil (0) and three (3) and four (4) equal to one (1). The sum of these scale scores yields a single score that ranges from 0 (for no symptoms) to 28 (severe pathology), for which threshold scores of ≥4 (bimodal scoring) would indicate probable psychological distress and/or psychiatric disorder, hereafter described as caseness.[17]

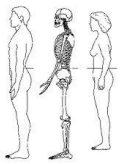
The median specificity of the GHQ-28 is 0.82 and the median sensitivity is 0.86.[18] Cronbach alpha-reliability coefficients ranged between 0.78 and 0.85 for different subscales in this study.

2.5 Biochemical analysis

Fasting blood samples were obtained by a registered nurse with a winged infusion set from the brachial vein branches from the dominant arm. Serum gamma glutamyl transferase and cotinine were used as markers of alcohol abuse and smoking respectively. Sodium fluoride glucose, serum HDL and triglycerides were handled according to standardized procedures and were stored at -80^{o}C. Analyses were done using the Konelab^{TM} 20i sequential multiple analyzer computer (SMAC) (Thermo Scientific, Vantaa, Finland) and Unicel DXC 800 (Beckman & Coulter, Germany) at accredited laboratories.

2.6 Statistical Analyses

Data analyses were performed with Statistica version 10.[19] Descriptive statistics and prevalence were obtained for the entire black African sample. A 2 X 2 analysis of covariance (ANCOVA) was executed to test the interaction between WC (JSC[1] as well as NPM[2]) and gender with GHQ-caseness and metabolic syndrome markers as outcome variables. Subsequent ANCOVAs followed independent of priori confounders age, BMI



and physical activity. Standardized differences in means as effect sizes (d) were also determined as a measure of practical significance, where practical significance can be understood to be a large enough difference to have an effect in practice.[20] As such, an effect size of 0.2 is described as small and not visible. Likewise, an effect size of 0.5 is described as medium and visible to a researcher. An effect size of 0.8 is practically significant and can be understood as a large enough difference to have an effect in practice. Odds Ratio analyses were performed to assess the odds of each component predicting psychological distress in high WC gender groups. Independent covariates included age, BMI, physical activity.

3. Results

In Table I the Africans demonstrated levels of obesity, high normal glucose and blood pressure values with 74.27% reporting a perception of own poorer health. Interaction on main effects (NPM x gender) demonstrated significance for somatic symptoms ($F(1,171),5.28$; $P = 0.02$ and GHQ-caseness ($F(1,171),4.62$; $P = 0.02$. Subsequently, groups were stratified into high and low WC groups for (1) JSC and (2) NPM. Separate analysis of covariance (ANCOVA) independent of confounders (age, BMI and physical activity) were done, firstly for the males (Table II), and thereafter for the females (Table III) to determine significant differences.

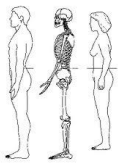


Table I: Descriptive statistics for the entire African group.

	Total African group N = 171
Males (N)	81
Females (N)	90
Age (years)	44.05 ± 8.30
Lifestyle variables	
Physical Activity (kCal)	2693.04 ± 809.67
Gamma-glutamyl transferase (µ/L)	62.59 ± 72.27
Cotinine (ng/ml)	20.94 ± 51.66
Physiological and anthropometric variables	
Body Mass Index (kg/m^2)	30.36 ± 7.14
Glucose (mmol/L)	5.50 ± 1.73
High Density Lipoprotein (mmol/L)	1.15 ± 0.35
Triglycerides (mmol/L)	1.38 ± 1.30
Systolic Blood Pressure (mmHg)	134 ± 20
Diastolic Blood Pressure (mmHg)	89 ± 13
Psychological variables: General Health Questionnaire	
Somatic Symptoms	2.54 ± 2.20
Anxiety & Sleeplessness	2.64 ± 2.46
Social Dysfunction	2.01 ± 2.12
Depressive Symptoms	1.16 ± 1.93
GHQ_Total	8.37 ± 6.61
GHQ caseness N (%)	127 (74.27%)
Medication usage	
Hypertension N (%)	34 (19.88%)

Variables indicated as arithmetic mean ± standard deviation (SD).

Subsequently, groups were stratified into high and low WC groups for (1) JSC and (2) NPM. Separate analysis of covariance (ANCOVA) independent of confounders (age, BMI and physical activity) were done, firstly for the males (Table II), and thereafter for the females (Table III) in order to determine significance.

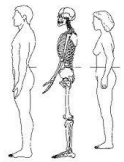
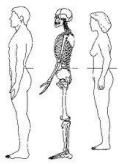


Table II: Comparing males' JSC[1] WC cut off and the NPM WC[2], independent of covariates (age, BMI and physical activity).

	2009 JSC Males (N=43) <94cm	2009 JSC Males (N=38) ≥94cm	Effect size (d)	NPM Males (N=36) <90cm	NPM Males (N=45) ≥90cm	Effect size (d)
Age (years)	41.37 ± 9.33	44.08 ± 6.90		40.50 ± 9.79	44.36 ± 6.60*	0.39
Lifestyle variables						
Physical Activity (kCal)	2350.24 ± 654.08	3145.41 ± 797.02*	1.00	2341.32 ± 705.58	3028.85 ± 788.40*	0.87
Gamma-glutamyl transferase (µ/L)	66.72 ± 86.10	87.10 ±52.21		71.08 ± 93.41	80.45 ± 50.78	
Cotinine (ng/ml)	25.42 ± 48.84	22.53 ± 46.76		25.81 ± 46.94	22.67 ± 48.61	
Physiological and anthropometric variables						
Body Mass Index (kg/m^2)	23.52 ± 3.15	32.37 ± 4.73*	1.87	23.06 ± 3.10	31.36 ± 5.03*	1.65
Glucose (mmol/L)	5.19 (4.41; 5.96)	6.94 (6.10; 7.79)*	0.67	5.21 (4.37; 6.05)	6.66 (5.93; 7.38)*	0.57
High Density Lipoprotein (mmol/L)	1.16 (1.02; 1.29)	1.0 (0.85; 1.15)		1.15 (1.01; 1.30)	1.02 (0.90; 1.15)	
Triglycerides (mmol/L)	1.48 (0.82; 2.13)	2.18 (1.46; 2.89)		1.63 (0.92; 2.34)	1.95 (1.33; 2.56)	
Systolic Blood Pressure (mmHg)	132 (125; 139)	149 (141; 157)*	0.67	131 (123; 139)	146 (140; 153)*	0.64
Diastolic Blood Pressure (mmHg)	89 (84; 95)	99 (93; 104)*	0.52	91 (85; 97)	96 (91; 101)	
Hypertension medication N (%)	4 (9.30 %)	9 (23.68 %)		4 (11.11 %)	9 (20 %)	
Psychological variables						
General Health Questionnaire						
Somatic Symptoms	1.88 (1.12; 2.64)	3.01 (2.18; 3.84)		1.58 (0.77; 2.38)	3.08 (2.39; 3.77)*	0.62
Anxiety & Sleeplessness	2.59 (1.65; 3.53)	2.44 (1.42; 3.46)		2.26 (1.25; 3.26)	2.73 (1.86; 3.60)	
Social Dysfunction	1.60 (0.78; 2.41)	2.07 (1.18; 2.95)		1.01 (0.16; 1.86)	2.46 (1.73; 3.20)*	0.57
Depressive Symptoms	0.54 (-0.07; 1.15)	1.36 (0.69; 2.02)		0.56 (-0.10; 1.22)	1.21 (0.65; 1.78)	
GHQ_Total	6.62 (4.12; 9.12)	8.89 (6.17; 11.61)		5.42 (2.79; 8.05)	9.49 (7.22; 11.77)*	0.51
GHQ caseness N (%)	26 (60.47 %)	28 (73.68 %)		21 (58.33 %)	33 (73.33 %)	

Variables indicated as arithmetic mean ± standard deviation (SD); subsequent data presented as geometric mean ± 95% confidence interval (95%CI). Statistical difference indicated with *, $p \leq 0.05$



In Table II, for both models (JSC and NPM), the lifestyle and physiological variables were less favourable for the high WC cut off male groups. The outcomes of the GHQ and its subscales demonstrated increases in somatic symptoms, social dysfunction and total poorer perception of own health in the high WC groups of the NPM only.

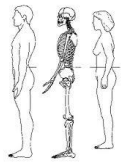
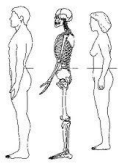


Table III: Comparing female's JSC[1] WC cut off and the NPM WC cut off[2], independent of covariates (age, BMI and physical activity).

	2009 JSC Females (N=17) <80cm	2009 JSC Females (N=73) ≥80cm	Effect size (d)	NPM Females (N=58) <98cm	NPM Females (N=32) ≥98cm	Effect size (d)
Age (years)	42.77 ± 6.54	45.92 ± 8.35		44.31 ± 7.28	47.16 ± 9.25	
Lifestyle variables						
Physical Activity (kCal)	1957.67 ± 383.15	2830.74 ± 783.68*	1.11	2325.34 ± 487.42	3282.97 ± 891.26*	1.07
Gamma-glutamyl transferase (µ/L)	39.99 ± 44.65	49.71 ± 73.99		39.00 ± 35.02	63.91 ± 105.22	
Cotinine (ng/ml)	20.31 ± 48.72	17.56 ± 56.90		18.26 ± 61.36	17.68 ± 42.72	
Physiological and anthropometric variables						
Body Mass Index (kg/m^2)	25.70 ± 3.50	34.43 ± 6.95*	1.26	29.26 ± 4.53	39.16 ± 7.04*	1.41
Glucose (mmol/L)	4.25 (3.65; 4.85)	5.20 (4.95; 5.45)*	0.79	4.75 (4.42; 5.07)	5.54 (5.05; 6.02)*	0.58
High Density Lipoprotein (mmol/L)	1.32 (1.14; 1.50)	1.20 (1.12; 1.26)		1.23 (1.14; 1.33)	1.18 (1.04; 1.32)	
Triglycerides (mmol/L)	0.78 (0.48; 1.08)	1.04 (0.91; 1.16)		0.90 (0.75; 1.06)	1.15 (0.92; 1.38)	
Systolic Blood Pressure (mmHg)	128 (119; 136)	130 (126; 134)		125 (120; 129)	138 (131; 145)*	0.69
Diastolic Blood Pressure (mmHg)	83 (77; 88)	85 (82; 87)		82 (79; 84)	89 (85; 94)*	0.62
Hypertension medication N (%)	1 (5.88 %)	20 (27.40 %)		7 (22.58 %)	14 (24.56 %)	
Psychological variables						
General Health Questionnaire						
Somatic Symptoms	2.92 (1.62; 4.22)	2.61 (2.03; 3.17)		2.97 (2.26; 3.68)	2.10 (1.04; 3.16)	
Anxiety & Sleeplessness	2.23 (0.84; 3.62)	2.88 (2.27; 3.48)		3.32 (2.57; 4.07)	1.74 (0.63; 2.85)*	-0.44
Social Dysfunction	1.55 (0.36; 2.74)	2.34 (1.82; 2.86)		2.10 (1.44; 2.76)	2.36 (1.38; 3.404)	
Depressive Symptoms	1.57 (0.37; 2.77)	1.32 (0.80; 1.84)		1.58 (0.92; 2.23)	0.99 (0.01; 1.96)	
GHQ_Total	8.37 (4.68; 11.07)	9.13 (7.51; 10.74)		9.98 (7.96; 11.99)	7.19 (4.20; 10.19)	
GHQ caseness N (%)	13 (76.47 %)	60 (82.19 %)		28 (87.5 %)	45 (77.59 %)	

Variables indicated as arithmetic mean ± standard deviation (SD); subsequent data presented as geometric mean ± 95% confidence interval (95%CI). Statistical difference indicated with *, $p \leq 0.05$



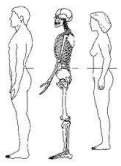
In Table III, a marked difference between the two models (JSC and NPM) is evident among female participants. The NPM demonstrated that the low WC group (< 98 cm) showed more anxiety and sleeplessness even though the high NPM group (≥ 98 cm) revealed a higher mean blood pressure. In line with this it is noteworthy that the low WC NPM group showed a trend toward more Somatic Symptoms, Depressive Symptoms and a higher GHQ Total Score than the high WC group.

Odds Ratios were performed and demonstrated that alcohol abuse best predicted psychological distress in both male high WC JSC and RPWC groups although clinically not indicating risk with an OR of > 1. In the female group the Odds Ratio revealed an odds of alcohol associated with psychological distress, although not clinically indicating risk in the high WC female JSC group. Interestingly, the female high WC RPWC cut off showed no odds of any of the variables predicting psychological distress.

4. Discussion

The main purpose of this study was to compare two proposed models of central obesity, the JSC[1] and an ethnic-specific newly proposed model (NPM).[2] The association between each model and perception of own mental health was assessed in a group of urban African males and females.

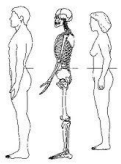
In the male group, it was found that both models were good discriminators between high WC and low WC groups for lifestyle and physiological variables. The NPM[2] though, revealed statistically significant differences between high and low WC groups pertaining to psychological distress. The NPM male high WC group demonstrated a less favourable metabolic profile, and also reported significantly poorer perception of own mental health as represented by somatic symptoms and social dysfunction. This is in line with findings by Bodenlos et al.[7] who reported that the relationship between mood disorders and obesity had a trend towards significance in African Americans. The prominence of somatic symptoms in this group also seemed to confirm the findings of Kirmayer and Young[21], who indicated that ethno-cultural groups in the same urban milieu, with equal access to healthcare services, almost exclusively demonstrate somatic symptoms rather than psychosocial distress.



The female cut offs differed extensively between the two models (≥80 cm vs. ≥98 cm). In an attempt to suggest population-specific cut offs for this population, Prinsloo et al. [2] did receiver operating characteristic (ROC) analyses for each of the Metabolic Syndrome components. The blood pressure cut off, used in our current sub-study, was the most significant predictor of pathology. Blood pressure is mostly a major risk factor in people of African descent, regardless of country of residence.[22-26]

Focusing on the female's perception of own health, the NPM distinguished between low and high groups with regard to the Anxiety and Sleeplessness sub-scale, indicating that the low group (<98 cm) had a higher occurrence of anxiety and sleeplessness even though the high group (≥98 cm) demonstrated higher mean blood pressure. Katzman and Lee[27] theorized that women juggling two cultural worlds exposed to "Western Ideals" in their home countries show an increase in disordered eating. The results of this study might also offer the hypothesis of metabolically healthy obese females as first put forward by Walker et al.[28] Kruger et al.[29] found that WC was associated with the risk for non-communicable disease in black South African women. In line with this, the current study shows that the high WC group is not metabolically healthy, but healthy by their own perception, whereas the low WC group is metabolically healthy with a very high occurrence of psychological distress. Healthy obesity in this group does not seem to refer to metabolic health but rather to improved perception of own health. This trend seems to be particularly prominent when the NPM cut offs are used.

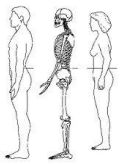
Dallman et al.[30] proposed that people eat comfort food in an attempt to reduce the activity of the chronic stress-response network. In line with this, Kivimäki et al.[4] suggested that internalization of negative obesity-related stereotypes, negative self-body image and unsuccessful weight control by dieting were related to decreased mental health among individuals who are obese. Oswald and Powdthavee[31] demonstrated that a 10-point increase in body mass index (BMI) was associated with a drop in mental health of approximately 0.3 points on the General Health Questionnaire[17]. Whether these findings hold true for the African population is not certain, especially in line with our findings.



No differences in GGT levels in the low vs. the high JSC and NPM cut off groups may rule out the fact that obesity is responsible for the increased GGT levels. Higher levels of especially GGT in both the high WC cut off JSC and NPM male groups were evident although odds ratio's revealed that alcohol abuse showed odds with low clinical significance for psychological distress in the high WC JSC males (OR 0.97, ±95%CI 0.93; 1.00; P = 0.05) and in high WC male NPM (0.98, 0.95;1.00; P = 0.08). Malan et al. [32] stated that urban gender groups reported higher alcohol consumption, maybe as a manner of coping. Conversely, Hamer et al.[33] confirmed that objectively measured alcohol intake, as indicated by GGT, exceeded normal cut off values and were associated with structural vascular disease (OR 3.9; 95% CI 1.0-15.5). Saxena[34] and the World Health Organization (WHO)[35] reported Africa to be one of the two regions with the most rapid rise in alcohol consumption, where the consumption of absolute alcohol per person per year is as much as six litres. Also, levels of alcohol consumption is an indication of the burden of disease for the country, leading to serious health and social consequences in our country[35]. Of note is the absence of the high WC female NPM group's odds of presenting with increased alcohol use, possibly indicating their own perception of own good health and not needed as a coping strategy. Further research is needed on this topic.

The results of the study must be viewed in light of its limitations. Given the cross-sectional nature of this study, causal relationships between central obesity and perception of health could currently not be determined. Another limitation was that the study sample was not representative of the entire African population. The participants included Setswana-speaking Africans, only one of the eleven ethnic groups residing in South Africa and we recommend that the findings be verified in other African communities.

In conclusion we compared two models of central obesity and its associations with perception of health in a group of urban African males and females: The model proposed by Prinsloo et al. [2] appeared to be a clearer discriminate for the perception of own health in both African males and females, with WC cut off points set at 90 cm and 98 cm, respectively.



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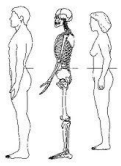
Disclosure

No conflict of interest

Author Contribution

Prof L Malan (principal investigator); Me J Prinsloo, Prof JC Potgieter, Prof HS Steyn, Prof JH de Ridder (staff members) (Potchefstroom). JP planned, analysed the data, wrote and edited the manuscript; LM planned, analysed the data and edited the manuscript; JCP edited the manuscript; HSS analysed the data and edited the manuscript, JHdR edited the manuscript.



References

1 Alberti KGMM, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Arteriosclerosis Society; and International Association for the Study Of Obesity. Circulation. 2009;120:1640-5.

2 Prinsloo J, Malan L, De Ridder HJ, et al. Determining the waist circumference cut off which best predicts the Metabolic Syndrome components in urban Africans: The SABPA study. Exp Clin Endocrinol Diabetes. 2011;119:599-603.

3 Atlantis E, Baker M. Obesity effects on depression: systematic review of epidemiological studies. Int J Obesity. 2008;32:881-91.

4 Kivimaki M, Batty D, Singh-Manoux A, Nabi H, Sabia S, Tabak AG, et al. Association between common mental disorder and obesity over the adult life course. Br J Psychiatry. 2009;195(2):149-55.

5 Akbaraly TN, Kivimaki M, Brunner EJ, et al. Association between metabolic syndrome and depressive symptoms in middle-aged adults. Diabetes Care. 2010;32:499-504.

6 Esteban y Pena MM, Barrera VH, Cordero XF, et al. Self-perception of health status, mental health and quality of life among adults with diabetes residing in a metropolitan area. Diabetes Metab. 2010;36:305-11.

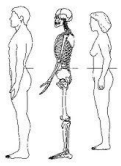
7 Bodenlos JS, Lemon SC, Schneider KL, et al. Associations of mood and anxiety disorders with obesity: Comparisons by ethnicity. J Psychosom Res. 2011. Article in Press.

8 Hildrum B, Mykletun A, Midthjell K, et al. No association of depression and anxiety with the metabolic syndrome: the Norwegian HUNT study. Acta Psychiatr Scand. 2009;120(1):14-22.

9 Van der Merwe M. Psychological correlates of obesity in women. Int J Obesity. 2007;31:S14-18.

10 Bjorntorp P, Rosmond R. Obesity and cortisol. Nutrition. 2000;16(10):924-36.

11 Malan L, Schutte AE, Malan NT, et al. Specific coping strategies of African during urbanization: comparing cardiovascular responses and perception of health data. Biol Psychol. 2006;72:305-310.



12 Szabo CP, Le Grange D. Eating disorders and the politics of identity. In Nasser, M., Katzman, M.A. & Gordon, R.A., eds. Eating disorders and cultures in transition. Brunner Routledge, New York, 2001;24-39.

13 Puoane T, Fourie JM, Shapiro M, et al. 'Big is beautiful' - an exploration with urban black community health workers in a South African township. SAJCN. 2005;18(1):6-14.

14 Caradas AA, Lambert EV, Charlton KE. An ethnic comparison of eating attitudes and associated body image concerns in adolescent South African schoolgirls. J Hum Nutr Diet. 2001;14920:111-20.

15 Marfell-Jones M, Olds T, Stewart A, et al. International Standards for Anthropometric Assessment. ISAK, New Zealand, 2006.

16 Goldberg DP, Hillier VF. A scaled version of the General Health Questionnaire. Psychol Med. 1979;9(1):139-145.

17 Jackson C. The General health questionnaire. A brief history. Occup Med (OXF). 2007;57:79.

18 Goldberg DP, Williams P. General health questionnaire. Mental Measurements Yearbook 12, NFER-Nelson Publishing Co., Ltd., Oxford, 1988.

19 StatSoft, Inc. STATISTICA (data analysis software system), version 10. www.statsoft.com, 2011.

20 Ellis SM, Steyn HS. Practical significance (effect sizes) versus or in combination with statistical significance (p-values). Manag dynamics. 2003;12(4):51-53.

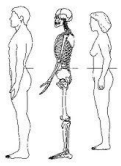
21 Kirmayer LJ, Young A. Culture and somatization: clinical, epidemiological, and ethnographic perspectives. Psychosom Med. 1998;60:420-30.

22 Agyemang C, Bhopal R. Is the blood pressure of people from African origin adults in the UK higher or lower than that in European origin white people? A review of cross-sectional data. J Hum Hypertens. 2003;17:523-34.

23 Van der Merwe M, Pepper MS. National prevalence of obesity: obesity in South Africa. Obes Reviews. 2006;7: 315-22.

24 Seedat, Y.K. Perspectives on research in hypertension. Cardiovasc J Afr. 2009;20(1): 39-42.

25 Du Plessis A, Malan L, Malan NT. Coping and metabolic syndrome indicators in urban black South African men: the SABPA study. Cardiovasc J Africa. 2010;21(5): 268-73.



26 Malan L, Malan NT, Du Plessis A et al. The cost of coping: a cardio-neuro-metabolic risk for black South Africans? Cardiovasc J Africa. 2010;21(4):183-5.

27 Katzman MA, Lee S. Beyond body image: The integration of feminist and transcultural theories in the understanding of self starvation. Int J Eat Disord. 1997;22:385-94.

28 Walker ARP, Walker BF, Walker AJ, et al. Low frequency of adverse sequelae of obesity in South African rural black women. Int J Vitam Nutr Res. 1989;59:224-8.

29 Kruger HS, Venter CS, Vorster HH. Obesity in African women in the North West province, South Africa is associated with an increased risk of non-communicable diseases: the THUSA study. Br J Nutr. 2001;86:733-40.

30 Dallman MF, Pecoraro N, Akana SF, et al. Chronic stress and obesity: a new view of "comfort food". Proc Natl Acad Sci U S A. 203;100(20):11696-701.

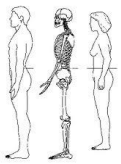
31 Oswald AJ, Powdthavee N. Obesity, unhappiness, and the challenge of affluence: theory and evidence. Discussion Paper No. 2717. http://ssrn.com/abstract=981703, 2007.

32 Malan L, Malan NT, Wissing MP, et al. Coping with ubanization: a cardiometabolic risk? The THUSA study. Biol Psychol. 2008;79:323-8.

33 Hamer M, Malan L, Schutte AE, et al. Conventional and behavioural risk factors explain differences in sub-clinical vascular disease between black and Caucasian South Africans: The SABPA study. Atherosclerosis. 2011;215:237-242.

34 Saxena S. Worldwide alcohol trends. http://www.who.int/mediacentre/multimedia/podcasts/2011/alcohol_20110315/en/, 2011.

35 World Health Organization (WHO). Global status report on alcohol and health 2011. http://www.who.int/substance_abuse/publications/global_alcohol_report/en/ , 2011.



Chapter 6 Conclusions and Recommendations

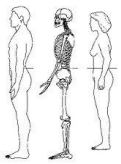
6.1 Summary
6.2 Conclusions
6.3 Recommendations

6.1 Summary

The aim of this study was firstly to determine which waist circumference best predicted metabolic syndrome in a group of urban African teachers. The second aim was to compare two WC models, namely the Joint Statement Consensus (JSC) and a new ethnicity-specific proposed model (NPM), and its contribution towards structural vascular disease as indicated by carotid intima-media thickness (CIMT). Validation of the NPM via logistic regression and neural networks illustrated that the NPM was comparable to the JSC cut offs currently in use. Thirdly, the aim of the study was to assess whether any of the two models (JSC or NPM) and markers of metabolic syndrome correlated with perception of own health.

This dissertation was presented in four main parts, namely an introduction (Chapter 1), a literature review (Chapter 2), and three research articles (Chapters 3, 4 and 5). The article format of the dissertation is approved by the North-West University (Potchefstroom Campus), and the three research articles have been submitted to appropriate and accredited journals.

Chapter 1 introduced the problem, and stated the aims and hypotheses of this study. The literature (Chapter 2) review focused on the relationship between central obesity and psychological distress.



Chapter 3 took the form of an article: **Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study.** This article was accepted for publication by Experimental and Clinical Endocrinology and Diabetes (Prinsloo, J., Malan, L., De Ridder, J.H., Potgieter, J.C. & Steyn, H.S. 2011. Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study. Experimental and Clinical Endocrinology and Diabetes, 119:599-603).

The second article, Chapter 4, consists of the second research article titled: **Comparing performances of two central obesity models to predict structural vascular disease by using ROC analyses, Logistic Regression and Neural networks: the SABPA study.** This article has been submitted to Atherosclerosis, a journal with an impact factor of 4.1.

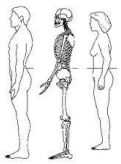
The final article, Chapter 5, was titled **Association of waist circumference with perception of own health in a group of urban African males and females: the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study.** This article has been submitted to the Journal of Endocrinology, Metabolism and Diabetes of South Africa and is currently in rebuttal.

6.2 Conclusions

The conclusions drawn from this research project are presented in accordance with the set hypotheses (Chapter 1).

- **Hypothesis 1: New population-specific WC cut off points in a cohort of urban Africans would differ from those proposed by the JSC.**

The first hypothesis is accepted, based on the research findings that, via ROC analyses, suggested new population- and ethnicity-specific cut off points that differed from the currently proposed JSC model, proposed by the International Diabetes Federation. This study suggest that the optimal cut off point for the males be set at 90 cm, as opposed to the current 94 cm; whilst the female cut off be set at 98 cm as opposed to the existing



cut off of 80 cm based on blood pressure, confirming the necessity of early diagnosis, especially in view of the high risk of hypertension in people of African descent.

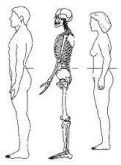
- **Hypothesis 2: The NPM would predict structural vascular disease (CIMT) in a cohort of urban Africans.**

The second hypothesis is accepted based on the research findings that overall, validation of the NPM model was comparable with the current JSC model in predicting structural vascular disease in a group of urban African teachers.

- **Hypothesis 3: The NPM would predict a poorer perception of own health in a cohort of urban Africans.**

The third hypothesis is accepted, based on the research findings that in this African cohort, when adding perception of health as a discriminatory variable between models, the NPM distinguished better between WC groups, based on their perception of own health, than the JSC model.

The Joint Statement Consensus, the most recent definition of the metabolic syndrome, declared set cut offs for all components except waist circumference, for which further ethnicity- and country-specific work is required (Alberti *et al.,* 2009:1640). A new population and ethnicity-specific WC cut off was recommended (NPM) for a group of urban Africans and subsequently validated via Logistic Regression and Neural Networks statistical analyses. The NPM was comparable with the JSC cut offs which are currently in use in predicting structural vascular disease with CIMT as marker. It is therefore proposed that the NPM cut offs be used in this population due to the strong association between blood pressure and the proposed WC cut offs, as blood pressure is a major risk factor in people of African descent, regardless of country of residence (Cappuccio et al., 1997; Wild and Mckeigue, 1997; Agyemang and Bhopal, 2003; Van der Merwe and Pepper, 2006; Vorster, 2002; Du Plessis et al., 2010; Sliwa et al., 2008). Furthermore, associations were demonstrated between the NPM and perception of own health in a group of urban Africans, adding weight to the NPM as a new ethnicity-specific cut off in this group.



6.3 Recommendations

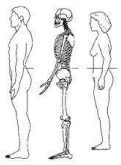
The results from this study contributed to the lack of data available on South African ethnicity- and population-specific WC cut offs that predict pathology. The findings of this study give support to the possibility of a population-specific WC cut off that differs substantially from the currently proposed WC cut offs in use. It is proposed that the NPM cut offs be used in this population due to the strong association between blood pressure and the proposed WC cut offs, validated by Logistic Regression and Neural Networks statistical analyses. As the NPM was associated with the GHQ, it is recommended that the ethnicity-specific cut off be used and that cultural differences could mask subtle changes.

Certain shortcomings regarding this study can, however, be indicated as there are some important factors that may have affected the results and could have caused weaknesses in this study and, therefore, might have influenced the different outcomes.

First, analyses used cross-sectional data. Therefore, our results do not establish a causal relationship between perception of own health and waist circumference cut offs (Hypothesis 3). A longitudinal follow-up of the subjects and changes in perception of own health status would provide stronger evidence for a causal association between perception of own health and body composition.

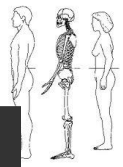
Secondly, the study consisted of a small number of subjects. As mentioned above, a longitudinal study design with larger numbers of participants would strengthen recommended WC cut off points for age, gender- and ethnicity-specific groups.

Lastly, the participants included Setswana-speaking Africans, only one of the eleven ethnic groups residing in South Africa, and we recommend that the findings be verified in other African communities.



In conclusion:

A new population and ethnicity-specific WC cut off was recommended (NPM) and subsequently validated with Logistic Regression and Neural Networks statistical analyses. The NPM was comparable with the JSC cut offs which are currently in use in predicting structural vascular disease via CIMT. It is therefore proposed that the NPM cut offs be used in this population due to the strong association between blood pressure and the proposed WC cut offs, validated by Logistic Regression and Neural Networks statistical analyses. Furthermore, associations were demonstrated between the NPM and perception of own health in a group of urban Africans.



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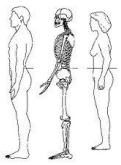


ℓ Logistic Regression: JSC males

Test of all effects

CIMT atherosclerosis or not - Test of all effects (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=1

Effect	Degr. of Freedom	Wald Stat.	p
Intercept	1	4.463965	0.034617
AGE	1	7.122030	0.007614
BMI	1	0.536494	0.463889
METS (kcal)	1	0.180470	0.670970
Alberti WC code	1	0.037260	0.846937

Parameter estimates

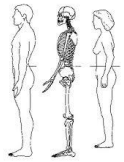
CIMT atherosclerosis or not - Parameter estimates (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=1

Effect	Level of Effect	Column	Estimate	Standard Error	Wald Stat.	Lower CL 95. %	Upper CL 95. %	p
Intercept		1	-5.08334	2.405962	4.463965	-9.79894	-0.367741	0.034617
AGE		2	0.09435	0.035354	7.122030	0.02506	0.163642	0.007614
BMI		3	0.05966	0.081454	0.536494	-0.09998	0.219308	0.463889
METS (kcal)		4	-0.00018	0.000431	0.180470	-0.00103	0.000662	0.670970
Alberti WC code	1	5	0.07075	0.366533	0.037260	-0.64764	0.789143	0.846937
Scale			1.00000	0.000000		1.00000	1.000000	

Goodness of fit: Hosmer-Lemeshow Test

CIMT atherosclerosis or not - Goodness of Fit: Hosmer-Lemeshow Test (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Hosmer Lemeshow = 10.485, p value = 0.2325
Include condition: v2=1

Response	Group1	Group2	Group3	Group4	Group5	Group6	Group7	Group8	Group9	Group10	Row Tot.
0: Observed	6.00	4.00	3.00	6.00	4.00	4.00	1.00	4.00	4.00	2.0	38.0
Expected	5.80	4.95	4.64	4.18	3.69	3.26	3.02	2.69	2.39	3.4	
1: Observed	1.00	3.00	4.00	1.00	3.00	3.00	6.00	3.00	3.00	14.0	41.0
Expected	1.20	2.05	2.36	2.82	3.31	3.74	3.98	4.31	4.61	12.6	
All Groups	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	16.0	79.0



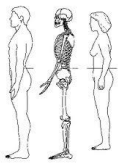
ℓ Neural Networks Statistics: JSC males

Summary of active networks

Summary of active networks (CIMT_NN_data.sta)								
Index	Net. name	Training perf.	Test perf.	Validation perf.	Training algorithm	Error function	Hidden activation	Output activation
8	MLP 5-5-2	71.92982	36.36364	72.72727	BFGS 0	Entropy	Tanh	Softmax

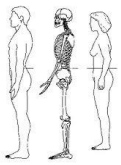
Classification summary

	CIMT atherosclerosis or not (Classification summary) (CIMT_NN_data.sta) Samples: Train, Test, Validation			
		CIMT atherosclerosis or not-1	CIMT atherosclerosis or not-2	CIMT atherosclerosis or not-All
8.MLP 5-5-2	Total	41.00000	38.00000	79.00000
	Correct	28.00000	25.00000	53.00000
	Incorrect	13.00000	13.00000	26.00000
	Correct (%)	68.29268	65.78947	67.08861
	Incorrect (%)	31.70732	34.21053	32.91139

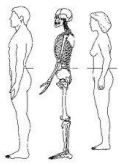


Network weights

Weight ID	Network weights (CIMT_NN_data.sta)	
	Connections 8.MLP 5-5-2	Weight values 8.MLP 5-5-2
1	Manne LOG Age --> hidden neuron 1	-1.04653
2	Manne LOG BMI --> hidden neuron 1	-0.83081
3	Manne LOG METS (kcal) --> hidden neuron 1	-0.26479
4	Alberti WC code(1) --> hidden neuron 1	0.51339
5	Alberti WC code(2) --> hidden neuron 1	0.26076
6	Manne LOG Age --> hidden neuron 2	2.19015
7	Manne LOG BMI --> hidden neuron 2	0.88337
8	Manne LOG METS (kcal) --> hidden neuron 2	-0.26245
9	Alberti WC code(1) --> hidden neuron 2	0.59248
10	Alberti WC code(2) --> hidden neuron 2	-0.62524
11	Manne LOG Age --> hidden neuron 3	-0.93239
12	Manne LOG BMI --> hidden neuron 3	-0.43454
13	Manne LOG METS (kcal) --> hidden neuron 3	0.02257
14	Alberti WC code(1) --> hidden neuron 3	-0.11548
15	Alberti WC code(2) --> hidden neuron 3	0.58931
16	Manne LOG Age --> hidden neuron 4	-0.91793
17	Manne LOG BMI --> hidden neuron 4	-0.55536
18	Manne LOG METS (kcal) --> hidden neuron 4	-0.39002
19	Alberti WC code(1) --> hidden neuron 4	-0.77518
20	Alberti WC code(2) --> hidden neuron 4	0.91287
21	Manne LOG Age --> hidden neuron 5	-0.04149
22	Manne LOG BMI --> hidden neuron 5	-0.01497
23	Manne LOG METS (kcal) --> hidden neuron 5	0.09211
24	Alberti WC code(1) --> hidden neuron 5	0.17856
25	Alberti WC code(2) --> hidden neuron 5	0.25215



26	input bias --> hidden neuron 1	0.86992
27	input bias --> hidden neuron 2	-0.03395
28	input bias --> hidden neuron 3	0.41882
29	input bias --> hidden neuron 4	0.13544
30	input bias --> hidden neuron 5	0.36291
31	hidden neuron 1 --> CIMT atherosclerosis or not(1)	-1.68511
32	hidden neuron 2 --> CIMT atherosclerosis or not(1)	1.47265
33	hidden neuron 3 --> CIMT atherosclerosis or not(1)	-0.87211
34	hidden neuron 4 --> CIMT atherosclerosis or not(1)	1.05080
35	hidden neuron 5 --> CIMT atherosclerosis or not(1)	-0.81870
36	hidden neuron 1 --> CIMT atherosclerosis or not(2)	1.68755
37	hidden neuron 2 --> CIMT atherosclerosis or not(2)	-1.35631
38	hidden neuron 3 --> CIMT atherosclerosis or not(2)	0.88307
39	hidden neuron 4 --> CIMT atherosclerosis or not(2)	-1.06426
40	hidden neuron 5 --> CIMT atherosclerosis or not(2)	0.78536
41	hidden bias --> CIMT atherosclerosis or not(1)	-0.38666
42	hidden bias --> CIMT atherosclerosis or not(2)	0.37702



ℓ Logistic Regression: NPM males

Test of all effects

CIMT atherosclerosis or not - Test of all effects (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=1

Effect	Degr. of Freedom	Wald Stat.	p
Intercept	1	4.808051	0.028327
AGE	1	6.895966	0.008639
BMI	1	0.639256	0.423980
METS (kcal)	1	0.175672	0.675119
Sphyg BP ROC male >=90cm en fem >= 98cm	1	0.021298	0.883970

Parameter estimates

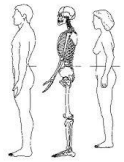
CIMT atherosclerosis or not - Parameter estimates (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=1

Effect	Level of Effect	Column	Estimate	Standard Error	Wald Stat.	Lower CL 95. %	Upper CL 95. %	p
Intercept		1	-5.16527	2.355639	4.808051	-9.78224	-0.548305	0.028327
AGE		2	0.09384	0.035734	6.895966	0.02380	0.163874	0.008639
BMI		3	0.06280	0.078540	0.639256	-0.09114	0.216730	0.423980
METS (kcal)		4	-0.00018	0.000432	0.175672	-0.00103	0.000665	0.675119
Sphyg BP ROC male >=90cm en fem >= 98cm	1	5	0.05103	0.349649	0.021298	-0.63427	0.736326	0.883970
Scale			1.00000	0.000000		1.00000	1.000000	

Goodness of fit: Hosmer-Lemeshow Test

CIMT atherosclerosis or not - Goodness of Fit: Hosmer-Lemeshow Test (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Hosmer Lemeshow = 6.7748, p value = 0.5611
Include condition: v2=1

Response	Group1	Group2	Group3	Group4	Group5	Group6	Group7	Group8	Group9	Group10	Row Tot.
0: Observed	6.00	4.00	3.00	6.00	4.00	3.00	2.00	3.00	4.00	3.0	38.0
Expected	5.81	4.95	4.64	4.19	3.66	3.28	3.01	2.67	2.40	3.4	
1: Observed	1.00	3.00	4.00	1.00	3.00	4.00	5.00	4.00	3.00	13.0	41.0
Expected	1.19	2.05	2.36	2.81	3.34	3.72	3.99	4.33	4.60	12.6	
All Groups	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	16.0	79.0



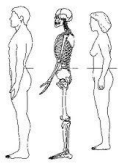
ℓ Neural Networks Statistics: NPM males

Summary of active networks

Summary of active networks (CIMT_NN_data.sta)								
Index	Net. name	Training perf.	Test perf.	Validation perf.	Training algorithm	Error function	Hidden activation	Output activation
3	MLP 5-3-2	64.91228	36.36364	81.81818	BFGS 0	Entropy	Tanh	Softmax

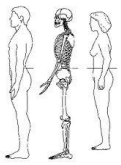
Classification summary

	CIMT atherosclerosis or not (Classification summary) (CIMT_NN_data.sta) Samples: Train, Test, Validation			
		CIMT atherosclerosis or not-1	CIMT atherosclerosis or not-2	CIMT atherosclerosis or not-All
3.MLP 5-3-2	Total	41.00000	38.00000	79.00000
	Correct	27.00000	23.00000	50.00000
	Incorrect	14.00000	15.00000	29.00000
	Correct (%)	65.85366	60.52632	63.29114
	Incorrect (%)	34.14634	39.47368	36.70886



Network weights

Weight ID	Network weights (CIMT_NN_data.sta)	
	Connections 3.MLP 5-3-2	Weight values 3.MLP 5-3-2
1	Manne LOG Age --> hidden neuron 1	-1.97776
2	Manne LOG BMI --> hidden neuron 1	-0.23588
3	Manne LOG METS (kcal) --> hidden neuron 1	-0.02218
4	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 1	-1.03776
5	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 1	1.61465
6	Manne LOG Age --> hidden neuron 2	-0.87175
7	Manne LOG BMI --> hidden neuron 2	-0.25618
8	Manne LOG METS (kcal) --> hidden neuron 2	-0.03557
9	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 2	0.42780
10	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 2	-0.13289
11	Manne LOG Age --> hidden neuron 3	-0.91978
12	Manne LOG BMI --> hidden neuron 3	-0.05704
13	Manne LOG METS (kcal) --> hidden neuron 3	0.38179
14	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 3	-0.26287
15	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 3	0.60379
16	input bias --> hidden neuron 1	0.59519
17	input bias --> hidden neuron 2	0.44966
18	input bias --> hidden neuron 3	0.29552
19	hidden neuron 1 --> CIMT atherosclerosis or not(1)	-1.07939
20	hidden neuron 2 --> CIMT atherosclerosis or not(1)	-2.77320
21	hidden neuron 3 --> CIMT atherosclerosis or not(1)	0.12390
22	hidden neuron 1 --> CIMT atherosclerosis or not(2)	0.94065
23	hidden neuron 2 --> CIMT atherosclerosis or not(2)	2.74530
24	hidden neuron 3 --> CIMT atherosclerosis or not(2)	-0.03638
25	hidden bias --> CIMT atherosclerosis or not(1)	-0.39581
26	hidden bias --> CIMT atherosclerosis or not(2)	0.47721



ℓ Logistic Regression: JSC females

Test of all effects

CIMT atherosclerosis or not - Test of all effects (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=2

Effect	Degr. of Freedom	Wald Stat.	p
Intercept	1	15.64418	0.000076
AGE	1	20.62929	0.000006
BMI	1	0.05629	0.812466
METS (kcal)	1	1.11534	0.290925
Alberti WC code	1	0.14351	0.704815

Parameter estimates

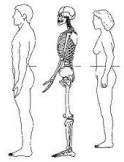
CIMT atherosclerosis or not - Parameter estimates (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=2

Effect	Level of Effect	Column	Estimate	Standard Error	Wald Stat.	Lower CL 95. %	Upper CL 95. %	p
Intercept		1	-9.03896	2.285293	15.64418	-13.5180	-4.55986	0.000076
AGE		2	0.17923	0.039461	20.62929	0.1019	0.25657	0.000006
BMI		3	-0.01224	0.051604	0.05629	-0.1134	0.08890	0.812466
METS (kcal)		4	0.00057	0.000536	1.11534	-0.0005	0.00162	0.290925
Alberti WC code	1	5	-0.14339	0.378497	0.14351	-0.8852	0.59846	0.704815
Scale			1.00000	0.000000		1.0000	1.00000	

Goodness of fit: Hosmer-Lemeshow Test

CIMT atherosclerosis or not - Goodness of Fit: Hosmer-Lemeshow Test (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Hosmer Lemeshow = 5.6976, p value = 0.6810
Include condition: v2=2

Response	Group1	Group2	Group3	Group4	Group5	Group6	Group7	Group8	Group9	Group10	Row Tot.
0: Observed	8.00	8.00	6.00	6.00	6.00	3.00	3.00	2.00	0.00	2.00	44.0
Expected	7.95	7.31	6.71	5.98	5.20	4.07	3.05	1.85	1.21	0.67	
1: Observed	1.00	1.00	3.00	3.00	3.00	6.00	6.00	7.00	9.00	7.00	46.0
Expected	1.05	1.69	2.29	3.02	3.80	4.93	5.95	7.15	7.79	8.33	
All Groups	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	90.0



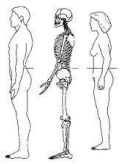
ℓ Neural Networks Statistics: JSC females

Summary of active networks

Summary of active networks (CIMT_NN_data.sta)								
Index	Net. name	Training perf.	Test perf.	Validation perf.	Training algorithm	Error function	Hidden activation	Output activation
1	MLP 5-3-2	71.87500	92.30769	92.30769	BFGS 22	Entropy	Tanh	Softmax

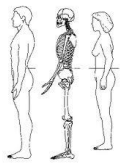
Classification summary

	CIMT atherosclerosis or not (Classification summary) (CIMT_NN_data.sta) Samples: Train, Test, Validation			
		CIMT atherosclerosis or not-1	CIMT atherosclerosis or not-2	CIMT atherosclerosis or not-All
1.MLP 5-3-2	Total	46.00000	44.00000	90.00000
	Correct	33.00000	37.00000	70.00000
	Incorrect	13.00000	7.00000	20.00000
	Correct (%)	71.73913	84.09091	77.77778
	Incorrect (%)	28.26087	15.90909	22.22222



Network weights

Weight ID	Network weights (CIMT_NN_data.sta)	
	Connections 1.MLP 5-3-2	Weight values 1.MLP 5-3-2
1	Vroue LOG Age --> hidden neuron 1	-0.193950
2	Vroue LOG BMI --> hidden neuron 1	-0.076115
3	Vroue LOG METS (kcal) --> hidden neuron 1	-0.093386
4	Alberti WC code(1) --> hidden neuron 1	-0.087266
5	Alberti WC code(2) --> hidden neuron 1	-0.036088
6	Vroue LOG Age --> hidden neuron 2	0.485818
7	Vroue LOG BMI --> hidden neuron 2	0.010753
8	Vroue LOG METS (kcal) --> hidden neuron 2	0.012111
9	Alberti WC code(1) --> hidden neuron 2	-0.070367
10	Alberti WC code(2) --> hidden neuron 2	-0.014241
11	Vroue LOG Age --> hidden neuron 3	-0.060991
12	Vroue LOG BMI --> hidden neuron 3	-0.020891
13	Vroue LOG METS (kcal) --> hidden neuron 3	-0.059849
14	Alberti WC code(1) --> hidden neuron 3	0.038860
15	Alberti WC code(2) --> hidden neuron 3	0.351678
16	input bias --> hidden neuron 1	-0.184003
17	input bias --> hidden neuron 2	-0.146762
18	input bias --> hidden neuron 3	0.381945
19	hidden neuron 1 --> CIMT atherosclerosis or not(1)	0.173825
20	hidden neuron 2 --> CIMT atherosclerosis or not(1)	0.447800
21	hidden neuron 3 --> CIMT atherosclerosis or not(1)	0.042662
22	hidden neuron 1 --> CIMT atherosclerosis or not(2)	-0.081742
23	hidden neuron 2 --> CIMT atherosclerosis or not(2)	-0.599712
24	hidden neuron 3 --> CIMT atherosclerosis or not(2)	0.085807
25	hidden bias --> CIMT atherosclerosis or not(1)	-0.030297
26	hidden bias --> CIMT atherosclerosis or not(2)	0.014487



ℓ Logistic Regression: NPM females

Test of all effects

CIMT atherosclerosis or not - Test of all effects (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=2

Effect	Degr. of Freedom	Wald Stat.	p
Intercept	1	5.93580	0.014836
AGE	1	18.10659	0.000021
BMI	1	1.38870	0.238625
METS (kcal)	1	0.54544	0.460188
Sphyg BP ROC male >=90cm en fem >= 98cm	1	3.17588	0.074733

Parameter estimates

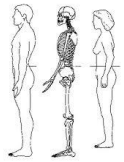
CIMT atherosclerosis or not - Parameter estimates (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Modeled probability that CIMT atherosclerosis or not = 1
Include condition: v2=2

Effect	Level of Effect	Column	Estimate	Standard Error	Wald Stat.	Lower CL 95. %	Upper CL 95. %	p
Intercept		1	-6.19732	2.543689	5.93580	-11.1829	-1.21178	0.014836
AGE		2	0.17421	0.040941	18.10659	0.0940	0.25445	0.000021
BMI		3	-0.07361	0.062468	1.38870	-0.1960	0.04882	0.238625
METS (kcal)		4	0.00040	0.000541	0.54544	-0.0007	0.00146	0.460188
Sphyg BP ROC male >=90cm en fem >= 98cm	1	5	0.71011	0.398467	3.17588	-0.0709	1.49109	0.074733
Scale			1.00000	0.000000		1.0000	1.00000	

Goodness of fit: Hosmer-Lemeshow Test

CIMT atherosclerosis or not - Goodness of Fit: Hosmer-Lemeshow Test (SABPA 2008 FINAL_2010 - 1 JUNE met standardize_2.sta)
Distribution : BINOMIAL, Link function: LOGIT
Hosmer Lemeshow = 4.5649, p value = 0.8029
Include condition: v2=2

Response	Group1	Group2	Group3	Group4	Group5	Group6	Group7	Group8	Group9	Group10	Row Tot.
0: Observed	8.00	8.00	7.00	6.00	6.00	2.00	4.00	1.00	1.00	1.00	44.0
Expected	8.12	7.42	6.90	5.98	4.87	4.13	3.32	1.87	1.00	0.40	
1: Observed	1.00	1.00	2.00	3.00	3.00	7.00	5.00	8.00	8.00	8.00	46.0
Expected	0.88	1.58	2.10	3.02	4.13	4.87	5.68	7.13	8.00	8.60	
All Groups	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	90.0



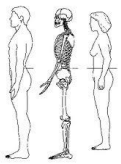
ℓ Neural Networks Statistics: NPM females

Summary of active networks

Summary of active networks (CIMT_NN_data.sta)								
Index	Net. name	Training perf.	Test perf.	Validation perf.	Training algorithm	Error function	Hidden activation	Output activation
7	MLP 5-3-2	75.00000	76.92308	84.61538	BFGS 18	Entropy	Exponential	Softmax

Classification summary

	CIMT atherosclerosis or not (Classification summary) (CIMT_NN_data.sta) Samples: Train, Test, Validation			
		CIMT atherosclerosis or not-1	CIMT atherosclerosis or not-2	CIMT atherosclerosis or not-All
7.MLP 5-3-2	Total	46.00000	44.00000	90.00000
	Correct	40.00000	29.00000	69.00000
	Incorrect	6.00000	15.00000	21.00000
	Correct (%)	86.95652	65.90909	76.66667
	Incorrect (%)	13.04348	34.09091	23.33333



Network weights

Weight ID	Network weights (CIMT_NN_data.sta)	
	Connections 7.MLP 5-3-2	Weight values 7.MLP 5-3-2
1	Vroue LOG Age --> hidden neuron 1	-0.27177
2	Vroue LOG BMI --> hidden neuron 1	0.11326
3	Vroue LOG METS (kcal) --> hidden neuron 1	0.52767
4	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 1	-0.88151
5	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 1	1.10550
6	Vroue LOG Age --> hidden neuron 2	0.56304
7	Vroue LOG BMI --> hidden neuron 2	0.36253
8	Vroue LOG METS (kcal) --> hidden neuron 2	0.13273
9	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 2	0.63340
10	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 2	0.29321
11	Vroue LOG Age --> hidden neuron 3	-1.35763
12	Vroue LOG BMI --> hidden neuron 3	0.34480
13	Vroue LOG METS (kcal) --> hidden neuron 3	-0.04387
14	Sphyg BP ROC male >=90cm en fem >= 98cm(1) --> hidden neuron 3	-0.35386
15	Sphyg BP ROC male >=90cm en fem >= 98cm(2) --> hidden neuron 3	0.82574
16	input bias --> hidden neuron 1	0.05921
17	input bias --> hidden neuron 2	0.90131
18	input bias --> hidden neuron 3	0.46831
19	hidden neuron 1 --> CIMT atherosclerosis or not(1)	0.46393
20	hidden neuron 2 --> CIMT atherosclerosis or not(1)	0.07446
21	hidden neuron 3 --> CIMT atherosclerosis or not(1)	-1.90609
22	hidden neuron 1 --> CIMT atherosclerosis or not(2)	-0.36036
23	hidden neuron 2 --> CIMT atherosclerosis or not(2)	0.01802
24	hidden neuron 3 --> CIMT atherosclerosis or not(2)	1.79037
25	hidden bias --> CIMT atherosclerosis or not(1)	1.34403
26	hidden bias --> CIMT atherosclerosis or not(2)	-1.15977